

# Correspondensi BIODIVERSITAS Erwan Via OJS System

## 1. Submit paper ke BIODIVERSITAS

The screenshot shows the OJS submission dashboard for a paper titled "12166 / Erwan et al. / Honey quality from the bee Apis cerana. honey potency produced by coconut and sugar palm saps". The interface includes a sidebar with the OJS logo and "Submissions" link, and a main content area with tabs for "Workflow" and "Publication". Under "Publication", there are sub-tabs for "Submission", "Review", "Copyediting", and "Production". The "Submission" sub-tab is active, showing a "Submission Files" section with a table of files and a "Pre-Review Discussions" section with an "Add discussion" button.

Submission Files				Search
1060571-1	erwan, BISMILLAH BIODIVERSITAS ERWAN SEPTEMBER 2022.doc	September 6, 2022	Article Text	

Pre-Review Discussions					Add discussion
Name	From	Last Reply	Replies	Closed	
No Items					

## 2. Proses review paper

The screenshot shows the OJS submission dashboard for the same paper, now in the "Review" stage. The "Review" sub-tab is active, showing a "Round 1 Status" section with a message: "New reviews have been submitted and are being considered by the editor." Below this is a "Notifications" section with a table of editor decisions.

Round 1 Status	
New reviews have been submitted and are being considered by the editor.	

Notifications	
[biodiv] Editor Decision	2022-09-27 03:03 AM
[biodiv] Editor Decision	2022-10-02 06:21 AM
[biodiv] Editor Decision	2022-11-01 03:35 AM
[biodiv] Editor Decision	2022-11-12 12:14 AM
[biodiv] Editor Decision	2022-11-18 09:34 AM

### 3. Informasi revisi paper dari Editor Jurnal Biodiversitas

The screenshot shows the 'Review Discussions' section of the Biodiversitas Journal author dashboard. The table lists several discussions:

Name	From	Last Reply	Replies	Closed
<a href="#">Revision Submission</a>	erwan 2022-10-01 01:30 PM	-	0	<input type="checkbox"/>
<a href="#">Ask reviewer comments</a>	erwan 2022-10-02 07:00 AM	-	0	<input type="checkbox"/>
<a href="#">Revision Submission</a>	erwan 2022-11-02 03:39 PM	-	0	<input type="checkbox"/>
<a href="#">Uncorrected Proof</a>	dewinurpratiwi 2022-11-09 09:11 AM	erwan 2022-11-10 11:16 AM	1	<input type="checkbox"/>
<a href="#">BILLING</a>	dewinurpratiwi 2022-11-09 09:19 AM	dewinurpratiwi 2022-11-17 07:10 AM	2	<input type="checkbox"/>

### 4. Submit revisi pertama paper ke system Biodivesitas

The screenshot shows a 'Revision Submission' modal window. It contains the following information:

**Participants** [Edit](#)

Smujo Editors (editors)  
Ayu Astuti (ayu)  
Erwan (erwan)

**Messages**

Note	From
Dear Editor in Chief Biodiversitas	erwan
We have been submission the revision for our paper	2022-10-01 01:30 PM
Best regards,	
Erwan	

[Add Message](#)

The screenshot shows the author dashboard for Biodiversitas Journal of Biological Diversity. The page is titled "Biodiversitas Journal of Biological Diversity" and "Tasks 0". The user is logged in as "erwan".

**Notifications**

<a href="#">[biodiv] Editor Decision</a>	2022-09-27 03:03 AM
<a href="#">[biodiv] Editor Decision</a>	2022-10-02 06:21 AM
<a href="#">[biodiv] Editor Decision</a>	2022-11-01 03:35 AM
<a href="#">[biodiv] Editor Decision</a>	2022-11-12 12:14 AM
<a href="#">[biodiv] Editor Decision</a>	2022-11-18 09:34 AM

**Reviewer's Attachments** [Search](#)

1062246-1	.12166-Article Text-1060789-1-4-20220909(1).doc	September 26, 2022
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**Revisions** [Search](#) [Upload File](#)

1062702-1	Article Text, A-12166-Article Text-1060789-1-4-20220909 REVISION.doc	October 1, 2022	Article Text
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## 5. Konfirmasi revisi ke Editor Biodiversitas melalui System

The screenshot shows the "Ask reviewer comments" dialog box. The dialog has a blue header with the title "Ask reviewer comments" and a close button (X).

**Participants** [Edit](#)

- Smujo Editors (editors)
- Ayu Astuti (ayu)
- Erwan (erwan)

**Messages**

Note	From
Dear Editor in Chief Biodiversitas	erwan
We receive email from Editor Biodiversitas for our paper required revision, but in the attached file in the email we can't found comments from reviewers or editor for our paper and the paper is same with the revision that we have been submit to smujo system. Can you help us to explain or send again the comments for our paper ?	2022-10-02 07:00 AM
Best regards,	
Erwan	

[Add Message](#)

On the right side of the dialog, there is an "Add discussion" section with a "Replies" column and a "Closed" checkbox. The replies are:

- 0
- 0
- 0
- 1
- 2

## 6. Submit revisi kedua paper ke system Biodiversitas

The screenshot shows a web browser window with the URL `smujo.id/biodiv/authorDashboard/submission/12166`. A modal window titled "Revision Submission" is open, displaying the following information:

- Participants** [Edit](#)
  - Smujo Editors (editors)
  - Ayu Astuti (ayu)
  - Erwan (erwan)
- Messages**

Note	From
Dear Editor in Chief Biodiversitas	erwan
We have been revising of manuscript according to reviewer comments and is made for red color	2022-11-02 03:39 PM
Best regards,	
Erwan	

[Add Message](#)

The screenshot shows the Biodiversitas author dashboard with the following sections:

- Notifications**

<a href="#">[biodiv] Editor Decision</a>	2022-09-27 03:03 AM
<a href="#">[biodiv] Editor Decision</a>	2022-10-02 06:21 AM
<a href="#">[biodiv] Editor Decision</a>	2022-11-01 03:35 AM
<a href="#">[biodiv] Editor Decision</a>	2022-11-12 12:14 AM
<a href="#">[biodiv] Editor Decision</a>	2022-11-18 09:34 AM
- Reviewer's Attachments** [Search](#)

1065355-1	, 12166-Article Text-1062944-1-4-20221004.doc	October 31, 2022
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- Revisions** [Search](#) [Upload File](#)

1065582-1	Article Text. A-12166-Article Text-1062944-1-4-20221004 Second REVISION.doc	November 2, 2022	Article Text
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## 7. Submit Proofread paper Biodiversitas

ERWAN, Honey quality from the

smujo.id/biodiv/authorDashboard/submission/12166

Biodiversitas Journal of Biological Diversity

Erwan (erwan)

**Messages**

Note	From
Dear Author(s), Pls, find attached file for an uncorrected proof (Copyedited file). The revised manuscript (Corrected proof) is awaited. Do not worry about layout changes due to revision; our staff will fix it again. Note: Kindly TURN ON track changes when you make improvements. <a href="#">dewinurpratiwi, bee Apis cerana - Erwan.doc</a>	dewinurpratiwi 2022-11-09 09:11 AM
Dear Editor in Chief Biodiversitas  We have been corrected proof for our paper and the green color as the mark for the correct revision. please find attached file  Best Regards  Erwan  <a href="#">erwan, 12166-Article Text-1066146-1-18-20221109 (Proofread).doc</a>	erwan 2022-11-10 11:16 AM

Add Message

English View Site erwan

Replies Closed

0

0

0

1

2



erwan apis &lt;apiserwan@gmail.com&gt;

---

**[biodiv] Submission Acknowledgement**

2 pesan

---

**Ahmad Dwi Setyawan** <smujo.id@gmail.com>  
Kepada: Erwan <apiserwan@gmail.com>

6 September 2022 pukul 19.52

Erwan:

Thank you for submitting the manuscript, "Honey quality from the bee Apis cerana, honey potency produced by coconut and sugar palm saps" to Biodiversitas Journal of Biological Diversity. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

Submission URL: <https://smujo.id/biodiv/authorDashboard/submission/12166>

Username: erwan

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Ahmad Dwi Setyawan

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[Biodiversitas Journal of Biological Diversity](#)

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**erwan apis** <apiserwan@gmail.com>  
Kepada: Ahmad Dwi Setyawan <smujo.id@gmail.com>

6 September 2022 pukul 19.55

Dear Editor in Chief Biodiversitas

Thanks very much for the information and we hope our paper can be accepted and published in Biodiversitas

[Kutipan teks disembunyikan]

--

Best Regards,

Dr. Ir. Erwan, M.Si.  
Faculty of Animal Science, University of Mataram, Indonesia

## COVERING LETTER

Dear Editor-in-Chief,

I herewith enclosed a research article,

**Title:**

Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

**Author(s) name:**

Erwan and Agussalim

**Address**

(Fill in your institution's name and address, your personal cellular phone and email)

Faculty of Animal Science, University of Mataram, Jl. Majapahit No. 62, Mataram – 83125, Indonesia. Telp.:

**For possibility publication on the journal:**

(fill in *Biodiversitas* or *Nusantara Bioscience* or mention the others)

Biodiversitas

**Novelty:**

(state your claimed novelty of the findings versus current knowledge)

The novelty of our study was the honey quality produced by the bee *Apis cerana* and the honey potency which are produced by sugar palm and coconut saps which have not studied by another researcher especially in Indonesia. Therefore, this manuscript is very informative for the beekeepers, researchers or scientist, and honey consumers.

**Statements:**

This manuscript has not been published and is not under consideration for publication to any other journal or any other type of publication (including web hosting) either by me or any of my co-authors.

Author(s) has been read and agree to the Ethical Guidelines.

**List of five potential reviewers**

(Fill in names of five potential reviewers and their email addresses. He/she should have Scopus ID and come from different institution with the authors; and from at least three different countries)

1. Dr. Jati Batoro (Department of Biology, Faculty of Mathematic and Natural Sciences, Brawijaya University); Email: [jati\\_batoro@yahoo.co.id](mailto:jati_batoro@yahoo.co.id); Scopus ID: 57204421874
2. Dr. Dewi Masyithoh, S.P., M.Pt. (Faculty of Agriculture, Islamic University of Malang, Indonesia), Email: [masyithoh.dewi@unisma.ac.id](mailto:masyithoh.dewi@unisma.ac.id), Scopus ID: 57217108400
3. Firman Jaya, S.Pt., MP. (Department of Animal Products Technology, Faculty of Animal Science, Brawijaya University, Indonesia), Email: [firmanjaya@ub.ac.id](mailto:firmanjaya@ub.ac.id), Scopus ID: 36800743500

**Place and date:**

Mataram, 29<sup>th</sup> August 2022

**Sincerely yours,**

(fill in your name, no need scanned autograph)

Dr. Ir. Erwan, M.Si.

# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,\*</sup>, AGUSSALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram. Jl. Majapahit No. 62, Mataram – 83125, Indonesia. Telp/Fax: +62370-633603/+62370-640592.  
\*email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

Manuscript received: DD MM 2016 (Date of abstract/manuscript submission). Revision accepted: ..... 2016. (8 pt)

**Abstract.** One of the big problems when keeping of honeybees is the limited of sustainable feed, especially in the rain season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* were divided into six treatments consists of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.35 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. It can be concluded that honey quality is produced by sugar palm and coconut saps, and potential as the bee feed.

**Key words:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

**Running title:** Honey quality of *Apis cerana* produced by sugar palm and coconut saps

## INTRODUCTION

Honeybee of *A. cerana* is one of the bees from the *Apis* genus which is include the local bee which is spread in some regions in Indonesia are Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by the beekeepers using a traditional hives (for example using a coconut log hive) and semi modern hive (box hive without nest frame). Furthermore, several regions have been practices the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok.

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is the very serious problem have been faced by the beekeepers because they have not area which is used to planted several plants which are used the feed source to produce the honeybees products. Honeybees feeds is divided into two types namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body part and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers is role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process continuously done by the foragers until the honey stomach is full by a nectar and their corbicula has been deposited by the pollen. This pollination which is impacts on the increasing the plants productivity (; Pohorecka et al. 2014).

One of the strategies to produce the sustainability honey from the bee *A. cerana* by using a sap from the plants such as sugar palm and coconut. Several studies have been conducted by using a sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed can enhancing the production of honey cells and bee bread cells. Furthermore, Erwan et al. (2022) was also reported that the use of sugar palm and coconut saps which each added by sugar palm pollen can improving the bee *A. cerana* productivity such as increase the honey production, brood cells number, and colony weight. In addition, the study use of extrafloral nectar namely sugar palm (*Arenga pinnata*) and coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed which is resulting the honey chemical composition which are acceptable by Indonesian national standard and international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, the studied about the chemical

Commented [u1]: The introduction at least consists of 600 words



47 composition of honey from the bee *A. cerana* which are produced from the sugar palm sap, coconut sap and their honey  
48 potency production from both sap sugar palm and coconut have not been studied. Therefore, the objectives of this study  
49 were to evaluate the honey quality based on the chemical composition from the bee *A. cerana*, honey potency produced by  
50 the coconut and sugar palm saps.

## 51 MATERIALS AND METHODS

### 52 Study area

53 This research has been conducted in the North Duman Village (8°32'10"S 116°09'32"E), Lingsar Sub-district, West  
54 Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty of *A. cerana* colonies were divided  
55 into six treatments and each five colonies per treatment as the replication. The saps were used in our study were obtained  
56 from coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*). The treatments in our study were sugar palm sap  
57 without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% +  
58 sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen  
59 (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by  
60 sugar palm pollen (SCP1).

61 The technique was used to given sugar palm and coconut saps and sugar palm pollen was according to previously  
62 method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and sugar palm saps were given  
63 to the bee *A. cerana* by using a plastic plate and split bamboo were completed by 4 to 5 twigs for foragers perch. The  
64 plastic plate and split bamboo were placed one meter of the box hives, while the sugar palm pollen was hung besides and  
65 above of the box hives. The distance of 600 meters to place colony to avoid the foragers to collect pollen and sap from the  
66 other treatments.

### 67 Proceduress

#### 68 Honey quality

69 Honey from the *A. cerana* was harvested after beekeeping for three months by using a coconut and sugar palm saps.  
70 Honey from the five hives in one treatment group was composited into one honey sample and then used to analysis of their  
71 chemical composition. Honey quality from the *A. cerana* were evaluated based on the chemical composition consists of  
72 moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and acidity. The moisture  
73 content was analyzed by using a proximate analysis based on the method from Association of Official Agricultural  
74 Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed by using a Layne-Enyon method and sucrose content was  
75 analyzed by a Luff Schoorl method were described by AOAC (2005). Diastase enzyme activity, hydroxymethylfurfural  
76 (HMF), and free acidity were analyzed based on the harmonised methods of the international honey commission  
77 (Bogdanovs 2009).

#### 78 Honey production from sugar palm and coconut saps

79 Sugar palm and coconut saps each ten liters were used to measuring the honey production from the bee *A. cerana* for  
80 three months of beekeeping. The sugar palm and coconut saps were placed in the plastic plate in front of the box hives at  
81 the distance of one meter. In addition, the honey production without using of sugar palm and coconut saps were measured  
82 for one year of the beekeeping which is used to calculate the contribution of sugar palm and coconut saps in honey  
83 production.

#### 84 Production of saps from coconut and sugar palm

85 The production of sap from coconut was measured for a year, while the sugar palm sap based on the previously studied  
86 was used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The  
87 production of coconut and sugar palm saps per hectare which was calculated from the sap production per hectare  
88 multiplied by the tress number in one hectare area. After three months of beekeeping, honey from both treatments sugar  
89 palm and coconut saps were harvested to measure the honey production from the use of ten liters sap and then honey  
90 production was measured by cylinder glass

### 91 Data analysis

92 The data of honey quality, production potency of honey from sugar palm and coconut saps, honey production, and  
93 production of saps were analyzed by using a descriptive analysis (Steel et al. 1997).

### Moisture content of honey

Honey is composed by water as the second largest of honey constituent and its ranging from 15 to 21 g/100 g, depending on the plant types as the nectar source which is affected by the botanical origin. Furthermore, honey moisture is also affected by honey maturity level, processing postharvest, and storage condition (Da Silva et al. 2016). The honey moisture is affecting the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the temperature and humidity or depending on the season (rain and dry seasons) and honey moisture can increase during the postharvest processing such as storage condition because honey is hygroscopic that can absorb the moisture in the air (Da Silva et al. 2016; Karabagias et al. 2014).

The recent study showed that the honey moisture from the bee *A. cerana* which was produced by sugar palm and coconut saps and their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted by Indonesian national standard (SNI) where the moisture for beekeeping honey including the bee *A. cerana* and *A. mellifera* is not exceed 22% (National Standardization Agency of Indonesia 2018) and higher compared to international standard which is regulated by Codex Alimentarius is not exceed 20% (Bogdanov et al. 1999; Thrasyvoulou et al. 2018). The variation of honey moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm and coconut, however in our study has not measured. The higher moisture content is requiring the long time to ripening of honey and process decreasing of honey moisture have been started by the bees when they are taken a nectar from plant flowers or saps as the raw material to produce honey. Furthermore, small portion of moisture content has been evaporated in the honey sack before transferred to the other bee which is working in the hive. This transfer is rapid depending on the temperature, colony strength, and nectar availability (Winston 1987).

**Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CP1	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

Honey production process is started from the foragers collecting a nectar from the plant flowers or extrafloral nectar and then stored in honey stomach. After that, the foragers will be transferring a nectar has been collected to the other bees whom working to processing a nectar into honey in their mouth, then put in honey stomach and then is transferred to other bees for several times until honey is ripening. A considerable of water amount will be evaporated in this process and this continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes (Winston 1987). The honey moisture content in our study was differed to reported by Wang et al. (2021) that honey moisture from the bee *A. cerana* which is collected from 42 different honeycombs from China is ranging from 17.03 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana* from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) was also reported that the honey moisture was produced by the *A. mellifera* bee by using a sugar palm and coconut saps is ranging from 19.34 to 20.94%. The different honey moisture content has been reported are affected by the different geographical origins which is impact on the different plant types can be growth each region, different environmental condition (temperature and humidity), and also different bee species which is impact on the different ability to evaporate water in the honey.

### Reducing sugar and sucrose contents of honey

Sugars in honey are composed by monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation (Da Silva et al. 2016; Kamal and Klein 2011). Several sugars in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerobiose, maltotriose, maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016; De La Fuente et al. 2011).

The recent study showed that the honey s reducing sugar from the bee *A. cerana* were beekeeping by using a sugar palm and coconut saps and their combination as the nectar source to produce honey is ranging from 62.78 to 68.37 % (Table 1). This honey reducing sugar is acceptable by the SNI for treatments SP0, CP0, CP1, and SCP1, but not acceptable for treatments SCP0, SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that change the sap sucrose into

146 simple sugars. It is known that this enzyme is responsible for the conversion of sucrose into glucose and fructose. These  
147 sugars are included in reducing sugar group and as the main component present in honey. In honey maturity process, the  
148 sucrose is break down by the invertase enzyme into simple sugars simultaneously and water will be evaporated so that it  
149 will be increasing the reducing sugar content. In addition, enzymes secreted by the worker bees are also can break down  
150 the carbohydrate into simple sugars. Furthermore, other enzyme present in honey is diastase enzyme that role to break  
151 down starch into simple sugars (Da Silva et al. 2016; Sihombing 2005). The honey reducing sugar in our study (Table 1)  
152 was differed to reported by Erwan et al. (2020) that honey reducing sugar from the bee *A. mellifera* which was produced  
153 by extrafloral nectar (sugar palm and coconut saps) is ranging from 60.15 to 73.69%. The different reducing sugar may be  
154 affected by the different bee species which is impact on the different their ability to evaporate water present in honey  
155 especially when they are convert the complex sugars into simple sugars and different season when done the study which  
156 are related to temperature and humidity environmental.

157 The honey sucrose content from the bee *A. cerana* in our study is ranging from 1.44 to 3.42% (Table 1) and acceptable  
158 by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency  
159 of Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed  
160 5% for blossom and honeydew honeys (Bogdanov et al. 1999; Thrasyvoulou et al. 2018). Naturally, sucrose present in  
161 honey in our study is originated from sugar palm and coconut saps. The low of honey sucrose content in our study is  
162 caused the honey which is harvested in mature condition that characterized by honey cells have been covered by the wax.  
163 Furthermore, the invertase enzyme which is produced by the worker bees is actively break down of sucrose from saps into  
164 simple sugars. There are two types of invertase enzymes which are produced by the worker bees, namely glucoinvertase  
165 which is converts sucrose into glucose and fructoinvertase which is converts sucrose into fructose. White (1992) explained  
166 these enzymes are mostly derived from the bee's secretion and only a small portion from the nectar, while the honeydew  
167 from the insect's secretion is mostly contain invertase enzyme. The honey sucrose content in our study (Table 1) was  
168 differed to reported by Erwan et al. (2020) that honey sucrose content from the bee *A. mellifera* was produced by  
169 extrafloral nectar (sugar palm and coconut saps) is ranging from 4.21 to 4.40%.

170 The honey sucrose content is a very important parameter to evaluate the maturity of honey to identifying manipulation,  
171 where the high levels may be indicated adulterations by adding the several sweeteners such cane sugar or refined beet  
172 sugar. In addition, also indicating the early of harvest, where sucrose is not completed transformed into fructose and  
173 glucose, the bees feeding artificial in prolonged time by using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013;  
174 Escuredo et al. 2013; Tornuk et al. 2013). Honey is sugar solution that is supersaturated and unstable so it's easy to  
175 crystallize. The honey crystallization is affected by concentration of glucose, fructose, and water. Fructose is the dominant  
176 sugar present in honey from *A. mellifera* was produced by several plants as the nectar source which is used by workers to  
177 produce honey such as eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey  
178 was produced by *Brassica napus*. Rape honey is higher in glucose and lower in fructose which is impact on the rapidly  
179 crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which  
180 is impact on the different plant types can growth in each region and impact on the different sugars content from the nectar  
181 which is produced by the nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016;  
182 Escuredo et al. 2014; Tornuk et al. 2013). Furthermore, sugars content in honey is influenced by climate (season,  
183 temperature, and humidity), processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014;  
184 Tornuk et al. 2013).

#### 185 **Diastase enzyme activity and hydroxymethylfurfural of honey**

186 The recent study showed that the diastase enzyme activity from the bee *A. cerana* honey was produced by the sugar  
187 palm and coconut saps was ranging from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with the  
188 minimum of 3 DN for the beekeeping honey including the bee *A. cerana* and *A. mellifera* (National Standardization  
189 Agency of Indonesia 2018) and also acceptable by international standard has been regulated by Codex Alimentarius with  
190 the minimum 3 DN (Bogdanov et al. 1999; Thrasyvoulou et al. 2018). One of the honey characteristics is contain enzymes  
191 which is originate from the bees, pollen, and nectar from plant flowers, but the mostly enzymes are added by the bees  
192 when they are convert nectar into honey (Bogdanov et al. 1999; Da Silva et al. 2016; Thrasyvoulou et al. 2018). The honey  
193 diastase enzyme activity in our study (Table 2) was differed to reported by Erwan et al. (2020) that the diastase enzyme  
194 activity of honey from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging  
195 from 16.48 to 17.12 Schade unit.

196 Diastases is divided into  $\alpha$ - and  $\beta$ -amylases which are the natural enzymes present in honey. The  $\alpha$ -amylase is separate  
197 the starch chain randomly in the central to produce dextrin, while the  $\beta$ -amylase to separate the maltose in the end chain.  
198 Diastase enzyme content in honey is influenced by nectar source (floral and extrafloral nectars) to produce honey and  
199 honey geographical origins which are impact on the different chemical composition of the nectar can be produced by the  
200 plants which is impact on the honey chemical composition especially diastase enzyme activity. In addition, the bee species  
201 is also influencing the activity diastase because it's related to the distance and the flowers plant numbers can be visited by  
202 the foragers when they are collecting nectar and pollen were using to produce honey and bee bread (Da Silva et al. 2016).

203 Generally, diastase enzyme is role to break down the complex sugars into simple sugars. This enzyme is role to digest  
204 of starch into maltose (disaccharide) and maltotriose (trisaccharide) which are sensitive to heat or thermolabile. Thus, this

condition can be used to evaluate of overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore, the diastase activity is also used to evaluate honey age which is related to storage time and the temperature because the diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed to reported by Wu et al. (2020) for multifloral honey produced by the *A. cerana cerana* from Hainan province (China) was 6.70 Göthe. Furthermore, also was differed to reported by Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling Mountains (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activity of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

Furthermore, the HMF of *A. cerana* honey was produced by the sugar palm and coconut saps in our study was ranging from 2.24 to 5.81 mg/kg (Table 2). This HMF indicate that honey from our study in fresh condition and acceptable by SNI for the beekeeping honey including from *A. cerana* and *A. mellifera* is not exceed 40 mg/kg (National Standardization Agency of Indonesia 2018) and also acceptable by the international standard has been regulated by Codex Alimentarius is not exceed 40 mg/kg for blossom and honeydew honeys (Bogdanov et al. 1999; Thrasylvoulou et al. 2018). The fresh honey after harvested is generally contain the low of HMF is ranging from 0.06 to 0.2 mg/100 g of honey (White 1992). Hydroxymethylfurfural is resulted from the degradation of honey monosaccharide especially fructose and glucose under acid condition and accelerated by the heating. This reaction is producing levulinic and formic acids (Da Silva et al. 2016; White 1992).

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CP1	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

Hydroxymethylfurfural is formed after honey removed from the comb or when the wax covers was opened and the advanced processing like heating process. The increasing of the HMF content is occur in honey with the high acidity and accelerated by the heating process. However, the HMF content also influenced by several factors such as sugars content, organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF is also can be formed at the low temperatures, acidic condition, and sugars dehydration reactions. Therefore, the higher of HMF content is impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). Karabournioti and Zervalaki (2001) reported that the heating process increasing the HMF content and decreasing the diastase enzyme activity. The HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

#### Acidity of honey

Free acidity is one of an important parameter to evaluate the honey deterioration which is characterized by the organic acids presence in equilibrium with internal esters, lactone and several inorganic ions such as sulfates, chlorides, and phosphates (Da Silva et al. 2016; Moreira et al. 2007). The recent study showed that the honey acidity from *A. cerana* was produced by the sugar palm and coconut saps was ranging from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is acceptable by SNI is not exceed 50 ml NaOH/kg for the beekeeping honey including *A. cerana* and *A. mellifera*. Furthermore, is also acceptable of the international standard has been regulated by the Codex Alimentarius is not exceed 50 meq/kg for blossom and honeydew honeys (Bogdanov et al. 1999; Thrasylvoulou et al. 2018).

The sour taste of honey originated from the several of organic and inorganic acids, where the dominant of organic acid present in honey is gluconic acid (Da Silva et al. 2016; White 1992). This organic acid is produced by the enzyme activity of glucose-oxidase which is added by the bees when they are convert a nectar into honey, so can protecting a nectar until honey maturity. This protecting mechanism is occurred by the inhibit of microorganisms activity present in honey (Da Silva et al. 2016; White 1992). This inhibit mechanism includes the combination several factors such as low moisture and presence hydrogen peroxide which is produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the

257 microbe cell through the destruction of cell wall resulting in change in cytoplasmic membrane permeability (Molan 1992;  
258 Nainu et al. 2021; Pasiyas et al. 2018).

259 The acidity total content in honey is small quantity, but the present in honey is very important because can influencing  
260 the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity is indicating the  
261 fermentation process had been occurred when some reducing sugar is break down into acetic acid. Ghazali et al. (1994)  
262 explained that honey acidity content is related to the yeast number where them is break down some reducing sugar into  
263 ethanol and if it's reaction with the oxygen is formed the acetic acid which is increasing the honey acidity. Da Silva et al.  
264 (2016) explained that the values higher of acidity may be indicating the fermentation process of sugars into organic acids.  
265 The honey acidity is affected by several factors such as different content of organic acids, different geographical origin and  
266 the seasonal when honey harvested (Da Silva et al. 2016; Tornuk et al. 2013). The honey acidity from the bee *A. cerana* in  
267 our study (Table 2) was differed to previously studied by Wu et al. (2020) for *A. cerana cerana* honey is 0.80 mol/kg and  
268 Guerzou et al. (2021) is ranging 11 to 47 meq/kg for Algerian honey. Furthermore, is differed to reported by Erwan et al.  
269 (2020) that honey acidity from the bee *A. mellifera* were produced by extrafloral nectar (sugar palm and coconut saps) is  
270 ranging from 22.00 to 43.00 ml NaOH/kg. The different acidity has been reported previously with our studied is affected  
271 by the different plant types as the nectar source to produce honey, honey pH, geographical origin, and organic acids  
272 compound, however in our study has not measured the organic acid compound and honey pH.

### 273 Honey production potency from the sugar palm and coconut saps

274 Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized  
275 which can contributing for communities' income. Generally, the main production from the coconut (*Cocos nucifera* L.)  
276 was harvested is coconut fruit to advanced process into coconut oil and copra. Theses commodities have a high price, but  
277 if just to producing coconut oil and copra are high risk for the farmers because they are just preparing in the raw material.  
278 Therefore, the utilizing of the sap can be produced by the coconut and sugar palm were also potency feed for the bees was  
279 used as the nectar source to produce honey. Sugar palm and coconut saps are the feed potential which is studied by Erwan  
280 et al. (2021b) that the coconut and sugar palm saps can increasing the number of honey cell and bee bread cell of the bee  
281 *A. cerana*. Furthermore, is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*  
282 such as increase the brood cells number, colony weight, and the honey production (Erwan et al. 2022). In addition, the saps  
283 from coconut and sugar palm are usually used by the farmers to produce sugar by using a traditional process.

284 The coconut plants can produce of 12 stalks in a year and in one of stalk can produce sap of 90 liters, thus, in one  
285 coconut plant can produce of 1,080 liters of sap. Furthermore, if the farmers have one hectare of the land which are planted  
286 by 100 coconut plants (distance 10 m × 10 m), so can be produced for about 108,000 liters of coconut sap. To produce 1  
287 kg of honey is required coconut sap for about 7 liters and in a year is required 84 liters to produce 12 kg of honey. Thus,  
288 honey potency in a year from 100 hectares of the land can be calculated as follows: 10,800,000 liters of sap divided by 84  
289 liters of sap and multiplied by 12 kg of honey and obtained 1,542,857,14 kg/year (1,542.857 tons/year) or equivalent with  
290 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big  
291 potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa  
292 Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

293 Sugar palm plant can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be tapping not  
294 exceed of 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant is ranging from 8 to 22  
295 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year).  
296 Furthermore, if in one hectare of plantation we have 100 sugar palm plants with the distance for planted is 10 m × 10 m, so  
297 can be obtained of sap for 115,000 liters.

298 Based on the field investigation showed that to produce 1 kg of honey from the sugar palm sap is required for about 10  
299 liters and in a year is required for about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm  
300 sap in a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and  
301 multiplied by 12 kg, so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833  
302 tons/month in 100 hectares area. This potency indicate that the sugar palm sap has a big potency to produce honey which is  
303 supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap  
304 productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46  
305 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. It can be concluded that Honey is produced  
306 by the bee *A. cerana* from sugar palm and coconut saps as the feed have the quality which is acceptable by Indonesian  
307 national standard and international standard has been regulated by the Codex Alimentarius. Honey potency production  
308 from the coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571  
309 tons/month, while in sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

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## REFERENCES

- Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas 22: 5205-5210. <https://doi.org/10.13057/biodiv/d221159>.
- Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*, from different regions. *Livest Res Rural Dev* 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/agus31091.html>.
- Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta. *Bul Peternak* 42(1): 50-56. <https://doi.org/10.21059/buletinpetermak.v42i1.28294>.
- Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. *Bul Peternak* 41(4): 448-460. <https://doi.org/10.21059/buletinpetermak.v41i4.13593>.
- AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin Franklin Station, Washington D.C.
- Bogdanov S. 2009. Harmonised Methods of the International IHC. *Bee Prod Sci* 1-63.
- Bogdanov S, Lüllmann C, Martin P, von der Ohe W, Russmann H, Vorwohl G, Oddo LP, Sabatini AG, Marcazzan GL, Piro R, Flamini C, Morlot, M., Lhéritier J, Borneck R, Mariouleas P, Tsigouri A, Kerkvliet J, Ortiz A, Ivanov T, D'Arcy B, Mossel B, Vit P. 1999. Honey quality and international regulatory standards: Review by the international honey commission. *Bee World* 80(2): 61-69. <https://doi.org/10.1080/0005772x.1999.11099428>.
- Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. *Food Chem* 196: 309-323. <https://doi.org/10.1016/j.foodchem.2015.09.051>.
- De La Fuente E, Ruiz-Matute AI, Valencia-Barrera RM, Sanz J, Martínez Castro I. 2011. Carbohydrate composition of Spanish unifloral honeys. *Food Chem* 129: 1483-1489. <https://doi.org/10.1016/j.foodchem.2011.05.121>.
- Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan Perkebunan Provinsi NTB, Mataram.
- Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. *J Sci Sci Educ* 1: 1-7. <https://doi.org/10.29303/jossed.v1i1.482>.
- Erwan, Franti, L.D., Purnamasari, D.K., Muhsinin, M., Agussalim, A., 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from *Apis cerana* from different regions in North Lombok Regency, Indonesia. *J Trop Anim Prod* 22: 35-41. <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>
- Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification. *Livest Res Rural Dev* 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.
- Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia. *Livest Res Rural Dev* 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>.
- Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization phenomenon. *Food Chem* 149: 84-90. <https://doi.org/10.1016/j.foodchem.2013.10.097>.
- Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic area. *Food Chem* 138: 851-856. <https://doi.org/10.1016/j.foodchem.2012.11.015>.
- Ghazali HM, Ming TC, Hashim DM. 1994. Effect of microwave heating on the storage and properties of starfruit honey. *Asean Food J* 9: 30-35.
- Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of physicochemical properties of Algerian honey. *Resources* 10: 94. <https://doi.org/https://doi.org/10.3390/resources10100094>.
- Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (Eds.), *Honeybees of Asia*. Springer, New York, pp. 51-68. DOI 10.1007/978-3-642-16422-4\_3.
- Kamal MA, Klein P. 2011. Determination of sugars in honey by liquid chromatography. *Saudi J Biol Sci* 18: 17-21. <https://doi.org/10.1016/j.sjbs.2010.09.003>.
- Karabagias IK, Badeka A, Kontakos S, Karabournioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to their geographical origin based on volatiles, physicochemical parameters and chemometrics. *Food Chem* 146: 548-557. <https://doi.org/10.1016/j.foodchem.2013.09.105>.
- Karabournioti S, Zervalaki P. 2001. The effect of heating on honey HMF and invertase. *Apiacta* 36: 177-181.
- Molan PC. 1992. The antibacterial activity of honey. *Bee World* 73: 59-76.
- Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*, *Apis dorsata* and *Apis mellifera*. *BMC Complement Altern Med* 13: 1-12.
- Moreira RFA, De Maria CAB, Pietrolungo M, Trugo LC. 2007. Chemical changes in the non-volatile fraction of Brazilian honeys during storage under tropical conditions. *Food Chem* 104: 1236-1241. <https://doi.org/10.1016/j.foodchem.2007.01.055>.
- Nainu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special focus on anticancer, antibacterial, antiviral, and antiparasitic properties. *Antibiotics* 10: 822. <https://doi.org/10.3390/antibiotics10070822>.
- National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.
- Pacini E, Nicolson S. 2007. Introduction. In: Nicolson S, Nepi M, Pacini E (Eds.), *Nectarines and Nectar*. Springer, Netherlands, pp. 1-18.
- Partap U. 2011. The Pollination Role of Honeybees. In: Hepburn HR, Radloff SE (Eds.), *Honeybees of Asia*. Springer, New York, pp. 227-255. DOI 10.1007/978-3-642-16422-4\_11.
- Pasias IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and quality parameters. *Food Chem* 242: 513-518. <https://doi.org/10.1016/j.foodchem.2017.09.083>.
- Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the epidemiological situation in apiaries varying in the level of colony losses. *J Apic Sci* 58: 107-132. <https://doi.org/10.2478/JAS-2014-0027>.
- Puscas A, Hosu A, Cimpoi C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control honey adulteration. *J Chromatogr A* 1272: 132-135. <https://doi.org/10.1016/j.chroma.2012.11.064>.
- Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of *Apis*. In: Hepburn HR, Radloff SE (Eds.), *Honeybees of Asia*. Springer, New York, pp. 1-22. DOI 10.1007/978-3-642-16422-4\_1.
- Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa Penida, and Sumbawa. *Bee World* 96: 45-49. <https://doi.org/10.1080/0005772x.2018.1564497>.
- Sihombing DTH. 2005. Ilmu Ternak Lebah Madu. Gadjah Mada University Press, Yogyakarta.
- Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.
- Thrasivoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. *J Apic Res* 57: 88-96. <https://doi.org/10.1080/00218839.2017.1411181>.
- Tornuk F, Karaman S, Ozturk I, Tokar OS, Tastemur B, Sagdic O, Dogan M, Kayaci A. 2013. Quality characterization of artisanal and retail Turkish blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. *Ind Crops Prod* 46: 124-131. <https://doi.org/10.1016/j.indcrop.2012.12.042>.
- Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. *Media Sains Indonesia*, Tangerang.

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388 antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. Food Chem 337: 127774.  
389 <https://doi.org/10.1016/j.foodchem.2020.127774>.  
390 White JW. 1992. Honey. In: Graham JM (Ed.). The Hive and the Honey Bee. Dadant & Sons Inc., Hamilton, p. 1324.  
391 Winston M. 1987. The Biology of Honey Bee. Harvard University Press, Cambridge, Massachusetts London.  
392 Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*,  
393 *Apis dorsata* and *Lepidotrigona flavibasis*. LWT - Food Sci Technol 134: 110225. <https://doi.org/10.1016/j.lwt.2020.110225>.  
394 Yücel Y, Sultanoğlu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food  
395 Biosci 1: 16-25. <https://doi.org/10.1016/j.fbio.2013.02.001>.  
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1. Dr. Jati Batoro (Department of Biology, Faculty of Mathematic and Natural Sciences, Brawijaya University); Email: [jati\\_batoro@yahoo.co.id](mailto:jati_batoro@yahoo.co.id); Scopus ID: 57204421874
2. Dr. Dewi Masyithoh, S.P., M.Pt. (Faculty of Agriculture, Islamic University of Malang, Indonesia), Email: [masyithoh.dewi@unisma.ac.id](mailto:masyithoh.dewi@unisma.ac.id), Scopus ID: 57217108400
3. Firman Jaya, S.Pt., MP. (Department of Animal Products Technology, Faculty of Animal Science, Brawijaya University, Indonesia), Email: [firmanjaya@ub.ac.id](mailto:firmanjaya@ub.ac.id), Scopus ID: 36800743500

**Place and date:**

Mataram, 6<sup>th</sup> September 2022

**Sincerely yours,**

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Dr. Ir. Erwan, M.Si.

# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,\*</sup>, AGUSSALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram. Jl. Majapahit No. 62, Mataram – 83125, Indonesia. Telp/Fax: +62370-633603/+62370-640592.

\*email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

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**Abstract.** One of the big problems when keeping of honeybees is the limited of sustainable feed, especially in the rain season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* were divided into six treatments consists of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.35 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. It can be concluded that honey quality is produced by sugar palm and coconut saps, and potential as the bee feed.

**Key words:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

**Running title:** Honey quality of *Apis cerana* produced by sugar palm and coconut saps

## INTRODUCTION

Honeybee of *A. cerana* is one of the bees from the *Apis* genus which is include the local bee which is spread in some regions in Indonesia are Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by the beekeepers using a traditional hives (for example using a coconut log hive) and semi modern hive (box hive without nest frame) to produce honey. Furthermore, several regions have been practices the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives although using a box hives because is not completed by the honey frame like a beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis, however their production is lower compared to the bee *A. mellifera*.

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is the very serious problem have been faced by the beekeepers because they have not area which is used to planted several plants which are used the feed source to produce the honeybees products. Honeybees feeds is divided into two types namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body part and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers is role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process is continuously done by the foragers until their honey stomach is full by a nectar and their corbicula has been deposited by the pollen. This pollination which is impacts on the increasing the plants productivity (Pohorecka et al., 2014; Supeno et al., 2021).

One of the strategies to produce the sustainability honey from the bee *A. cerana* by using a sap from the plants such as sugar palm and coconut. Several studies have been conducted by using a sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed can enhancing the production of honey cells and bee bread cells. However, the use each of sap from coconut and sugar palm can increasing the honey and bee bread cells compared to control group without sap as the feed (multifloral nectar). Furthermore, Erwan et al. (2022) was also reported that the use of sugar palm and coconut saps which each added by sugar

47 palm pollen can improving the bee *A. cerana* productivity such as increase the honey production, brood cells number, and  
48 colony weight. In addition, in other study showed that the use of extrafloral nectar namely sugar palm (*Arenga pinnata*)  
49 and coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed which is resulting the honey chemical composition  
50 (reducing sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian national  
51 standard and international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, the studied  
52 about the chemical composition of honey from the bee *A. cerana* which are produced from the sugar palm sap, coconut sap  
53 and their honey potency production from both sap sugar palm and coconut have not been studied. Therefore, the objectives  
54 of this study were to evaluate the honey quality based on the chemical composition from the bee *A. cerana*, honey potency  
55 produced by the coconut and sugar palm saps.

56

## MATERIALS AND METHODS

### 57 Study area

58 This research has been conducted in the North Duman Village (8°32'10"S 116°09'32"E), Lingsar Sub-district, West  
59 Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty of *A. cerana* colonies were divided  
60 into six treatments and each five colonies per treatment as the replication. The saps were used in our study were obtained  
61 from coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*). The treatments in our study were sugar palm sap  
62 without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% +  
63 sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen  
64 (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by  
65 sugar palm pollen (SCP1).

66 The technique was used to given sugar palm and coconut saps and sugar palm pollen was according to previously  
67 method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and sugar palm saps were given  
68 to the bee *A. cerana* by using a plastic plate and split bamboo were completed by 4 to 5 twigs for foragers perch. The  
69 plastic plate and split bamboo were placed one meter of the box hives, while the sugar palm pollen was hung besides and  
70 above of the box hives. The distance of 600 meters to place colony to avoid the foragers to collect pollen and sap from the  
71 other treatments.

### 72 Proceduress

#### 73 Honey quality

74 Honey from the *A. cerana* was harvested after beekeeping for three months by using a coconut and sugar palm saps.  
75 Honey from the five hives in one treatment group was composited into one honey sample and then used to analysis of their  
76 chemical composition. Honey quality from the *A. cerana* were evaluated based on the chemical composition consists of  
77 moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and acidity. The moisture  
78 content was analyzed by using a proximate analysis based on the method from Association of Official Agricultural  
79 Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed by using a Layne-Enyon method and sucrose content was  
80 analyzed by a Luff Schoorl method were described by AOAC (2005). Diastase enzyme activity, hydroxymethylfurfural  
81 (HMF), and free acidity were analyzed based on the harmonised methods of the international honey commission (Machado  
82 et al. 2022).

#### 83 Honey production from sugar palm and coconut saps

84 Sugar palm and coconut saps each ten liters were used to measuring the honey production from the bee *A. cerana* for  
85 three months of beekeeping. The sugar palm and coconut saps were placed in the plastic plate in front of the box hives at  
86 the distance of one meter. In addition, the honey production without using of sugar palm and coconut saps were measured  
87 for one year of the beekeeping which is used to calculate the contribution of sugar palm and coconut saps in honey  
88 production.

#### 89 Production of saps from coconut and sugar palm

90 The production of sap from coconut was measured for a year, while the sugar palm sap based on the previously studied  
91 was used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The  
92 production of coconut and sugar palm saps per hectare which was calculated from the sap production per hectare  
93 multiplied by the tress number in one hectare area. After three months of beekeeping, honey from both treatments sugar  
94 palm and coconut saps were harvested to measure the honey production from the use of ten litters sap and then honey  
95 production was measured by cylinder glass

### 96 Data analysis

97 The data of honey quality, production potency of honey from sugar palm and coconut saps, honey production, and  
98 production of saps were analyzed by using a descriptive analysis (Steel et al. 1997).

### 100 **Moisture content of honey**

101 Honey is composed by water as the second largest of honey constituent and its ranging from 15 to 21 g/100 g,  
 102 depending on the plant types as the nectar source which is affected by the botanical origin. Furthermore, honey moisture is  
 103 also affected by honey maturity level, processing postharvest, and storage condition (Da Silva et al. 2016). The honey  
 104 moisture is affecting the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific  
 105 gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the  
 106 temperature and humidity or depending on the season (rain and dry seasons) and honey moisture can increase during the  
 107 postharvest processing such as storage condition because honey is hygroscopic that can absorbs the moisture in the air (Da  
 108 Silva et al. 2016; Karabagias et al. 2014).

109 The recent study showed that the honey moisture from the bee *A. cerana* which was produced by sugar palm and  
 110 coconut saps and their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted  
 111 by Indonesian national standard (SNI) where the moisture for beekeeping honey including the bee *A. cerana* and *A.*  
 112 *mellifera* is not exceed 22% (National Standardization Agency of Indonesia 2018) and higher compared to international  
 113 standard which is regulated by Codex Alimentarius is not exceed 20% (Thrasylvoulou et al. 2018). The variation of honey  
 114 moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm  
 115 and coconut, however in our study has not measured. The higher moisture content is requiring the long time to ripening of  
 116 honey and process decreasing of honey moisture have been started by the bees when they are taken a nectar from plant  
 117 flowers or saps as the raw material to produce honey. Furthermore, small portion of moisture content has been evaporated  
 118 in the honey sack before transferred to the other bee which is working in the hive. This transfer is rapid depending on the  
 119 temperature, colony strength, and nectar availability (Da Silva et al. 2016).

120  
121

**Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CPI	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

122 Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0);  
 123 coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm  
 124 pollen (SP1); coconut sap was added by sugar palm pollen (CPI); coconut sap of 50% + sugar palm sap of 50% was added by sugar  
 125 palm pollen (SCP1).  
126

127 Honey production process is started from the foragers collecting a nectar from the plant flowers or extrafloral nectar  
 128 and then stored in honey stomach. After that, the foragers will be transferring a nectar has been collected to the other bees  
 129 whom working to processing a nectar into honey in their mouth, then put in honey stomach and then is transferred to other  
 130 bees for several times until honey is ripening. A considerable of water amount will be evaporated in this process and this  
 131 continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes (Balasubramanyam  
 132 2021; Zhang et al. 2021). The honey moisture content in our study was differed to reported by Wang et al. (2021) that  
 133 honey moisture from the bee *A. cerana* which is collected from 42 different honeycombs from China is ranging from 17.03  
 134 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana* from  
 135 Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) was also reported that the honey  
 136 moisture was produced by the *A. mellifera* bee by using a sugar palm and coconut saps is ranging from 19.34 to 20.94%.  
 137 The different honey moisture content has been reported are affected by the different geographical origins which is impact  
 138 on the different plant types can be growth each region, different environmental condition (temperature and humidity), and  
 139 also different bee species which is impact on the different ability to evaporate water in the honey.

### 140 **Reducing sugar and sucrose contents of honey**

141 Sugars in honey are composed by monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in  
 142 small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars  
 143 in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerbiose, maltotriose,  
 144 maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

145 The recent study showed that the honey s reducing sugar from the bee *A. cerana* were beekeeping by using a sugar  
 146 palm and coconut saps and their combination as the nectar source to produce honey is ranging from 62.78 to 68.37 %  
 147 (Table 1). This honey reducing sugar is acceptable by the SNI for treatments SP0, CP0, CPI, and SCP1, but not acceptable  
 148 for treatments SCP0, SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of  
 149 Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that change the sap sucrose into  
 150 simple sugars. It is known that this enzyme is responsible for the conversion of sucrose into glucose and fructose. These

151 sugars are included in reducing sugar group and as the main component present in honey. In honey maturity process, the  
152 sucrose is break down by the invertase enzyme into simple sugars simultaneously and water will be evaporated so that it  
153 will be increasing the reducing sugar content. In addition, enzymes secreted by the worker bees are also can break down  
154 the carbohydrate into simple sugars. Furthermore, other enzyme present in honey is diastase enzyme that role to break  
155 down starch into simple sugars (Da Silva et al. 2016). The honey reducing sugar in our study (Table 1) was differed to  
156 reported by Erwan et al. (2020) that honey reducing sugar from the bee *A. mellifera* which was produced by extrafloral  
157 nectar (sugar palm and coconut saps) is ranging from 60.15 to 73.69%. The different reducing sugar may be affected by  
158 the different bee species which is impact on the different their ability to evaporate water present in honey especially when  
159 they are convert the complex sugars into simple sugars and different season when done the study which are related to  
160 temperature and humidity environmental.

161 The honey sucrose content from the bee *A. cerana* in our study is ranging from 1.44 to 3.42% (Table 1) and acceptable  
162 by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency  
163 of Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed  
164 5% for blossom and honeydew honeys (Thrasyvoulou et al. 2018). Naturally, sucrose present in honey in our study is  
165 originated from sugar palm and coconut saps. The low of honey sucrose content in our study is caused the honey which is  
166 harvested in mature condition that characterized by honey cells have been covered by the wax. Furthermore, the invertase  
167 enzyme which is produced by the worker bees is actively break down of sucrose from saps into simple sugars. There are  
168 two types of invertase enzymes which are produced by the worker bees, namely glucoinvertase which is converts sucrose  
169 into glucose and fructoinvertase which is converts sucrose into fructose. These enzymes are mostly derived from the bee's  
170 secretion and only a small portion from the nectar, while the honeydew from the insect's secretion is mostly contain  
171 invertase enzyme (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) was differed to reported by  
172 Erwan et al. (2020) that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm  
173 and coconut saps) is ranging from 4.21 to 4.40%.

174 The honey sucrose content is a very important parameter to evaluate the maturity of honey to identifying manipulation,  
175 where the high levels may be indicated adulterations by adding the several sweeteners such cane sugar or refined beet  
176 sugar. In addition, also indicating the early of harvest, where sucrose is not completed transformed into fructose and  
177 glucose, the bees feeding artificial in prolonged time by using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013;  
178 Escuredo et al. 2013; Tornuk et al. 2013). Honey is sugar solution that is supersaturated and unstable so it's easy to  
179 crystallize. The honey crystallization is affected by concentration of glucose, fructose, and water. Fructose is the dominant  
180 sugar present in honey from *A. mellifera* was produced by several plants as the nectar source which is used by workers to  
181 produce honey such as eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey  
182 was produced by *Brassica napus*. Rape honey is higher in glucose and lower in fructose which is impact on the rapidly  
183 crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which  
184 is impact on the different plant types can growth in each region and impact on the different sugars content from the nectar  
185 which is produced by the nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016;  
186 Escuredo et al. 2014; Tornuk et al. 2013). Furthermore, sugars content in honey is influenced by climate (season,  
187 temperature, and humidity), processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014;  
188 Tornuk et al. 2013).

### 189 **Diastase enzyme activity and hydroxymethylfurfural of honey**

190 The recent study showed that the diastase enzyme activity from the bee *A. cerana* honey was produced by the sugar  
191 palm and coconut saps was ranging from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with the  
192 minimum of 3 DN for the beekeeping honey including the bee *A. cerana* and *A. mellifera* (National Standardization  
193 Agency of Indonesia 2018) and also acceptable by international standard has been regulated by Codex Alimentarius with  
194 the minimum 3 DN (Thrasyvoulou et al. 2018). One of the honey characteristics is contain enzymes which is originate  
195 from the bees, pollen, and nectar from plant flowers, but the mostly enzymes are added by the bees when they are convert  
196 nectar into honey (Da Silva et al. 2016; Thrasyvoulou et al. 2018). The honey diastase enzyme activity in our study (Table  
197 2) was differed to reported by Erwan et al. (2020) that the diastase enzyme activity of honey from the bee *A. mellifera* was  
198 produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

199 Diastases is divided into  $\alpha$ - and  $\beta$ -amylases which are the natural enzymes present in honey. The  $\alpha$ -amylase is separate  
200 the starch chain randomly in the central to produce dextrin, while the  $\beta$ -amylase to separate the maltose in the end chain.  
201 Diastase enzyme content in honey is influenced by nectar source (floral and extrafloral nectars) to produce honey and  
202 honey geographical origins which are impact on the different chemical composition of the nectar can be produced by the  
203 plants which is impact on the honey chemical composition especially diastase enzyme activity. In addition, the bee species  
204 is also influencing the activity diastase because it's related to the distance and the flowers plant numbers can be visited by  
205 the foragers when they are collecting nectar and pollen were using to produce honey and bee bread (Da Silva et al. 2016).

206 Generally, diastase enzyme is role to break down the complex sugars into simple sugars. This enzyme is role to digest  
207 of starch into maltose (disaccharide) and maltotriose (trisaccharide) which are sensitive to heat or thermolabile. Thus, this  
208 condition can be used to evaluate of overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore, the  
209 diastase activity is also used to evaluate honey age which is related to storage time and the temperature because the

210 diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and  
 211 Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed to reported by  
 212 Wu et al. (2020) for multifloral honey produced by the *A. cerana cerana* from Hainan province (China) was 6.70 Göthe.  
 213 Furthermore, also was differed to reported by Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling  
 214 Mountains (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activity of honey from *A. cerana* were  
 215 reported by previously researchers are influenced by the different plant types as the nectar source to produce honey,  
 216 different sugars content, and different geographical origin.

217 Furthermore, the HMF of *A. cerana* honey was produced by the sugar palm and coconut saps in our study was ranging  
 218 from 2.24 to 5.81 mg/kg (Table 2). This HMF indicate that honey from our study in fresh condition and acceptable by SNI  
 219 for the beekeeping honey including from *A. cerana* and *A. mellifera* is not exceed 40 mg/kg (National Standardization  
 220 Agency of Indonesia 2018) and also acceptable by the international standard has been regulated by Codex Alimentarius  
 221 not exceed 40 mg/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018). The fresh honey after harvested is  
 222 generally contain the low of HMF is ranging from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is resulted from the  
 223 degradation of honey monosaccharide especially fructose and glucose under acid condition and accelerated by the heating.  
 224 This reaction is producing levulinic and formic acids (Da Silva et al. 2016).

225 **Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CP1	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

227 *Abbreviations:* sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0);  
 228 coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm  
 229 pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar  
 230 palm pollen (SCP1).

231 Hydroxymethylfurfural is formed after honey removed from the comb or when the wax covers was opened and the  
 232 advanced processing like heating process. The increasing of the HMF content is occur in honey with the high acidity and  
 233 accelerated by the heating process. However, the HMF content also influenced by several factors such as sugars content,  
 234 organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In  
 235 addition, HMF is also can be formed at the low temperatures, acidic condition, and sugars dehydration reactions.  
 236 Therefore, the higher of HMF content is impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The  
 237 HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for  
 238 multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling  
 239 Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* were reported by previously  
 240 researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and  
 241 different geographical origin.

### 242 **Acidity of honey**

243 Free acidity is one of an important parameter to evaluate the honey deterioration which is characterized by the organic  
 244 acids presence in equilibrium with internal esters, lactone and several inorganic ions such as sulfates, chlorides, and  
 245 phosphates (Da Silva et al. 2016). The recent study showed that the honey acidity from *A. cerana* was produced by the  
 246 sugar palm and coconut saps was ranging from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in  
 247 our study is acceptable by SNI is not exceed 50 ml NaOH/kg for the beekeeping honey including *A. cerana* and *A.*  
 248 *mellifera*. Furthermore, is also acceptable of the international standard has been regulated by the Codex Alimentarius is not  
 249 exceed 50 meq/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018).

250 The sour taste of honey originated from the several of organic and inorganic acids, where the dominant of organic acid  
 251 present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase which is added  
 252 by the bees when they are convert a nectar into honey, so can protecting a nectar until honey maturity. This protecting  
 253 mechanism is occurred by the inhibit of microorganisms activity present in honey (Da Silva et al. 2016). This inhibit  
 254 mechanism includes the combination several factors such as low moisture and presence hydrogen peroxide which is  
 255 produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of  
 256 cell wall resulting in change in cytoplasmic membrane permeability (Nainu et al. 2021; Pasiyas et al. 2018).

257 The acidity total content in honey is small quantity, but the present in honey is very important because can influencing  
 258 the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity is indicating the  
 259 fermentation process had been occurred when some reducing sugar is break down into acetic acid. Honey acidity content is  
 260 related to the yeast number where them is break down some reducing sugar into ethanol and if it's reaction with the  
 261 oxygen is formed the acetic acid which is increasing the honey acidity. The values higher of acidity may be indicating the  
 262

263 fermentation process of sugars into organic acids. The honey acidity is affected by several factors such as different content  
264 of organic acids, different geographical origin and the seasonal when honey harvested (Da Silva et al. 2016; Tornuk et al.  
265 2013). The honey acidity from the bee *A. cerana* in our study (Table 2) was differed to previously studied by Wu et al.  
266 (2020) for *A. cerana cerana* honey is 0.80 mol/kg and Guerzou et al. (2021) is ranging 11 to 47 meq/kg for Algerian  
267 honey. Furthermore, is differed to reported by Erwan et al. (2020) that honey acidity from the bee *A. mellifera* were  
268 produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 22.00 to 43.00 ml NaOH/kg. The different  
269 acidity has been reported previously with our studied is affected by the different plant types as the nectar source to produce  
270 honey, honey pH, geographical origin, and organic acids compound, however in our study has not measured the organic  
271 acid compound and honey pH.

### 272 **Honey production potency from the sugar palm and coconut saps**

273 Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized  
274 which can contributing for communities' income. Generally, the main production from the coconut (*Cocos nucifera* L.)  
275 was harvested is coconut fruit to advanced process into coconut oil and copra. Theses commodities have a high price, but  
276 if just to producing coconut oil and copra are high risk for the farmers because they are just preparing in the raw material.  
277 Therefore, the utilizing of the sap can be produced by the coconut and sugar palm were also potency feed for the bees was  
278 used as the nectar source to produce honey. Sugar palm and coconut saps are the feed potential which is studied by Erwan  
279 et al. (2021b) that the coconut and sugar palm saps can increasing the number of honey cell and bee bread cell of the bee  
280 *A. cerana*. Furthermore, is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*  
281 such as increase the brood cells number, colony weight, and the honey production (Erwan et al. 2022). In addition, the saps  
282 from coconut and sugar palm are usually used by the farmers to produce sugar by using a traditional process.

283 The coconut plants can produce of 12 stalks in a year and in one of stalk can produce sap of 90 liters, thus, in one  
284 coconut plant can produce of 1,080 liters of sap. Furthermore, if the farmers have one hectare of the land which are planted  
285 by 100 coconut plants (distance 10 m × 10 m), so can be produced for about 108,000 liters of coconut sap. To produce 1  
286 kg of honey is required coconut sap for about 7 liters and in a year is required 84 liters to produce 12 kg of honey. Thus,  
287 honey potency in a year from 100 hectares of the land can be calculated as follows: 10,800,000 liters of sap divided by 84  
288 liters of sap and multiplied by 12 kg of honey and obtained 1,542,857,14 kg/year (1,542.857 tons/year) or equivalent with  
289 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big  
290 potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa  
291 Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

292 Sugar palm plant can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be tapping not  
293 exceed of 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant is ranging from 8 to 22  
294 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year).  
295 Furthermore, if in one hectare of plantation we have 100 sugar palm plants with the distance for planted is 10 m × 10 m, so  
296 can be obtained of sap for 115,000 liters.

297 Based on the field investigation showed that to produce 1 kg of honey from the sugar palm sap is required for about 10  
298 liters and in a year is required for about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm  
299 sap in a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and  
300 multiplied by 12 kg, so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833  
301 tons/month in 100 hectares area. This potency indicate that the sugar palm sap has a big potency to produce honey which is  
302 supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap  
303 productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46  
304 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. It can be concluded that Honey is produced  
305 by the bee *A. cerana* from sugar palm and coconut saps as the feed have the quality which is acceptable by Indonesian  
306 national standard and international standard has been regulated by the Codex Alimentarius. Honey potency production  
307 from the coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571  
308 tons/month, while in sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

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311 Duman Village, Lingsar Sub-district, West Lombok, Indonesia.

### 312 **REFERENCES**

- 313 Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas  
314 22: 5205-5210. <https://doi.org/10.13057/biodiv/d221159>.  
315 Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*,  
316 from different regions. Livest Res Rural Dev 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/aguss31091.html>.

- 317 Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta.  
318 Bul Peternak 42(1): 50-56. <https://doi.org/10.21059/buletinpeternak.v42i1.28294>.
- 319 Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bul  
320 Peternak 41(4): 448-460. <https://doi.org/10.21059/buletinpeternak.v41i4.13593>.
- 321 AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin  
322 Franklin Station, Washington D.C.
- 323 Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis Cerana Indica*. Int J Biol Innov 03: 271-277.  
324 <https://doi.org/10.46505/ijbi.2021.3204>.
- 325 Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323.  
326 <https://doi.org/10.1016/j.foodchem.2015.09.051>.
- 327 Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan  
328 Perkebunan Provinsi NTB, Mataram.
- 329 Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci  
330 Educ 1: 1-7. <https://doi.org/10.29303/jossed.v1i1.482>.
- 331 Erwan, Franti, L.D., Purnamasari, D.K., Muhsinin, M., Agussalim, A., 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from  
332 *Apis cerana* from different regions in North Lombok Regency, Indonesia. J Trop Anim Prod 22: 35-41.  
333 <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>
- 334 Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification.  
335 Livest Res Rural Dev 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.
- 336 Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and  
337 pollen) in West Lombok, Indonesia. Livest Res Rural Dev 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>.
- 338 Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization  
339 phenomenon. Food Chem 149: 84-90. <https://doi.org/10.1016/j.foodchem.2013.10.097>.
- 340 Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic  
341 area. Food Chem 138: 851-856. <https://doi.org/10.1016/j.foodchem.2012.11.015>.
- 342 Guertzou M, Aouissi HA, Guertzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of  
343 physicochemical properties of Alergian honey. Resources 10: 94. <https://doi.org/https://doi.org/10.3390/resources10100094>.
- 344 Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York, pp. 51-68. DOI  
345 10.1007/978-3-642-16422-4\_3.
- 346 Karabagias IK, Badeka A, Kontakos S, Karabournioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to  
347 their geographical origin based on volatiles, physicochemical parameters and chemometrics. Food Chem 146: 548-557.  
348 <https://doi.org/10.1016/j.foodchem.2013.09.105>.
- 349 Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça Miguel M, Cristina Figueiredo A. 2022. Quality assessment of  
350 Portuguese monofloral honeys. Physicochemical parameters as tools in botanical source differentiation. Food Res Int 157: 111362.  
351 <https://doi.org/10.1016/j.foodres.2022.111362>.
- 352 Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*,  
353 *Apis dorsata* and *Apis mellifera*. BMC Complement Altern Med 13: 1-12.
- 354 Nainu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special  
355 focus on anticancer, antibacterial, antiviral, and antiparasitic properties. Antibiotics 10: 822. <https://doi.org/10.3390/antibiotics10070822>.
- 356 National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.
- 357 Pasiás IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and  
358 quality parameters. Food Chem 242: 513-518. <https://doi.org/10.1016/j.foodchem.2017.09.083>.
- 359 Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the  
360 epidemiological situation in apiaries varying in the level of colony losses. J Apic Sci 58: 107-132. <https://doi.org/10.2478/JAS-2014-0027>.
- 361 Puscas A, Hosu A, Cimpoi C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control  
362 honey adulteration. J Chromatogr A 1272: 132-135. <https://doi.org/10.1016/j.chroma.2012.11.064>.
- 363 Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of *Apis*. In: Hepburn HR, Radloff SE (Eds.). Honeybees of Asia. Springer, New York. pp.  
364 1-22. DOI 10.1007/978-3-642-16422-4\_1.
- 365 Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa  
366 Penida, and Sumbawa. Bee World 96: 45-49. <https://doi.org/10.1080/0005772x.2018.1564497>.
- 367 Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.
- 368 Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from  
369 *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. Biodiversitas 22: 4687-4693. <https://doi.org/10.13057/biodiv/d221062>.
- 370 Thrasylvoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. J  
371 Apic Res 57: 88-96. <https://doi.org/10.1080/00218839.2017.1411181>.
- 372 Tornuk F, Karaman S, Ozturk I, Toker OS, Tastemur B, Sagdic O, Dogan M, Kayacier A. 2013. Quality characterization of artisanal and retail Turkish  
373 blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. Ind Crops Prod 46: 124-131.  
374 <https://doi.org/10.1016/j.indcrop.2012.12.042>.
- 375 Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina. Isdar. 2021. Vinegar Nira Aren. Media Sains Indonesia, Tangerang.
- 376 Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the  
377 antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. Food Chem 337: 127774.  
378 <https://doi.org/10.1016/j.foodchem.2020.127774>.
- 379 Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*,  
380 *Apis dorsata* and *Lepidotrigona flavibasis*. LWT - Food Sci Technol 134: 110225. <https://doi.org/10.1016/j.lwt.2020.110225>.
- 381 Yücel Y, Sultanoğlu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food  
382 Biosci 1: 16-25. <https://doi.org/10.1016/j.fbio.2013.02.001>.
- 383 Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process:  
384 The case of rape honey. Foods 10: 2882. <https://doi.org/10.3390/foods10112882>.
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# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

**Abstract.** One of the big problems when keeping of honeybees is the limited of sustainable feed, especially in the rain season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* were divided into six treatments consists of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.35 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. It can be concluded that honey quality is produced by sugar palm and coconut saps, and potential as the bee feed.

**Keywords:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

**Running title:** Honey quality of *Apis cerana* produced by sugar palm and coconut saps

## INTRODUCTION

Honeybee of *A. cerana* is one of the bees from the *Apis* genus which is include the local bee which is spread in some regions in Indonesia are Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by the beekeepers using a traditional hives (for example using a coconut log hive) and semi modern hive (box hive without nest frame) to produce honey. Furthermore, several regions have been practices the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives although using a box hives because is not completed by the honey frame like a beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis, however their production is lower compared to the bee *A. mellifera*.

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is the very serious problem have been faced by the beekeepers because they have not area which is used to planted several plants which are used the feed source to produce the honeybees products. Honeybees feeds is divided into two types namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body part and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers is role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process is continuously done by the foragers until their honey stomach is full by a nectar and their corbicula has been deposited by the pollen. This pollination which is impacts on the increasing the plants productivity (Pohorecka et al., 2014; Supeno et al., 2021).

One of the strategies to produce the sustainability honey from the bee *A. cerana* by using a sap from the plants such as sugar palm and coconut. Several studies have been conducted by using a sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed can enhancing the production of honey cells and bee bread cells. However, the use each of sap from coconut and sugar palm can increasing the honey and bee bread cells compared to control group without sap as the feed (multifloral nectar). Furthermore, Erwan et al. (2022) was also reported that the use of sugar palm and coconut saps which each added by sugar palm pollen can improving the bee *A. cerana* productivity such as increase the honey production, brood cells number, and

**Commented [I1]:** Maybe better the conclusion can be replaced by:  
It can be concluded that the quality of *A. cerana* honey which are produced by the sugar palm and coconut saps are acceptable by the Indonesia national standard and international standard. The sugar palm and coconut saps have a big potential as the bee feed especially for the bee *A. cerana*.

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48 colony weight. In addition, in other study showed that the use of extrafloral nectar namely sugar palm (*Arenga pinnata*)  
49 and coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed which is resulting the honey chemical composition  
50 (reducing sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian national  
51 standard and international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, the studied  
52 about the chemical composition of honey from the bee *A. cerana* which are produced from the sugar palm sap, coconut sap  
53 and their honey potency production from both sap sugar palm and coconut have not been studied. Therefore, the objectives  
54 of this study were to evaluate the honey quality based on the chemical composition from the bee *A. cerana*, honey potency  
55 produced by the coconut and sugar palm saps.

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## 56 MATERIALS AND METHODS

### 57 Study area

58 This research has been conducted in the North Duman Village (8°32'10"S 116°09'32"E), Lingsar Sub-district, West  
59 Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty of *A. cerana* colonies were divided  
60 into six treatments and each five colonies per treatment as the replication. The saps were used in our study were obtained  
61 from coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*). The treatments in our study were sugar palm sap  
62 without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% +  
63 sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen  
64 (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by  
65 sugar palm pollen (SCP1).

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Please add briefly the method used to harvest and obtained the sugar palm and coconut saps

66 The technique was used to given sugar palm and coconut saps and sugar palm pollen was according to previously  
67 method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and sugar palm saps were given  
68 to the bee *A. cerana* by using a plastic plate and split bamboo were completed by 4 to 5 twigs for foragers perch. The  
69 plastic plate and split bamboo were placed one meter of the box hives, while the sugar palm pollen was hung besides and  
70 above of the box hives. The distance of 600 meters to place colony to avoid the foragers to collect pollen and sap from the  
71 other treatments.

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### 72 Proceduress

#### 73 Honey quality

74 Honey from the *A. cerana* was harvested after beekeeping for three months by using a coconut and sugar palm saps.  
75 Honey from the five hives in one treatment group was composited into one honey sample and then used to analysis of their  
76 chemical composition. Honey quality from the *A. cerana* were evaluated based on the chemical composition consists of  
77 moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and acidity. The moisture  
78 content was analyzed by using a proximate analysis based on the method from Association of Official Agricultural  
79 Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed by using a Layne-Enyon method and sucrose content was  
80 analyzed by a Luff Schoorl method were described by AOAC (2005). Diastase enzyme activity, hydroxymethylfurfural  
81 (HMF), and free acidity were analyzed based on the harmonised methods of the international honey commission (Machado  
82 et al. 2022).

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#### 83 Honey production from sugar palm and coconut saps

84 Sugar palm and coconut saps each ten liters were used to measuring the honey production from the bee *A. cerana* for  
85 three months of beekeeping. The sugar palm and coconut saps were placed in the plastic plate in front of the box hives at  
86 the distance of one meter. In addition, the honey production without using of sugar palm and coconut saps were measured  
87 for one year of the beekeeping which is used to calculate the contribution of sugar palm and coconut saps in honey  
88 production.

#### 89 Production of saps from coconut and sugar palm

90 The production of sap from coconut was measured for a year, while the sugar palm sap based on the previously studied  
91 was used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The  
92 production of coconut and sugar palm saps per hectare which was calculated from the sap production per hectare  
93 multiplied by the trees number in one hectare area. After three months of beekeeping, honey from both treatments sugar  
94 palm and coconut saps were harvested to measure the honey production from the use of ten liters sap and then honey  
95 production was measured by cylinder glass

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### 96 Data analysis

97 The data of honey quality, production potency of honey from sugar palm and coconut saps, honey production, and  
98 production of saps were analyzed by using a descriptive analysis (Steel et al. 1997).

## RESULTS AND DISCUSSION

**Moisture content of honey**

Honey is composed by water as the second largest of honey constituent and its ranging from 15 to 21 g/100 g, depending on the plant types as the nectar source which is affected by the botanical origin. Furthermore, honey moisture is also affected by honey maturity level, processing postharvest, and storage condition (Da Silva et al. 2016). The honey moisture is affecting the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the temperature and humidity or depending on the season (rain and dry seasons) and honey moisture can increase during the postharvest processing such as storage condition because honey is hygroscopic that can absorbs the moisture in the air (Da Silva et al. 2016; Karabagias et al. 2014).

The recent study showed that the honey moisture from the bee *A. cerana* which was produced by sugar palm and coconut saps and their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted by Indonesian national standard (SNI) where the moisture for beekeeping honey including the bee *A. cerana* and *A. mellifera* is not exceed 22% (National Standardization Agency of Indonesia 2018) and higher compared to international standard which is regulated by Codex Alimentarius is not exceed 20% (Thrasylvoulou et al. 2018). The variation of honey moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm and coconut, however in our study has not measured. The higher moisture content is requiring the long time to ripening of honey and process decreasing of honey moisture have been started by the bees when they are taken a nectar from plant flowers or saps as the raw material to produce honey. Furthermore, small portion of moisture content has been evaporated in the honey sack before transferred to the other bee which is working in the hive. This transfer is rapid depending on the temperature, colony strength, and nectar availability (Da Silva et al. 2016).

**Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CP1	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

Honey production process is started from the foragers collecting a nectar from the plant flowers or extrafloral nectar and then stored in honey stomach. After that, the foragers will be transferring a nectar has been collected to the other bees whom working to processing a nectar into honey in their mouth, then put in honey stomach and then is transferred to other bees for several times until honey is ripening. A considerable of water amount will be evaporated in this process and this continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes (Balasubramanyam 2021; Zhang et al. 2021). The honey moisture content in our study was differed to reported by Wang et al. (2021) that honey moisture from the bee *A. cerana* which is collected from 42 different honeycombs from China is ranging from 17.03 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana* from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) was also reported that the honey moisture was produced by the *A. mellifera* bee by using a sugar palm and coconut saps is ranging from 19.34 to 20.94%. The different honey moisture content has been reported are affected by the different geographical origins which is impact on the different plant types can be growth each region, different environmental condition (temperature and humidity), and also different bee species which is impact on the different ability to evaporate water in the honey.

**Reducing sugar and sucrose contents of honey**

Sugars in honey are composed by monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerobiose, maltotriose, maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

The recent study showed that the honey reducing sugar from the bee *A. cerana* were beekeeping by using a sugar palm and coconut saps and their combination as the nectar source to produce honey is ranging from 62.78 to 68.37 % (Table 1). This honey reducing sugar is acceptable by the SNI for treatments SP0, CP0, CP1, and SCP1, but not acceptable for treatments SCP0, SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that change the sap sucrose into simple sugars. It is known that this enzyme is responsible for the conversion of sucrose into glucose and fructose. These

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151 sugars are included in reducing sugar group and as the main component present in honey. In honey maturity process, the  
152 sucrose is break down by the invertase enzyme into simple sugars simultaneously and water will be evaporated so that it  
153 will be increasing the reducing sugar content. In addition, enzymes secreted by the worker bees are also can break down  
154 the carbohydrate into simple sugars. Furthermore, other enzyme present in honey is diastase enzyme that role to break  
155 down starch into simple sugars (Da Silva et al. 2016). The honey reducing sugar in our study (Table 1) was differed to  
156 reported by Erwan et al. (2020) that honey reducing sugar from the bee *A. mellifera* which was produced by extrafloral  
157 nectar (sugar palm and coconut saps) is ranging from 60.15 to 73.69%. The different reducing sugar may be affected by  
158 the different bee species which is impact on the different their ability to evaporate water present in honey especially when  
159 they are convert the complex sugars into simple sugars and different season when done the study which are related to  
160 temperature and humidity environmental.

161 The honey sucrose content from the bee *A. cerana* in our study is ranging from 1.44 to 3.42% (Table 1) and acceptable  
162 by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency  
163 of Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed  
164 5% for blossom and honeydew honeys (Thrasyvoulou et al. 2018). Naturally, sucrose present in honey in our study is  
165 originated from sugar palm and coconut saps. The low of honey sucrose content in our study is caused the honey which is  
166 harvested in mature condition that characterized by honey cells have been covered by the wax. Furthermore, the invertase  
167 enzyme which is produced by the worker bees is actively break down of sucrose from saps into simple sugars. There are  
168 two types of invertase enzymes which are produced by the worker bees, namely glucoinvertase which is converts sucrose  
169 into glucose and fructoinvertase which is converts sucrose into fructose. These enzymes are mostly derived from the bee's  
170 secretion and only a small portion from the nectar, while the honeydew from the insect's secretion is mostly contain  
171 invertase enzyme (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) was differed to reported by  
172 Erwan et al. (2020) that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm  
173 and coconut saps) is ranging from 4.21 to 4.40%.

174 The honey sucrose content is a very important parameter to evaluate the maturity of honey to identifying manipulation,  
175 where the high levels may be indicated adulterations by adding the several sweeteners such cane sugar or refined beet  
176 sugar. In addition, also indicating the early of harvest, where sucrose is not completed transformed into fructose and  
177 glucose, the bees feeding artificial in prolonged time by using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013;  
178 Escuredo et al. 2013; Tornuk et al. 2013). Honey is sugar solution that is supersaturated and unstable so it's easy to  
179 crystallize. The honey crystallization is affected by concentration of glucose, fructose, and water. Fructose is the dominant  
180 sugar present in honey from *A. mellifera* was produced by several plants as the nectar source which is used by workers to  
181 produce honey such as eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey  
182 was produced by *Brassica napus*. Rape honey is higher in glucose and lower in fructose which is impact on the rapidly  
183 crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which  
184 is impact on the different plant types can growth in each region and impact on the different sugars content from the nectar  
185 which is produced by the nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016;  
186 Escuredo et al. 2014; Tornuk et al. 2013). Furthermore, sugars content in honey is influenced by climate (season,  
187 temperature, and humidity), processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014;  
188 Tornuk et al. 2013).

### 189 Diastase enzyme activity and hydroxymethylfurfural of honey

190 The recent study showed that the diastase enzyme activity from the bee *A. cerana* honey was produced by the sugar  
191 palm and coconut saps was ranging from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with the  
192 minimum of 3 DN for the beekeeping honey including the bee *A. cerana* and *A. mellifera* (National Standardization  
193 Agency of Indonesia 2018) and also acceptable by international standard has been regulated by Codex Alimentarius with  
194 the minimum 3 DN (Thrasyvoulou et al. 2018). One of the honey characteristics is contain enzymes which is originate  
195 from the bees, pollen, and nectar from plant flowers, but the mostly enzymes are added by the bees when they are convert  
196 nectar into honey (Da Silva et al. 2016; Thrasyvoulou et al. 2018). The honey diastase enzyme activity in our study (Table  
197 2) was differed to reported by Erwan et al. (2020) that the diastase enzyme activity of honey from the bee *A. mellifera* was  
198 produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

199 Diastases is divided into  $\alpha$ - and  $\beta$ -amylases which are the natural enzymes present in honey. The  $\alpha$ -amylase is separate  
200 the starch chain randomly in the central to produce dextrin, while the  $\beta$ -amylase to separate the maltose in the end chain.  
201 Diastase enzyme content in honey is influenced by nectar source (floral and extrafloral nectars) to produce honey and  
202 honey geographical origins which are impact on the different chemical composition of the nectar can be produced by the  
203 plants which is impact on the honey chemical composition especially diastase enzyme activity. In addition, the bee species  
204 is also influencing the activity diastase because it's related to the distance and the flowers plant numbers can be visited by  
205 the foragers when they are collecting nectar and pollen were using to produce honey and bee bread (Da Silva et al. 2016).

206 Generally, diastase enzyme is role to break down the complex sugars into simple sugars. This enzyme is role to digest  
207 of starch into maltose (disaccharide) and maltotriose (trisaccharide) which are sensitive to heat or thermostable. Thus, this  
208 condition can be used to evaluate of overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore, the  
209 diastase activity is also used to evaluate honey age which is related to storage time and the temperature because the

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diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed to reported by Wu et al. (2020) for multifloral honey produced by the *A. cerana cerana* from Hainan province (China) was 6.70 Göthe. Furthermore, also was differed to reported by Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling Mountains (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activity of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

Furthermore, the HMF of *A. cerana* honey was produced by the sugar palm and coconut saps in our study was ranging from 2.24 to 5.81 mg/kg (Table 2). This HMF indicate that honey from our study in fresh condition and acceptable by SNI for the beekeeping honey including from *A. cerana* and *A. mellifera* is not exceed 40 mg/kg (National Standardization Agency of Indonesia 2018) and also acceptable by the international standard has been regulated by Codex Alimentarius is not exceed 40 mg/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018). The fresh honey after harvested is generally contain the low of HMF is ranging from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is resulted from the degradation of honey monosaccharide especially fructose and glucose under acid condition and accelerated by the heating. This reaction is producing levulinic and formic acids (Da Silva et al. 2016).

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CP1	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

Hydroxymethylfurfural is formed after honey removed from the comb or when the wax covers was opened and the advanced processing like heating process. The increasing of the HMF content is occur sin honey with the high acidity and accelerated by the heating process. However, the HMF content also sinfluenced by several factors such as sugars content, organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF is also can be formed at the low temperatures, acidic condition, and sugars dehydration reactions. Therefore, the higher of HMF content is impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

#### Acidity of honey

Free acidity is one of an important parameter to evaluate the honey deterioration which is characterized by the organic acids presence in equilibrium with internal esters, lactone and several inorganic ions such as sulfates, chlorides, and phosphates (Da Silva et al. 2016). The recent study showed that the honey acidity from *A. cerana* was produced by the sugar palm and coconut saps was ranging from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is acceptable by SNI is not exceed 50 ml NaOH/kg for the beekeeping honey including *A. cerana* and *A. mellifera*. Furthermore, is also acceptable of the international standard has been regulated by the Codex Alimentarius is not exceed 50 meq/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018).

The sour taste of honey originated from the several of organic and inorganic acids, where the dominant of organic acid present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase which is added by the bees when they are convert a nectar into honey, so can protecting a nectar until honey maturity. This protecting mechanism is occurs by the inhibit of microorganisms activity present in honey (Da Silva et al. 2016). This inhibit mechanism includes the combination several factors such as low moisture and presence hydrogen peroxide which is produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of cell wall resulting in change in cytoplasmic membrane permeability (Nainu et al. 2021; Pasiyas et al. 2018).

The acidity total content in honey is small quantity, but the present in honey is very important because can influencing the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity is indicating the fermentation process had been occurred when some reducing sugar is break down into acetic acid. Honey acidity content is related to the yeast number where they is break down some reducing sugar into ethanol and if it's reaction with the oxygen is formed the acetic acid which is increasing the honey acidity. The values higher of acidity may be indicating the

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263 fermentation process of sugars into organic acids. The honey acidity is affected by several factors such as different content  
264 of organic acids, different geographical origin and the seasonal when honey harvested (Da Silva et al. 2016; Tornuk et al.  
265 2013). The honey acidity from the bee *A. cerana* in our study (Table 2) was differed to previously studied by Wu et al.  
266 (2020) for *A. cerana cerana* honey is 0.80 mol/kg and Guerzou et al. (2021) is ranging 11 to 47 meq/kg for Algerian  
267 honey. Furthermore, is differed to reported by Erwan et al. (2020) that honey acidity from the bee *A. mellifera* were  
268 produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 22.00 to 43.00 ml NaOH/kg. The different  
269 acidity has been reported previously with our studied is affected by the different plant types as the nectar source to produce  
270 honey, honey pH, geographical origin, and organic acids compound, however in our study has not measured the organic  
271 acid compound and honey pH.

### 272 Honey production potency from the sugar palm and coconut saps

273 Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized  
274 which can contributing for communities' income. Generally, the main production from the coconut (*Cocos nucifera* L.)  
275 was harvested is coconut fruit to advanced process into coconut oil and copra. These commodities have a high price, but  
276 if just to producing coconut oil and copra are high risk for the farmers because they are just preparing in the raw material.  
277 Therefore, the utilizing of the sap can be produced by the coconut and sugar palm were also potency feed for the bees was  
278 used as the nectar source to produce honey. Sugar palm and coconut saps are the feed potential which is studied by Erwan  
279 et al. (2021b) that the coconut and sugar palm saps can increasing the number of honey cell and bee bread cell of the bee  
280 *A. cerana*. Furthermore, is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*  
281 such as increase the brood cells number, colony weight, and the honey production (Erwan et al. 2022). In addition, the saps  
282 from coconut and sugar palm are usually used by the farmers to produce sugar by using a traditional process.

283 The coconut plants can produce of 12 stalks in a year and in one of stalk can produce sap of 90 liters, thus, in one  
284 coconut plant can produce of 1,080 liters of sap. Furthermore, if the farmers have one hectare of the land which are planted  
285 by 100 coconut plants (distance 10 m × 10 m), so can be produced for about 108,000 liters of coconut sap. To produce 1  
286 kg of honey is required coconut sap for about 7 liters and in a year is required 84 liters to produce 12 kg of honey. Thus,  
287 honey potency in a year from 100 hectares of the land can be calculated as follows: 10,800,000 liters of sap divided by 84  
288 liters of sap and multiplied by 12 kg of honey and obtained 1,542,857,14 kg/year (1,542.857 tons/year) or equivalent with  
289 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big  
290 potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa  
291 Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

292 Sugar palm plant can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be tapping not  
293 exceed of 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant is ranging from 8 to 22  
294 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year).  
295 Furthermore, if in one hectare of plantation we have 100 sugar palm plants with the distance for planted is 10 m × 10 m, so  
296 can be obtained of sap for 115,000 liters.

297 Based on the field investigation showed that to produce 1 kg of honey from the sugar palm sap is required for about 10  
298 liters and in a year is required for about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm  
299 sap in a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and  
300 multiplied by 12 kg, so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833  
301 tons/month in 100 hectares area. This potency indicate that the sugar palm sap has a big potency to produce honey which is  
302 supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap  
303 productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46  
304 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. It can be concluded that Honey is produced  
305 by the bee *A. cerana* from sugar palm and coconut saps as the feed have the quality which is acceptable by Indonesian  
306 national standard and international standard has been regulated by the Codex Alimentarius. Honey potency production  
307 from the coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571  
308 tons/month, while in sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

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311 Duman Village, Lingsar Sub-district, West Lombok, Indonesia.

### 312 REFERENCES

313 Agus A. Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas  
314 22: 5205-5210. <https://doi.org/10.13057/biodiv/d221159>.  
315 Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*,  
316 from different regions. Livest Res Rural Dev 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/aguss31091.html>.

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317 Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta.  
318 Bul Peternak 42(1): 50-56. <https://doi.org/10.21059/buletinpeternak.v42i1.28294>.

319 Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bul  
320 Peternak 41(4): 448-460. <https://doi.org/10.21059/buletinpeternak.v41i4.13593>.

321 AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin  
322 Franklin Station, Washington D.C.

323 Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis Cerana Indica*. Int J Biol Innov 03: 271-277.  
324 <https://doi.org/10.46505/ijbi.2021.3204>.

325 Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323.  
326 <https://doi.org/10.1016/j.foodchem.2015.09.051>.

327 Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan  
328 Perkebunan Provinsi NTB, Mataram.

329 Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci  
330 Educ 1: 1-7. <https://doi.org/10.29303/jossed.v1i1.482>.

331 Erwan, Franti, L.D., Purnamasari, D.K., Muhsinin, M., Agussalim, A., 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from  
332 Apis cerana from different regions in North Lombok Regency, Indonesia. J Trop Anim Prod 22: 35-41.  
333 <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>

334 Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification.  
335 Livest Res Rural Dev 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.

336 Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and  
337 pollen) in West Lombok, Indonesia. Livest Res Rural Dev 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>.

338 Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization  
339 phenomenon. Food Chem 149: 84-90. <https://doi.org/10.1016/j.foodchem.2013.10.097>.

340 Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic  
341 area. Food Chem 138: 851-856. <https://doi.org/10.1016/j.foodchem.2012.11.015>.

342 Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of  
343 physicochemical properties of Alergian honey. Resources 10: 94. <https://doi.org/https://doi.org/10.3390/resources10100094>.

344 Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York, pp. 51-68. DOI  
345 10.1007/978-3-642-16422-4\_3.

346 Karabagias IK, Badeka A, Kontakos S, Karabournioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to  
347 their geographical origin based on volatiles, physicochemical parameters and chemometrics. Food Chem 146: 548-557.  
348 <https://doi.org/10.1016/j.foodchem.2013.09.105>.

349 Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça Miguel M, Cristina Figueiredo A. 2022. Quality assessment of  
350 Portuguese monofloral honeys. Physicochemical parameters as tools in botanical source differentiation. Food Res Int 157: 111362.  
351 <https://doi.org/10.1016/j.foodres.2022.111362>.

352 Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*,  
353 *Apis dorsata* and *Apis mellifera*. BMC Complement Altern Med 13: 1-12.

354 Naimu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special  
355 focus on anticancer, antibacterial, antiviral, and antiparasitic properties. Antibiotics 10: 822. <https://doi.org/10.3390/antibiotics10070822>.

356 National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.

357 Pasiás IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and  
358 quality parameters. Food Chem 242: 513-518. <https://doi.org/10.1016/j.foodchem.2017.09.083>.

359 Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the  
360 epidemiological situation in apiaries varying in the level of colony losses. J Apic Sci 58: 107-132. <https://doi.org/10.2478/JAS-2014-0027>.

361 Puscas A, Hosu A, Cimpoiu C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control  
362 honey adulteration. J Chromatogr A 1272: 132-135. <https://doi.org/10.1016/j.chroma.2012.11.064>.

363 Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of Apis. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York. pp.  
364 1-22. DOI 10.1007/978-3-642-16422-4\_1.

365 Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa  
366 Penida, and Sumbawa. Bee World 96: 45-49. <https://doi.org/10.1080/0005772x.2018.1564497>.

367 Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition, McGraw-Hill Inc., New York.

368 Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from  
369 *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. Biodiversitas 22: 4687-4693. <https://doi.org/10.13057/biodiv/d221062>.

370 Thrasivoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. J  
371 Apic Res 57: 88-96. <https://doi.org/10.1080/00218839.2017.1411181>.

372 Tornuk F, Karaman S, Ozturk I, Toker OS, Tastemur B, Sagdic O, Dogan M, Kayaci A. 2013. Quality characterization of artisanal and retail Turkish  
373 blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. Ind Crops Prod 46: 124-131.  
374 <https://doi.org/10.1016/j.indcrop.2012.12.042>.

375 Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. Media Sains Indonesia, Tangerang.

376 Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the  
377 antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. Food Chem 337: 127774.  
378 <https://doi.org/10.1016/j.foodchem.2020.127774>.

379 Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*,  
380 *Apis dorsata* and *Lepidotrigona flavivasis*. LWT - Food Sci Technol 134: 110225. <https://doi.org/10.1016/j.lwt.2020.110225>.

381 Yücel Y, Sultanoglu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food  
382 Biosci 1: 16-25. <https://doi.org/10.1016/j.fbio.2013.02.001>.

383 Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process:  
384 The case of rape honey. Foods 10: 2882. <https://doi.org/10.3390/foods10112882>.





erwan apis &lt;apiserwan@gmail.com&gt;

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**[biodiv] Editor Decision**

3 pesan

**Smujo Editors** <smujo.id@gmail.com>

1 November 2022 pukul 10.35

Kepada: Erwan &lt;apiserwan@gmail.com&gt;, Agussalim &lt;agussalim@mail.ugm.ac.id&gt;

Erwan, Agussalim:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Honey quality from the bee Apis cerana, honey potency produced by coconut and sugar palm saps".

Our decision is: Revisions Required

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Reviewer A:

This study aimed to evaluate the honey quality based on the chemical composition from the bee A. cerana and the honey potency produced by the coconut and sugar palm saps. The paper is clear objectives. The topic is an important subject. However, I have the following comments for revision consideration that I put in the text.

Recommendation: Revisions Required

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[Biodiversitas Journal of Biological Diversity](#)

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**erwan apis** <apiserwan@gmail.com>

1 November 2022 pukul 13.26

Kepada: Smujo Editors &lt;smujo.id@gmail.com&gt;

Dear Editor in Chief Biodiversitas

Thanks very much for the information and we will revise according to reviewer comments

[Kutipan teks disembunyikan]

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Best Regards,

Dr. Ir. Erwan, M.Si.  
Faculty of Animal Science, University of Mataram, Indonesia

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**erwan apis** <apiserwan@gmail.com>  
Kepada: Smujo Editors <smujo.id@gmail.com>

2 November 2022 pukul 22.38

Dear Editor in Chief Biodiversitas

We have been revising our paper according to reviewer comments and the revision is made for red color (File is attached). In addition, we also have been submitted to the Biodiversitas System. Please find the attached file.

[Kutipan teks disembunyikan]



**A-12166-Article Text-1062944-1-4-20221004 Second REVISION.doc**  
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# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,\*</sup>, AGUSSALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram. Jl. Majapahit No. 62, Mataram – 83125, Indonesia. Telp/Fax: +62370-633603/+62370-640592.

\*email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

Manuscript received: DD MM 2016 (Date of abstract/manuscript submission). Revision accepted: ..... 2016. (8 pt)

**Abstract.** One of the big problems when keeping of honeybees is the limited of sustainable feed, especially in the rain season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* were divided into six treatments consists of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.35 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. **It can be concluded that the quality of *A. cerana* honey which are produced by the sugar palm and coconut saps are acceptable by the Indonesia national standard and international standard. The sugar palm and coconut saps have a big potential as the bee feed especially for the bee *A. cerana*.**

**Key words:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

**Running title:** Honey quality of *Apis cerana* produced by sugar palm and coconut saps

## INTRODUCTION

Honeybee of *A. cerana* is one of the bees from the *Apis* genus which is include the local bee which is spread in some regions in Indonesia are Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by the beekeepers using traditional hives (for example using a coconut log hive) and semi modern hive (box hive without nest frame) to produce honey. Furthermore, several regions have been practicing the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives or use box hives, but is not completed by the honey frame like a beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis, however their production is lower compared to the bee *A. mellifera*.

One of the problems faced by the beekeepers in Indonesia is the limited feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is the very serious problem have been faced by the beekeepers because they have no area which is used to plant several plants which are used as the feed source to produce the honeybees products. Honeybees feeds is divided into two types namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body parts and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process is continuously done by the foragers until their honey stomach is full of nectar and their corbicula has been deposited by the pollen. This pollination impacts on the increasing the plants productivity (Pohorecka et al., 2014; Supeno et al., 2021).

One of the strategies to produce the sustainability honey from the bee *A. cerana* by using a sap from the plants such as sugar palm and coconut. Several studies have been conducted by using a sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed can enhance the production of honey cells and bee bread cells. However, the use of sap from coconut and sugar palm can increasing the honey and bee bread cells compared to control group without sap as the feed (multifloral nectar). Furthermore, Erwan et al. (2022) was also reported that the use of sugar palm and coconut saps which are each added by

48 sugar palm pollen can improving the bee *A. cerana* productivity such as increase the honey production, brood cells  
49 number, and colony weight. In addition, in other study showed that the use of extrafloral nectar namely sugar palm  
50 (*Arenga pinnata*) and coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed which is resulting the honey chemical  
51 composition (reducing sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian  
52 national standard and international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, the  
53 studies about the chemical composition of honey from the bee *A. cerana* which are produced from the sugar palm sap,  
54 coconut sap and their honey potency production from both sap sugar palm and coconut have not been studied. Therefore,  
55 the objectives of this study were to evaluate the honey quality based on the chemical composition from the bee *A. cerana*,  
56 honey potency produced by the coconut and sugar palm saps.

57

## MATERIALS AND METHODS

### Study area

58 This research has been conducted in the North Duman Village (8°32'10"S 116°09'32"E), Lingsar Sub-district, West  
59 Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty of *A. cerana* colonies were divided  
60 into six treatments and each five colonies per treatment as the replication. The saps were used in our study were obtained  
61 from the stalk of coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*) and the pollen source from the sugar palm  
62 were shown in Figure 1. The stalks of coconut and sugar palm were cut and then put in the plastic bottle which was used to  
63 storage the sap which was secreted by their stalks. The treatments in our study were sugar palm sap without added by  
64 sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of  
65 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was  
66 added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).  
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Figure 1. Coconut sap (left), sugar palm sap (center), and sugar palm pollen (right)

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The technique was used to given sugar palm and coconut saps and sugar palm pollen (shown in Figure 2) was according to previously method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and sugar palm saps were given to the bee *A. cerana* by using a plastic plate and split bamboo were completed by 4 to 5 twigs for foragers perch. The plastic plate and split bamboo were placed one meter of the box hives, while the sugar palm pollen was hung besides and above of the box hives. The distance of 600 meters to place colony to avoid the foragers to collect pollen and sap from the other treatments.

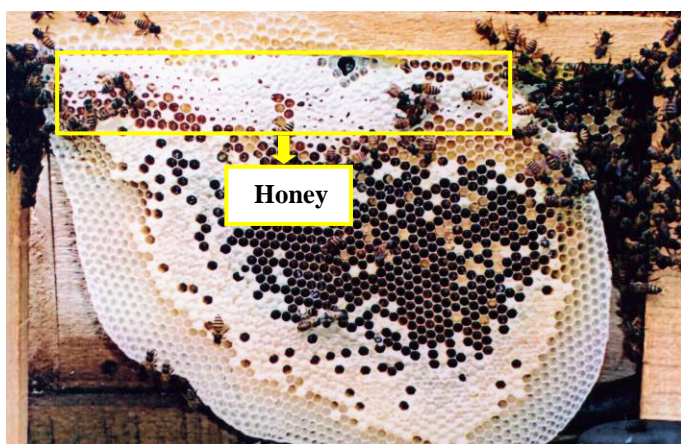


Figure 2. Technique to give the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)

107 **Procedures**

108 *Honey quality*

109 Honey from the *A. cerana* (shown in Figure 2) was harvested after beekeeping for three months by using a coconut and  
110 sugar palm saps. Honey from the five hives in one treatment group was composited into one honey sample and then used  
111 to analysis of their chemical composition. Honey quality from the *A. cerana* were evaluated based on the chemical  
112 composition consists of moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and  
113 acidity. The moisture content was analyzed by using a proximate analysis based on the method from Association of  
114 Official Agricultural Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed by using a Layne-Enyon method and  
115 sucrose content was analyzed by a Luff Schoorl method were described by AOAC (2005). Diastase enzyme activity,  
116 hydroxymethylfurfural (HMF), and free acidity were analyzed based on the harmonised methods of the international honey  
117 commission (Machado et al. 2022).



134 **Figure 2.** Honey from *A. cerana* was produced from the sugar palm and coconut saps

135 *Honey production from sugar palm and coconut saps*

136 Sugar palm and coconut saps each ten liters were used to measuring the honey production from the bee *A. cerana* for  
137 three months of beekeeping. The sugar palm and coconut saps were placed in the plastic plate in front of the box hives at  
138 the distance of one meter. In addition, the honey production without using of sugar palm and coconut saps were measured  
139 for one year of the beekeeping which is used to calculate the contribution of sugar palm and coconut saps in honey  
140 production. Honey from *A. cerana* was harvested with cut the honey cells (Figure 2) and squeezed to separate wax and  
141 honey. Afterward, honey was measured their production by using a digital scale and stored in the refrigerator.

142 *Production of saps from coconut and sugar palm*

143 The production of sap from coconut was measured for a year, while the sugar palm sap based on the previously studied  
144 was used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The  
145 production of coconut and sugar palm saps per hectare which was calculated from the sap production per tree multiplied  
146 by the trees number in one hectare area. After three months of beekeeping, honey from both treatments sugar palm and  
147 coconut saps were harvested to measure the honey production from the use of ten liters sap and then honey production  
148 was measured by cylinder glass

149 **Data analysis**

150 The data of honey quality, production potency of honey from sugar palm and coconut saps, honey production, and  
151 production of saps were analyzed by using a descriptive analysis (Steel et al. 1997).

152 **RESULTS AND DISCUSSION**

153 **Moisture content of honey**

154 Honey is composed by water as the second largest of honey constituents and its ranging from 15 to 21 g/100 g,  
155 depending on the plant types as the nectar source which is affected by the botanical origin. Furthermore, honey moisture is  
156 also affected by honey maturity level, processing postharvest, and storage condition (Da Silva et al. 2016). The honey  
157 moisture is affecting the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific  
158 gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the  
159 temperature and humidity or depending on the season (rain and dry seasons) and honey moisture can increase during the

160 postharvest processing such as storage condition because honey is hygroscopic that can absorb the moisture in the air (Da  
161 Silva et al. 2016; Karabagias et al. 2014).

162 The recent study showed that the honey moisture from the bee *A. cerana* which was produced by sugar palm and  
163 coconut saps and their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted  
164 by Indonesian national standard (SNI) where the moisture for beekeeping honey including the bee *A. cerana* and *A.*  
165 *mellifera* is not exceed 22% (National Standardization Agency of Indonesia 2018) and higher compared to international  
166 standard which is regulated by Codex Alimentarius is not exceed 20% (Thrasylvoulou et al. 2018). The variation of honey  
167 moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm  
168 and coconut, however in our study has not been measured. The higher moisture content is requiring the long time to  
169 ripening of honey and process of decreasing honey moisture has been started by the bees when they are taking nectar from  
170 plant flowers or saps as the raw material to produce honey. Furthermore, a small portion of moisture content has been  
171 evaporated in the honey sack before transferred to the other bee which is working in the hive. This transfer is rapid  
172 depending on the temperature, colony strength, and nectar availability (Da Silva et al. 2016).

173  
174 **Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CP1	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

175 Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0);  
176 coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm  
177 pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar  
178 palm pollen (SCP1).

179  
180 Honey production process is started from the foragers collecting a nectar from the plant flowers or extrafloral nectar  
181 and then stored in the honey stomach. After that, the foragers will be transferring a nectar that has been collected to the  
182 other bees who are working to process a nectar into honey in their mouth, then put in honey stomach and then is  
183 transferred to other bees for several times until honey is ripening. A considerable amount of water will be evaporated in  
184 this process and this continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes  
185 (Balasubramanyam 2021; Zhang et al. 2021). The honey moisture content in our study was differed to reported by Wang et  
186 al. (2021) that honey moisture from the bee *A. cerana* which is collected from 42 different honeycombs from China is  
187 ranging from 17.03 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99%  
188 for *A. cerana* from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) was also  
189 reported that the honey moisture produced by the *A. mellifera* bee by using sugar palm and coconut saps is ranging from  
190 19.34 to 20.94%. The different honey moisture content has been reported are affected by the different geographical origins  
191 which is impact on the different plant types can be growth each region, different environmental condition (temperature and  
192 humidity), and also different bee species which is impact on the different ability to evaporate water in the honey.

### 193 Reducing sugar and sucrose contents of honey

194 Sugars in honey are composed by monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in  
195 small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars  
196 in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerbiose, maltotriose,  
197 maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

198 The recent study showed that the honey reducing sugar from the bee *A. cerana* were beekeeping by using a sugar palm  
199 and coconut saps and their combination as the nectar source to produce honey is ranging from 62.78 to 68.37 % (Table 1).  
200 This honey reducing sugar is acceptable by the SNI for treatments SP0, CP0, CP1, and SCP1, but not acceptable for  
201 treatments SCP0, SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of  
202 Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that change the sap sucrose into  
203 simple sugars. It is known that this enzyme is responsible for the conversion of sucrose into glucose and fructose. These  
204 sugars are included in reducing sugar group and as the main component present in honey. In honey maturity process, the  
205 sucrose is break down by the invertase enzyme into simple sugars simultaneously and water will be evaporated so that it  
206 will be increasing the reducing sugar content. In addition, enzymes secreted by the worker bees are also can break down  
207 the carbohydrate into simple sugars. Furthermore, other enzyme present in honey is diastase enzyme that role to break  
208 down starch into simple sugars (Da Silva et al. 2016). The honey reducing sugar in our study (Table 1) was differed to  
209 reported by Erwan et al. (2020) that honey reducing sugar from the bee *A. mellifera* which was produced by extrafloral  
210 nectar (sugar palm and coconut saps) is ranging from 60.15 to 73.69%. The different reducing sugar may be affected by  
211 the different bee species which is impact on the different their ability to evaporate water present in honey especially when  
212 they are convert the complex sugars into simple sugars and different season when done the study which are related to  
213 temperature and humidity environmental.

214 The honey sucrose content from the bee *A. cerana* in our study is ranging from 1.44 to 3.42% (Table 1) and acceptable  
215 by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency  
216 of Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed  
217 5% for blossom and honeydew honeys (Thrasyvoulou et al. 2018). Naturally, sucrose present in honey in our **study**  
218 **originated** from sugar palm and coconut saps. The **low honey** sucrose content in our study is **caused by** the honey which is  
219 harvested in mature condition that **is** characterized by honey cells **that** have been covered **by wax**. Furthermore, the  
220 invertase enzyme which is produced by the worker **bees actively break down sucrose** from saps into simple sugars. There  
221 are two types of invertase enzymes which are produced by the worker bees, namely glucoinvertase **which converts** sucrose  
222 into glucose and fructoinvertase **which converts** sucrose into fructose. These enzymes are mostly derived from the bee's  
223 secretion and only a small portion from the nectar, while the honeydew from the insect's **secretion mostly contains**  
224 **invertase enzymes** (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) was differed to reported by  
225 Erwan et al. (2020) that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm  
226 and coconut saps) is ranging from 4.21 to 4.40%.

227 The honey sucrose content is a very important parameter to evaluate the maturity of honey to **identify manipulation**,  
228 where the high levels may be **indicate** adulterations by adding the several sweeteners such cane sugar or refined beet sugar.  
229 In addition, also indicating the early of harvest, where sucrose is not completed transformed into fructose and glucose, the  
230 bees feeding artificial in prolonged time by using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013; Escuredo et al.  
231 2013; Tornuk et al. 2013). Honey is sugar solution that is supersaturated and unstable so it's easy to crystallize. The honey  
232 crystallization is affected by concentration of glucose, fructose, and water. Fructose is the dominant sugar present in honey  
233 from *A. mellifera* was produced by several plants as the nectar source which is used by workers to produce honey such as  
234 eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey was produced by  
235 *Brassica napus*. Rape honey is higher in glucose and lower in fructose which is impact on the rapidly crystallization  
236 (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which is impact on  
237 the different plant types can growth in each region and impact on the different sugars content from the nectar which is  
238 produced by the nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016; Escuredo et  
239 al. 2014; Tornuk et al. 2013). Furthermore, sugars content in honey is influenced by climate (season, temperature, and  
240 humidity), processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014; Tornuk et al. 2013).

#### 241 **Diastase enzyme activity and hydroxymethylfurfural of honey**

242 The recent study showed that the diastase enzyme activity from the bee *A. cerana* honey was produced by the sugar  
243 palm and coconut saps was ranging from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with the  
244 minimum of 3 DN for the beekeeping honey including the bee *A. cerana* and *A. mellifera* (National Standardization  
245 Agency of Indonesia 2018) and also acceptable by international standard has been regulated by Codex Alimentarius with  
246 the minimum 3 DN (Thrasyvoulou et al. 2018). One of the honey characteristics is contain enzymes which is originate  
247 from the bees, pollen, and nectar from plant flowers, but the mostly enzymes are added by the bees when they are convert  
248 nectar into honey (Da Silva et al. 2016; Thrasyvoulou et al. 2018). The honey diastase enzyme activity in our study (Table  
249 2) was differed to reported by Erwan et al. (2020) that the diastase enzyme activity of honey from the bee *A. mellifera* was  
250 produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

251 Diastases **are** divided into  $\alpha$ - and  $\beta$ -amylases which are the natural enzymes present in honey. The  $\alpha$ -amylase **separates**  
252 the starch chain randomly in the central to produce dextrin, while the  $\beta$ -amylase **separates** the maltose in the end chain.  
253 Diastase enzyme content in honey is influenced by nectar source (floral and extrafloral nectars) to produce honey and  
254 honey geographical origins which are impact on the different chemical composition of the nectar can be produced by the  
255 plants which is impact on the honey chemical composition especially diastase enzyme activity. In addition, the bee species  
256 is also influencing the activity diastase because it's related to the distance and the flowers plant numbers can be visited by  
257 the foragers when they are collecting nectar and pollen were **used** to produce honey and bee bread (Da Silva et al. 2016).

258 Generally, diastase enzyme is role to break **down complex** sugars into simple sugars. This enzyme is role to **digesting**  
259 starch into maltose (disaccharide) and maltotriose (trisaccharide) which are sensitive to heat or thermolabile. Thus, this  
260 condition can be used to evaluate **the** overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore,  
261 the diastase activity is also used to evaluate honey age which is related to storage time and the temperature because the  
262 diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and  
263 Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed to reported by  
264 Wu et al. (2020) for multifloral honey produced by the *A. cerana cerana* from Hainan province (China) was 6.70 Göthe.  
265 Furthermore, **it was also** differed to reported by Wang et al. (2021) that the diastase activity of *A. cerana* honey from  
266 Qinling Mountains (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activity of honey from *A. cerana*  
267 were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey,  
268 different sugars content, and different geographical origin.

269 Furthermore, the HMF of *A. cerana* honey was produced by the sugar palm and coconut saps in our study was ranging  
270 from 2.24 to 5.81 mg/kg (Table 2). This HMF indicate that honey from our study in fresh condition and acceptable by SNI  
271 for the beekeeping honey including from *A. cerana* and *A. mellifera* is not exceed 40 mg/kg (National Standardization  
272 Agency of Indonesia 2018) and also acceptable by the international standard has been regulated by Codex Alimentarius is

not to exceed 40 mg/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018). The fresh honey after harvested is generally contains the low of HMF is ranging from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is the result of the degradation of honey monosaccharide, especially fructose and glucose, under acid conditions and accelerated by heating. This reaction is producing levulinic and formic acids (Da Silva et al. 2016).

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CP1	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

Hydroxymethylfurfural is formed after honey removed from the comb or when the wax cover was opened and the advanced processing like heating process. The increasing of the HMF content occurs in honey with the high acidity and accelerated by the heating process. However, the HMF content is also influenced by several factors such as sugars content, organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF can also be formed at low temperatures, acidic condition, and sugars dehydration reactions. Therefore, the higher of HMF content's impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

### Acidity of honey

Free acidity is one of an important parameter to evaluate the honey deterioration which is characterized by the organic acids presence in equilibrium with internal esters, lactone and several inorganic ions such as sulfates, chlorides, and phosphates (Da Silva et al. 2016). The recent study showed that the honey acidity from *A. cerana* was produced by the sugar palm and coconut saps was ranging from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is acceptable by SNI is not to exceed 50 ml NaOH/kg for the beekeeping honey including *A. cerana* and *A. mellifera*. Furthermore, it is also acceptable by the international standard has been regulated by the Codex Alimentarius is not to exceed 50 meq/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018).

The sour taste of honey originated from the several organic and inorganic acids, where the dominant organic acid present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase which is added by the bees when they convert a nectar into honey, so it can protect a nectar until honey maturity. This protecting mechanism is caused by the inhibition of microorganisms activity in honey (Da Silva et al. 2016). This inhibit mechanism includes the combination several factors such as low moisture and presence hydrogen peroxide which is produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of cell wall resulting in change in cytoplasmic membrane permeability (Nainu et al. 2021; Pasiyas et al. 2018).

The acidity total content in honey is small quantity, but the present in honey is very important because can influencing the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity is indicating the fermentation process had been occurred when some reducing sugar is break down into acetic acid. Honey acidity content is related to the yeast number where them is break down some reducing sugar into ethanol and if it's reaction with the oxygen is formed the acetic acid which is increasing the honey acidity. The values higher of acidity may be indicating the fermentation process of sugars into organic acids. The honey acidity is affected by several factors such as different content of organic acids, different geographical origin and the seasonal when honey harvested (Da Silva et al. 2016; Tornuk et al. 2013). The honey acidity from the bee *A. cerana* in our study (Table 2) was differed to previously studied by Wu et al. (2020) for *A. cerana cerana* honey is 0.80 mol/kg and Guerzou et al. (2021) is ranging 11 to 47 meq/kg for Algerian honey. Furthermore, is differed to reported by Erwan et al. (2020) that honey acidity from the bee *A. mellifera* were produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 22.00 to 43.00 ml NaOH/kg. The different acidity has been reported previously with our studied is affected by the different plant types as the nectar source to produce honey, honey pH, geographical origin, and organic acids compound, however in our study has not measured the organic acid compound and honey pH.



324 **Honey production potency from the sugar palm and coconut saps**

325 Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized  
326 which can contribute to communities' income. Generally, the main production from the coconut (*Cocos nucifera* L.) was  
327 harvested as coconut fruit to advance the process into coconut oil and copra. These commodities have a high price, but  
328 producing coconut oil and copra are high risk for the farmers because they are just preparing raw material. Therefore, the  
329 utilizing of the sap can be produced by the coconut and sugar palm were also potency feed for the bees was used as the  
330 nectar source to produce honey. Sugar palm and coconut saps are the feed potential which is studied by Erwan et al.  
331 (2021b) that the coconut and sugar palm saps can increase the number of honey cell and bee bread cells of the bee *A.*  
332 *cerana*. Furthermore, it is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*  
333 such as increasing the brood cells number, colony weight, and the honey production (Erwan et al. 2022). In addition, the  
334 saps from coconut and sugar palm are usually used by the farmers to produce sugar by using a traditional process.

335 The coconut plants can produce 12 stalks in a year and in one stalk can produce sap of 90 liters, thus, in one coconut  
336 plant can produce 1,080 liters of sap. Furthermore, if the farmers have one hectare of the land which are planted by 100  
337 coconut plants (distance 10 m × 10 m), so can be produced for about 108,000 liters of coconut sap. To produce 1 kg of  
338 honey requires coconut sap for about 7 liters and in a year 84 liters is required to produce 12 kg of honey. Thus, honey  
339 potency in a year from 100 hectares of the land can be calculated as follows: 10,800,000 liters of sap divided by 84 liters  
340 of sap and multiplied by 12 kg of honey and obtained 1,542,857,14 kg/year (1,542.857 tons/year) or equivalent with  
341 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big  
342 potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa  
343 Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

344 Sugar palm plants can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be tapped not to  
345 exceed 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant is ranging from 8 to 22  
346 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year).  
347 Furthermore, if in one hectare of plantation we have 100 sugar palm plants with the distance for planted is 10 m × 10 m, so  
348 can be obtained of sap for 115,000 liters.

349 The field investigation showed that to produce 1 kg of honey from the sugar palm sap is required for about 10 liters and  
350 in a year it is required for about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm sap in  
351 a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and multiplied by  
352 12 kg, so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833 tons/month in 100  
353 hectares area. This potency indicate that the sugar palm sap has a big potency to produce honey which is supported by the  
354 report data from the Department of Agricultural and Plantations (2021) that the sap production, sap productivity, and  
355 harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46 tones, 304.80  
356 quintals/hectare, and 188.52, respectively, in the year of 2021. It can be concluded that honey is produced by the bee *A.*  
357 *cerana* from sugar palm and coconut saps as the feed have the quality which are acceptable by Indonesian national  
358 standard and international standard has been regulated by the Codex Alimentarius. Honey potency production from the  
359 coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571 tons/month, while  
360 in sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

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364 **REFERENCES**

- 365 Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas  
366 22: 5205-5210. <https://doi.org/10.13057/biodiv/d221159>.
- 367 Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*,  
368 from different regions. Livest Res Rural Dev 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/aguss31091.html>.
- 369 Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta.  
370 Bul Peternak 42(1): 50-56. <https://doi.org/10.21059/buletinpeternak.v42i1.28294>.
- 371 Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bul  
372 Peternak 41(4): 448-460. <https://doi.org/10.21059/buletinpeternak.v41i4.13593>.
- 373 AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin  
374 Franklin Station, Washington D.C.
- 375 Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis Cerana Indica*. Int J Biol Innov 03: 271-277.  
376 <https://doi.org/10.46505/ijbi.2021.3204>.
- 377 Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323.  
378 <https://doi.org/10.1016/j.foodchem.2015.09.051>.
- 379 Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan  
380 Perkebunan Provinsi NTB, Mataram.

381 Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci  
382 Educ 1: 1-7. <https://doi.org/10.29303/jossed.v1i1.482>.

383 Erwan, Franti, L.D., Purnamasari, D.K., Muhsinin, M., Agussalim, A., 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from  
384 *Apis cerana* from different regions in North Lombok Regency, Indonesia. J Trop Anim Prod 22: 35-41.  
385 <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>

386 Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification.  
387 Livest Res Rural Dev 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.

388 Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and  
389 pollen) in West Lombok, Indonesia. Livest Res Rural Dev 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>.

390 Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization  
391 phenomenon. Food Chem 149: 84-90. <https://doi.org/10.1016/j.foodchem.2013.10.097>.

392 Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic  
393 area. Food Chem 138: 851-856. <https://doi.org/10.1016/j.foodchem.2012.11.015>.

394 Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of  
395 physicochemical properties of Algerian honey. Resources 10: 94. <https://doi.org/https://doi.org/10.3390/resources10100094>.

396 Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York, pp. 51-68. DOI  
397 10.1007/978-3-642-16422-4\_3.

398 Karabagias IK, Badeka A, Kontakos S, Karabournioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to  
399 their geographical origin based on volatiles, physicochemical parameters and chemometrics. Food Chem 146: 548-557.  
400 <https://doi.org/10.1016/j.foodchem.2013.09.105>.

401 Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça Miguel M, Cristina Figueiredo A. 2022. Quality assessment of  
402 Portuguese monofloral honeys. Physicochemical parameters as tools in botanical source differentiation. Food Res Int 157: 111362.  
403 <https://doi.org/10.1016/j.foodres.2022.111362>.

404 Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*,  
405 *Apis dorsata* and *Apis mellifera*. BMC Complement Altern Med 13: 1-12.

406 Nainu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special  
407 focus on anticancer, antibacterial, antiviral, and antiparasitic properties. Antibiotics 10: 822. <https://doi.org/10.3390/antibiotics10070822>.

408 National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.

409 Pasiás IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and  
410 quality parameters. Food Chem 242: 513-518. <https://doi.org/10.1016/j.foodchem.2017.09.083>.

411 Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the  
412 epidemiological situation in apiaries varying in the level of colony losses. J Apic Sci 58: 107-132. <https://doi.org/10.2478/JAS-2014-0027>.

413 Puscas A, Hosu A, Cimpoi C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control  
414 honey adulteration. J Chromatogr A 1272: 132-135. <https://doi.org/10.1016/j.chroma.2012.11.064>.

415 Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of *Apis*. In: Hepburn HR, Radloff SE (Eds.). Honeybees of Asia. Springer, New York. pp.  
416 1-22. DOI 10.1007/978-3-642-16422-4\_1.

417 Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa  
418 Penida, and Sumbawa. Bee World 96: 45-49. <https://doi.org/10.1080/0005772x.2018.1564497>.

419 Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.

420 Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from  
421 *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. Biodiversitas 22: 4687-4693. <https://doi.org/10.13057/biodiv/d221062>.

422 Thrasylvoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. J  
423 Apic Res 57: 88-96. <https://doi.org/10.1080/00218839.2017.1411181>.

424 Tornuk F, Karaman S, Ozturk I, Toker OS, Tastemur B, Sagdic O, Dogan M, Kayacier A. 2013. Quality characterization of artisanal and retail Turkish  
425 blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. Ind Crops Prod 46: 124-131.  
426 <https://doi.org/10.1016/j.indcrop.2012.12.042>.

427 Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. Media Sains Indonesia, Tangerang.

428 Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the  
429 antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. Food Chem 337: 127774.  
430 <https://doi.org/10.1016/j.foodchem.2020.127774>.

431 Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*,  
432 *Apis dorsata* and *Lepidotrigona flavibasis*. LWT - Food Sci Technol 134: 110225. <https://doi.org/10.1016/j.lwt.2020.110225>.

433 Yücel Y, Sultanoğlu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food  
434 Biosci 1: 16-25. <https://doi.org/10.1016/j.fbio.2013.02.001>.

435 Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process:  
436 The case of rape honey. Foods 10: 2882. <https://doi.org/10.3390/foods10112882>.

# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,\*</sup>, AGUSSALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram. Jl. Majapahit No. 62, Mataram – 83125, Indonesia. Telp/Fax: +62370-633603/+62370-640592.  
\*email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

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**Abstract.** One of the big problems when keeping-of honeybees is the limited of sustainable feed, especially in the rainy season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, and honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* was divided into six treatments consisting of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.35 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. It can be concluded that the quality of *A. cerana* honey, which are produced by the sugar palm and coconut saps, is acceptable by the Indonesian national standard and international standards. The sugar palm and coconut saps have a big potential as the bee feed, especially for the bee *A. cerana*.

**Key words:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

**Running title:** Honey quality of *Apis cerana* produced by sugar palm and coconut saps

## INTRODUCTION

The honeybee of *A. cerana* is one of the bees from the *Apis* genus, which includes the local bee which is spread in some regions in Indonesia, including are Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by the beekeepers using traditional hives (for example using a coconut log hive) and semi-modern hives (box hives without nest frames) to produce honey. Furthermore, several regions have been practicing the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives or use box hives, but is not completed by the honey frame like the beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis. However their production is lower compared to the bee *A. mellifera*.

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is a very serious problem that has been faced by the beekeepers because they have no area which is used to plant several plants which are used as the feed source to produce the honeybees' products. Honeybees feeds are divided into two types, namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral, which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body parts and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process is continuously done by the foragers until their honey stomach is full of nectar and their corbicula has been deposited by the pollen. This pollination impacts on the increasing the plants productivity (Pohorecka et al., 2014; Supeno et al., 2021).

One of the strategies to produce the sustainable honey from the bee *A. cerana* is by using a sap from the plants such as sugar palm and coconut. Several studies have been conducted by using a sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed could enhance the production of honey cells and bee bread cells. However, the use of sap from coconut and sugar palm can increase the honey and bee bread cells compared to the control group without sap as the feed (multi-floral nectar).

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48 Furthermore, Erwan et al. (2022) was also reported that the using of sugar palm and coconut saps which are each added  
49 with by sugar palm pollen can improving the bee *A. cerana* productivity, such as increasing the honey production, brood  
50 cells number, and colony weight. In addition, in another study showed that the use of extrafloral nectar, namely sugar palm  
51 (*Arenga pinnata*) and coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed, which is resulting the honey chemical  
52 composition (reducing sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian  
53 national standard and the international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However,  
54 the studies about the chemical composition of honey from the bee *A. cerana* which are produced from the sugar palm sap,  
55 coconut sap, and their honey potency production from both sap sugar palm and coconut have yet to be not been studied.  
56 Therefore, the objectives of this study were to evaluate the honey quality based on the chemical composition of from the bee  
57 *A. cerana* and, the honey potency produced by the coconut and sugar palm saps.

## 58 MATERIALS AND METHODS

### 59 Study area

60 This research has been conducted in the North Duman Village (8°32'10"S; 116°09'32"E), Lingsar Sub-district, West  
61 Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty of *A. cerana* colonies were divided  
62 into six treatments and every each five colonies per treatment as the replication. The saps were used in our study were  
63 obtained from the stalk of coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*) and the pollen source from the  
64 sugar palm were shown in (Figure 1). The stalks of coconut and sugar palm were cut and then put in the plastic bottle,  
65 which was used to storage the sap which was secreted by their stalks. The treatments in our study were sugar palm sap  
66 without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% +  
67 sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen  
68 (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by  
69 sugar palm pollen (SCP1).



86 **Figure 1.** Coconut sap (left), sugar palm sap (center), and sugar palm pollen (right)

88 The technique was used to given sugar palm and coconut saps and sugar palm pollen (shown in Figure 2) was  
89 according to the previously method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and  
90 sugar palm saps were given to the bee *A. cerana* by using a plastic plate and split bamboo wasere completed by 4 to 5  
91 twigs for foragers perch. The plastic plate and split bamboo wasere placed one meter from of the box hives, while the sugar  
92 palm pollen was hung besides and above of the box hives. The distance of 600 meters to place the colony to avoid the  
93 foragers to collectin pollen and sap from the other treatments.

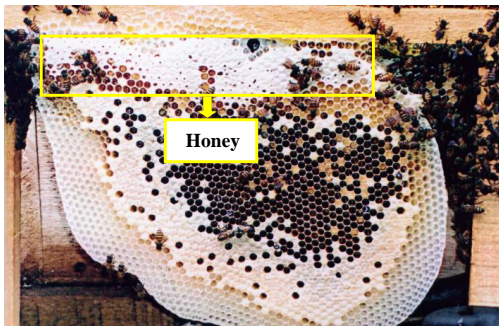


107  
108 **Figure 2.** Technique to given the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)

## 109 **Procedures**

### 110 *Honey quality*

111 Honey from the *A. cerana* (shown in Figure 2) was harvested after beekeeping for three months by using a coconut  
112 and sugar palm saps. Honey from the five hives in one treatment group was composited into one honey sample and then  
113 used to analysis of their chemical composition. Honey quality from the *A. cerana* was evaluated based on the chemical  
114 composition consisting of moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF),  
115 and acidity. The moisture content was analyzed by using a proximate analysis based on the method from the Association  
116 of Official Agricultural Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed by using a Layne-Enyon method,  
117 and sucrose content was analyzed by a Luff Schoorl method, were described by AOAC (2005). Diastase enzyme activity,  
118 hydroxymethylfurfural (HMF), and free acidity were analyzed based on the harmonized methods of the international  
119 honey commission (Machado et al. 2022).



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136 **Figure 2.** Honey from *A. cerana* was produced from the sugar palm and coconut saps

### 137 *Honey production from sugar palm and coconut saps*

138 Sugar palm and coconut saps every ten liters were used to measuring the honey production from the bee *A. cerana*  
139 for three months of beekeeping. The sugar palm and coconut saps were placed on the plastic plate in front of the box hives  
140 at the distance of one meter. In addition, the honey production without using of sugar palm and coconut saps were was  
141 measured for one year of the beekeeping, which is used to calculate the contribution of sugar palm and coconut saps in  
142 honey production. Honey from *A. cerana* was harvested with cut the honey cells (Figure 2) and squeezed to separate wax  
143 and honey. Afterward, honey was measured their production by using a digital scale and stored in the refrigerator.

### 144 *Production of saps from coconut and sugar palm*

145 The production of sap from coconut was measured for a year, while the sugar palm sap based on the previously studied  
146 was used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The  
147 production of coconut and sugar palm saps per hectare which was calculated from the sap production per tree multiplied  
148 by the trees number of trees in a one hectare area. After three months of beekeeping, honey from both treatments, sugar  
149 palm and coconut saps were harvested to measure the honey production from the use of ten liters sap, and then honey  
150 production was measured by cylinder glass

### 151 **Data analysis**

152 The data of honey quality, production potency of honey from sugar palm and coconut saps, honey production, and  
153 production of saps were analyzed by using a descriptive analysis (Steel et al. 1997).

## 154 **RESULTS AND DISCUSSION**

### 155 **Moisture content of honey**

156 Honey is composed of by water as the second largest of honey constituents, and its ranging from 15 to 21 g/100 g,  
157 depending on the plant species types as the nectar source, which is affected by the botanical origin. Furthermore, honey  
158 moisture is also affected by honey maturity level, processing postharvest, and storage conditions (Da Silva et al. 2016).

The honey moisture affects the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the temperature and humidity depending on the season (rainy and dry seasons), and honey moisture can increase during the postharvest processing, such as storage conditions, because honey is hygroscopic that can absorb the moisture in the air (Da Silva et al. 2016; Karabagias et al. 2014).

The recent study showed that the honey moisture from the bee *A. cerana*, which was produced by sugar palm and coconut saps, and their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted by the Indonesian national standard (SNI), where the moisture for beekeeping honey, including the bee *A. cerana* and *A. mellifera*, does not exceed 22% (National Standardization Agency of Indonesia 2018) and is higher compared to the international standard which is regulated by Codex Alimentarius regulated is not exceed 20% (Thrasylvoulou et al. 2018). The variation of honey moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm and coconut, however in our study has not been measured. The higher moisture content is requiring a long time to for ripening of honey, and process of decreasing honey moisture has been started by the bees start the process of decreasing honey moisture when they are taking nectar from plant flowers or saps as the raw material to produce honey. Furthermore, a small portion of moisture content has been evaporated in the honey sack before being transferred to the other bee, which is working in the hive. This transfer is rapid depending on the temperature, colony strength, and nectar availability (Da Silva et al. 2016).

**Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CP1	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

The honey production process is started with the foragers collecting a nectar from the plant flowers or extrafloral nectar and then stored in the honey stomach. After that, the foragers will be transferring the nectar that has been collected to the other bees who are working to process the nectar into honey in their mouth, then put it in the honey stomach and then is transferred to other bees for several times until honey is ripening. A considerable amount of water will be evaporated in this process, which continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes (Balasubramanyam 2021; Zhang et al. 2021). The honey moisture content in our study was differed from reported by Wang et al. (2021) that honey moisture from the bee *A. cerana*, which is collected from 42 different honeycombs from China ranges from 17.03 to 18.44%, 18.65% for *A. cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana* from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) was also reported that the honey moisture produced by the *A. mellifera* bee by using sugar palm and coconut saps is ranging from 19.34 to 20.94%. The different honey moisture content has been reported to be affected by the different geographical origins, which impacts on the different plant types that can be grown in each region, different environmental conditions (temperature and humidity), and also different bee species, which impact on the different ability to evaporate water in the honey.

### Reducing sugar and sucrose contents of honey

Sugars in honey are composed of monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerbiose, maltotriose, maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

The recent study showed that the honey-reducing sugar from the bee *A. cerana* was beekeeping by using a sugar palm and coconut saps, and their combination as the nectar source to produce honey is ranging from 62.78 to 68.37% (Table 1). This honey-reducing sugar is acceptable by the SNI for treatments SP0, CP0, CP1, and SCP1, but not acceptable for treatments SCP0, and SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that changes the sap sucrose into simple sugars. It is known that this enzyme is responsible for the conversion of sucrose into glucose and fructose. These sugars are included in the reducing sugar group and as the main component present in honey. In the honey maturity process, the sucrose is break down by the invertase enzyme into simple sugars simultaneously, and water will be evaporated so that it will be increasing the reducing sugar content. In addition, enzymes secreted by the worker bees are also can also break down the carbohydrate into simple sugars. Furthermore, another enzyme present in honey is the diastase enzyme that breaks down starch into simple sugars (Da Silva et al. 2016). The honey-reducing sugar in our

study (Table 1) ~~was differed from what waste~~ reported by Erwan et al. (2020), that honey reducing sugar from the bee *A. mellifera* which was produced by extrafloral nectar (sugar palm and coconut saps) ~~is-rangesing~~ from 60.15 to 73.69%. The different reducing sugar may be affected by the different bee species, which ~~is-impacts on the different~~ their ability to evaporate water ~~present~~ in honey, especially when they ~~are~~ convert the complex sugars into simple sugars and different seasons when ~~done~~ the study ~~which areis~~ related to temperature and humidity environmental.

The honey sucrose content from the bee *A. cerana* in our study ~~is-rangesing~~ from 1.44 to 3.42% (Table 1) and acceptable by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed 5% for blossom and honeydew honeys (Thrasylvoulou et al. 2018). Naturally, sucrose present in honey in our study ~~originated~~ from sugar palm and coconut saps. The low honey sucrose content in our study is ~~caused by~~ the honey ~~which is~~ harvested in mature condition ~~that is~~ characterized by honey cells ~~that have been covered by wax~~. Furthermore, the invertase enzyme which is produced by the worker bees ~~actively breaks down~~ sucrose from saps into simple sugars. There are two types of invertase enzymes ~~thatwhich~~ are produced by the worker bees, namely glucoinvertase, ~~which converts~~ sucrose into glucose and fructoinvertase, ~~which converts~~ sucrose into fructose. These enzymes are mostly derived from the bee's secretion and only a small portion from the nectar, while the honeydew from the insect's ~~secretion mostly contains invertase enzymes~~ (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) ~~was differed from to reported by~~ Erwan et al. (2020), that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 4.21 to 4.40%.

The honey sucrose content is a very important parameter to evaluate the maturity of honey to ~~identify manipulation~~, where the high levels may ~~be indicate~~ adulterations by adding ~~the~~ several sweeteners such ~~as~~ cane sugar or refined beet sugar. In addition, ~~also~~ indicating the early ~~of~~ harvest, where sucrose is not completely ~~yd~~ transformed into fructose and glucose, the bees ~~feeding~~ artificially ~~for a#~~ prolonged time ~~by~~ using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013; Escuredo et al. 2013; Tornuk et al. 2013). Honey is ~~a~~ sugar solution that is supersaturated and unstable, so it's easy to crystallize. The honey crystallization is affected by ~~the~~ concentration of glucose, fructose, and water. Fructose is the dominant sugar present in honey from *A. mellifera* was produced by several plants as the nectar source ~~that workers usewhich is used by workers~~ to produce honey such as eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey was produced by *Brassica napus*. Rape honey is higher in glucose and ~~lowers~~ in fructose which ~~is-impacts on theits~~ rapidly crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which ~~is-impacts~~ on the different plant types ~~that~~ can ~~growth~~ in each region and ~~impact-on~~ the different sugars content from the nectar, which is produced by the nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016; Escuredo et al. 2014; Tornuk et al. 2013). Furthermore, ~~the~~ sugars content in honey is influenced by climate (season, temperature, and humidity), processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014; Tornuk et al. 2013).

#### Diastase enzyme activity and hydroxymethylfurfural (HMF) of honey

~~TheA~~ recent study showed that the diastase enzyme activity from the bee *A. cerana* honey ~~was~~ produced by the sugar palm and coconut saps ~~was rangeding~~ from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with ~~the a~~ minimum of 3 DN for ~~the~~ beekeeping honey, including the bee *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018), and also acceptable by ~~the~~ international standard has been regulated by Codex Alimentarius with the minimum 3 DN (Thrasylvoulou et al. 2018). One of the honey characteristics is ~~that it contains~~ enzymes ~~which is~~ ~~originatinge~~ from the bees, pollen, and nectar from plant flowers, but ~~the~~ mostly enzymes are added by the bees when they are convert nectar into honey (Da Silva et al. 2016; Thrasylvoulou et al. 2018). The honey diastase enzyme activity in our study (Table 2) ~~was differed from what waste~~ reported by Erwan et al. (2020), that the diastase enzyme activity of honey from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

Diastases ~~are~~ divided into  $\alpha$ - and  $\beta$ -amylases, ~~which are~~ the natural enzymes present in honey. The  $\alpha$ -amylase ~~separates~~ the starch chain randomly in the center~~ral~~ to produce dextrin, while the  $\beta$ -amylase ~~separates~~ the maltose in the end chain. ~~The nectar source Diastase enzyme content in honey is influenceds diatase enzyme content in honey by nectar sourcee~~ (floral and extrafloral nectars) to produce honey and honey geographical origins, which ~~are-impacts on~~ the different chemical composition of the nectar can be produced by the plants which ~~is-impacts on~~ the honey chemical composition, especially diastase enzyme activity. In addition, the bee species ~~are-is~~ also influencing the activity diastase because it's related to the distance, and the flowers plant numbers ~~that~~ can be visited by the foragers when they are collecting nectar and pollen ~~were-used~~ to produce honey and bee bread (Da Silva et al. 2016).

Generally, ~~the~~ diastase enzyme ~~has theis~~ role ~~of to~~ breaking ~~down~~ complex sugars into simple sugars. ~~In addition, tThis~~ enzyme is role to ~~digesting~~ starch into maltose (disaccharide) and maltotriose (trisaccharide), which are sensitive to heat or thermolabile. Thus, this condition can be used to evaluate ~~the~~ overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore, ~~the~~ diastase activity is also used to evaluate honey age, ~~which is~~ related to storage time and ~~the~~ temperature because the diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed ~~to reported byfrom~~ Wu et al. (2020) for multifloral honey produced by the *A. cerana cerana* from ~~the~~ Hainan province

(China) was 6.70 Göthe. Furthermore, it was also differed from to reported by Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling Mountains (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activities of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

Furthermore, the HMF of *A. cerana* honey was produced by the sugar palm and coconut saps in our study was ranging from 2.24 to 5.81 mg/kg (Table 2). This HMF indicates that honey from our study in fresh condition and acceptable by SNI for the beekeeping honey, including from *A. cerana* and *A. mellifera*, is not exceed 40 mg/kg (National Standardization Agency of Indonesia 2018) and also acceptable by the international standard has been regulated by Codex Alimentarius is not to exceed 40 mg/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018). After harvesting, the fresh honey after harvested is generally contains at the low of HMF is ranging from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is the result of the degradation of honey monosaccharides, especially fructose and glucose, under acid conditions and accelerated by heating. This reaction is producing levulinic and formic acids (Da Silva et al. 2016).

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CP1	8.51	5.81	28.26
SCP1	6.85	2.24	30.61
SNI	>3	<40	<50
Codex Alimentarius	>3	<40	<50

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

Hydroxymethylfurfural is formed after the honey is removed from the comb or when the wax cover iwas opened and the advanced processing like heating process. The increasing of the HMF content occurs in honey with the high acidity and is accelerated by the heating process. However, the HMF content is also influenced by several factors such as sugars content, organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF can also be formed at low temperatures, acidic conditions, and sugars dehydration reactions. Therefore, the higher of HMF content's impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* were reported by previously researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

### Acidity of honey

Free acidity is one of the an important parameters to evaluate the honey deterioration which is characterized by the presence of the organic acids presence in equilibrium with internal esters, lactone, and several inorganic ions such as sulfates, chlorides, and phosphates (Da Silva et al. 2016). ThisThe recent study showed that the honey acidity from *A. cerana* was produced by the sugar palm and coconut saps was ranging from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is acceptable by SNI is not to exceed 50 ml NaOH/kg for the beekeeping honey, including *A. cerana* and *A. mellifera*. Furthermore, it is also acceptable by the international standard has been regulated by the Codex Alimentarius is not to exceed 50 meq/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018).

The sour taste of honey originated from the several organic and inorganic acids, where the dominant organic acid present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase, which is added by the bees when they convert a nectar into honey, so that it can protect thea nectar until honey maturity. This protectioning mechanism is caused by the inhibitiong of microorganisms' activity in honey (Da Silva et al. 2016). This inhibit mechanism includes the combination of several factors, such as low moisture and the presence of hydrogen peroxide, which is produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of the cell wall resulting in a change in cytoplasmic membrane permeability (Nainu et al. 2021; Pasiyas et al. 2018).

The total acidity total content in honey is a small quantity. Still, but the presence in honey is very important because it can influenceing the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity is indicateing the fermentation process had been occurred when some reducing sugar is brokeak down into acetic acid. Honey acidity content is related to the yeast number where they is break down some reducing sugar into ethanol, and if theit's reaction with the oxygen is formed, the acetic acid which is increasing the honey acidity. Therefore, the higher

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acidity values higher of acidity may be indicating the sugars fermentation process of sugars into organic acids. The honey acidity is affected by several factors, such as different content of organic acids, different geographical origins, and the seasonal when honey is harvested (Da Silva et al. 2016; Tornuk et al. 2013). The honey acidity from the bee *A. cerana* in our study (Table 2) was differed from previously studied by Wu et al. (2020) for *A. cerana cerana* honey is 0.80 mol/kg, and Guerzou et al. (2021) is ranging from 11 to 47 meq/kg for Algerian honey. Furthermore, it is differed from reported by Erwan et al. (2020) that honey acidity from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 22.00 to 43.00 ml NaOH/kg. The different acidity has been reported previously with our study is affected by the different plant types as the nectar source to produce honey, honey pH, geographical origin, and organic acids compound; however in our study has not measured the organic acid compound and honey pH.

### Honey production potency from the sugar palm and coconut saps

Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized which can contribute to communities' income. Generally, the main production from the coconut (*Cocos nucifera* L.) was harvested as coconut fruit to advance the process into coconut oil and copra. These commodities have a high price, but producing coconut oil and copra are high risk for the farmers because they are just preparing raw materials. Therefore, the utilizing of the sap can be produced by the coconut and sugar palm were also potency feed for the bees was used as the nectar source to produce honey. Sugar palm and coconut saps are the feed potential which is studied by Erwan et al. (2021b) that the coconut and sugar palm saps can increase the number of honey cells and bee bread cells of the bee *A. cerana*. Furthermore, it is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*, such as increasing the brood cells number, colony weight, and the honey production (Erwan et al. 2022). In addition, the saps from coconut and sugar palms are usually used by the farmers to produce sugar by using a traditional process.

The coconut plants can produce 12 stalks in a year, and in one stalk can produce sap of 90 liters. Thus, in one coconut plant can produce 1,080 liters of sap. Furthermore, if the farmers have one hectare of the land which are planted by 100 coconut plants (distance 10 m × 10 m), so they can be produced for about 108,000 liters of coconut sap. To produce 1 kg of honey requires coconut sap for about 7 liters, and in a year 84 liters are required to produce 12 kg of honey. Thus, honey potency in a year from 100 hectares of the land can be calculated as follows: 10,800,000 liters of sap divided by 84 liters of sap and multiplied by 12 kg of honey and obtained 1,542,857.14 kg/year (1,542.857 tons/year) or equivalent with 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

Sugar palm plants can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be tapped not to exceed 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant is ranging from 8 to 22 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year). Furthermore, if in one hectare of the plantation, we have 100 sugar palm plants, with the distance for planted is 10 m × 10 m, so can be obtained of sap for 115,000 liters.

The field investigation showed that to produce 1 kg of honey from the sugar palm sap is required for about 10 liters, and in a year, it is required for about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm sap in a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and multiplied by 12 kg, so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833 tons/month in 100 hectares area. This potency indicates that the sugar palm sap has a big potency to produce honey which is supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. Therefore, it can be concluded that honey is produced by the bee *A. cerana* from sugar palm and coconut saps as the feed have at the quality which that is acceptable by Indonesian national standard, and the international standard has been regulated by the Codex Alimentarius. Honey potency production from the coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571 tons/month, while in sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

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### ACKNOWLEDGEMENTS

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### REFERENCES

- Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas 22: 5205-5210. <https://doi.org/10.13057/biodiv/d221159>.
- Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*, from different regions. Livest Res Rural Dev 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/aguss31091.html>.

377 Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta.  
378 Bul Peternak 42(1): 50-56. <https://doi.org/10.21059/buletinpeternak.v42i1.28294>.

379 Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bul  
380 Peternak 41(4): 448-460. <https://doi.org/10.21059/buletinpeternak.v41i4.13593>.

381 AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin  
382 Franklin Station, Washington D.C.

383 Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis Cerana Indica*. Int J Biol Innov 03: 271-277.  
384 <https://doi.org/10.46505/ijbi.2021.3204>.

385 Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323.  
386 <https://doi.org/10.1016/j.foodchem.2015.09.051>.

387 Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan  
388 Perkebunan Provinsi NTB, Mataram. <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>

389 Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci  
390 Educ 1: 1-7. <https://doi.org/10.29303/jossed.v1i1.482>.

391 Erwan, Franti, L-D., Purnamasari, D-K., Muhsinin, M., Agussalim, A., 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from  
392 *Apis cerana* from different regions in North Lombok Regency, Indonesia. J Trop Anim Prod 22: 35-41.  
393 <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>

394 Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification.  
395 Livest Res Rural Dev 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.

396 Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and  
397 pollen) in West Lombok, Indonesia. Livest Res Rural Dev 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>.

398 Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization  
399 phenomenon. Food Chem 149: 84-90. <https://doi.org/10.1016/j.foodchem.2013.10.097>.

400 Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic  
401 area. Food Chem 138: 851-856. <https://doi.org/10.1016/j.foodchem.2012.11.015>.

402 Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of  
403 physicochemical properties of Alergian honey. Resources 10: 94. <https://doi.org/https://doi.org/10.3390/resources10100094>.

404 Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York, pp. 51-68. DOI  
405 10.1007/978-3-642-16422-4\_3.

406 Karabagias IK, Badeka A, Kontakos S, Karabournioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to  
407 their geographical origin based on volatiles, physicochemical parameters and chemometrics. Food Chem 146: 548-557.  
408 <https://doi.org/10.1016/j.foodchem.2013.09.105>.

409 Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça Miguel M, Cristina Figueiredo A. 2022. Quality assessment of  
410 Portuguese monofloral honeys. Physicochemical parameters as tools in botanical source differentiation. Food Res Int 157: 111362.  
411 <https://doi.org/10.1016/j.foodres.2022.111362>.

412 Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*,  
413 *Apis dorsata* and *Apis mellifera*. BMC Complement Altern Med 13: 1-12.

414 Naimu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special  
415 focus on anticancer, antibacterial, antiviral, and antiparasitic properties. Antibiotics 10: 822. <https://doi.org/10.3390/antibiotics10070822>.

416 National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.

417 Pasiás IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and  
418 quality parameters. Food Chem 242: 513-518. <https://doi.org/10.1016/j.foodchem.2017.09.083>.

419 Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the  
420 epidemiological situation in apiaries varying in the level of colony losses. J Apic Sci 58: 107-132. <https://doi.org/10.2478/JAS-2014-0027>.

421 Puscas A, Hosu A, Cimpoiu C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control  
422 honey adulteration. J Chromatogr A 1272: 132-135. <https://doi.org/10.1016/j.chroma.2012.11.064>.

423 Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of *Apis*. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York. pp.  
424 1-22. DOI 10.1007/978-3-642-16422-4\_1.

425 Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa  
426 Penida, and Sumbawa. Bee World 96: 45-49. <https://doi.org/10.1080/0005772x.2018.1564497>.

427 Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.

428 Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from  
429 *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. Biodiversitas 22: 4687-4693. <https://doi.org/10.13057/biodiv/d221062>.

430 Thrasivoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. J  
431 Apic Res 57: 88-96. <https://doi.org/10.1080/00218839.2017.1411181>.

432 Tornuk F, Karaman S, Ozturk I, Tokar OS, Tastemur B, Sagdic O, Dogan M, Kayaci A. 2013. Quality characterization of artisanal and retail Turkish  
433 blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. Ind Crops Prod 46: 124-131.  
434 <https://doi.org/10.1016/j.indcrop.2012.12.042>.

435 Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. Media Sains Indonesia, Tangerang.

436 Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the  
437 antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. Food Chem 337: 127774.  
438 <https://doi.org/10.1016/j.foodchem.2020.127774>.

439 Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*,  
440 *Apis dorsata* and *Lepidotrigona flavivasis*. LWT - Food Sci Technol 134: 110225. <https://doi.org/10.1016/j.lwt.2020.110225>.

441 Yücel Y, Sultanoglu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food  
442 Biosci 1: 16-25. <https://doi.org/10.1016/j.fbio.2013.02.001>.

443 Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process:  
444 The case of rape honey. Foods 10: 2882. <https://doi.org/10.3390/foods10112882>.

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# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,\*</sup>, AGUSSALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram. Jl. Majapahit No. 62, Mataram – 83125, Indonesia. Telp/Fax: +62370-633603/+62370-640592.

\*email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta – 55281, Indonesia

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**Abstract.** One of the big problems when keeping honeybees is the limited of sustainable feed, especially in the rainy season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, and honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* was divided into six treatments consisting of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.35 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. It can be concluded that the quality of *A. cerana* honey, produced by the sugar palm and coconut saps, is acceptable by the Indonesian national and international standards. The sugar palm and coconut saps have a big potential as the bee feed especially for the bee *A. cerana*.

**Key words:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

**Running title:** Honey quality of *Apis cerana* produced by sugar palm and coconut saps

## INTRODUCTION

The honeybee of *A. cerana* is one of the bees from the *Apis* genus which includes the local bee which is spread in some regions in Indonesia, including Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by beekeepers using traditional hives (for example using a coconut log hive) and semi-modern hives (box hives without nest frames) to produce honey. Furthermore, several regions have been practicing the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives or use box hives but is not completed by the honey frame like the beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis. However their production is lower compared to the bee *A. mellifera* (Agussalim and Agus 2022).

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is a very serious problem that has been faced by beekeepers because they have no area used to plant several plants which are used as the feed source to produce the honeybees' products. Honeybee feeds are divided into two types, namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral, which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body parts and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process is continuously done by the foragers until their honey stomach is full of nectar and their corbicula has been deposited by the pollen. This pollination impacts on the increasing the plants productivity (Pohorecka et al. 2014; Supeno et al. 2021).

One of the strategies to produce sustainable honey from the bee *A. cerana* is by using sap from the plants such as sugar palm and coconut. Several studies have been conducted by using sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed could enhance the production of honey cells and bee bread cells. However, the use of sap from coconut and sugar palm can increase the honey and bee bread cells compared to the control group without sap as the feed (multifloral nectar). Furthermore, Erwan et al. (2022) also reported using sugar palm and coconut saps which are each added with sugar palm

48 pollen can improve the bee *A. cerana* productivity, such as increasing honey production, brood cell number, and colony  
49 weight. In addition, another study showed that the use of extrafloral nectar namely sugar palm (*Arenga pinnata*) and  
50 coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed which is resulting the honey chemical composition (reducing  
51 sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian national standard and  
52 the international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, studies about the  
53 chemical composition of honey from the bee *A. cerana* produced from the sugar palm sap, coconut sap, and their honey  
54 potency production from both sap sugar palm and coconut have yet to be studied. Therefore, the objectives of this study  
55 were to evaluate the honey quality based on the chemical composition of the bee *A. cerana*, honey potency produced by  
56 the coconut and sugar palm saps.

57

## MATERIALS AND METHODS

### Study area

58 This research has been conducted in the North Duman Village (8°32'10"S 116°09'32"E), Lingsar Sub-district, West  
59 Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty *A. cerana* colonies were divided into  
60 six treatments and every five colonies per treatment as the replication. The saps used in our study were obtained from the  
61 stalk of coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*) and the pollen source from the sugar palm (Figure  
62 1). The stalks of coconut and sugar palm were cut and then put in a plastic bottle which was used to store the sap secreted  
63 by their stalks. The treatments in our study were sugar palm sap without added by sugar palm pollen (SP0); coconut sap  
64 without added sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added sugar palm pollen  
65 (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1);  
66 coconut sap of 50% + sugar palm sap of 50% was added sugar palm pollen (SCP1).  
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84 **Figure 1.** Coconut sap (left), sugar palm sap (center), and sugar palm pollen (right)  
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86 The technique was used to give sugar palm and coconut saps and sugar palm pollen (Figure 2) was according to the  
87 previous method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and sugar palm saps  
88 were given to the bee *A. cerana* by using a plastic plate and split bamboo was completed by 4 to 5 twigs for foragers  
89 perch. The plastic plate and split bamboo was placed one meter from the box hives, while the sugar palm pollen was hung  
90 besides and above of the box hives. The distance of 600 meters to place the colony to avoid the foragers collecting  
91 pollen and sap from the other treatments.  
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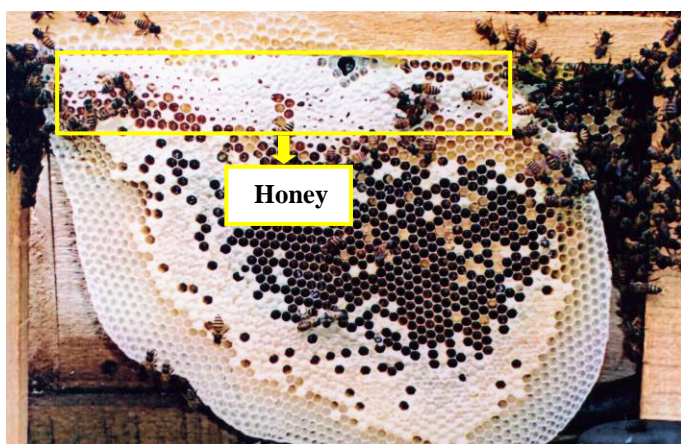


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106 **Figure 2.** Technique to give the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)

## 107 Procedures

### 108 Honey quality

109 Honey from the *A. cerana* (Figure 3) was harvested after beekeeping for three months using coconut and sugar palm saps. Honey from the five hives in one treatment group was composited into one honey sample and then used to analysis of their chemical composition. Honey quality from the *A. cerana* was evaluated based on the chemical composition consisting of moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and acidity. The moisture content was analyzed by using a proximate analysis based on the method from the Association of Official Agricultural Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed using a Layne-Enyon method and sucrose content was analyzed by a Luff School method, described by AOAC (2005). Diastase enzyme activity, hydroxymethylfurfural (HMF), and free acidity were analyzed based on the harmonized methods of the international honey commission (Machado et al. 2022).



134 **Figure 3.** Honey from *A. cerana* was produced from the sugar palm and coconut saps

### 135 Honey production from sugar palm and coconut saps

136 Sugar palm and coconut saps every ten liters were used to measure the honey production from the bee *A. cerana* for three months of beekeeping. The sugar palm and coconut saps were placed on the plastic plate in front of the box hives at a distance of one meter. In addition, the honey production without using sugar palm and coconut saps was measured for one year of the beekeeping, which calculates the contribution of sugar palm and coconut saps in honey production. Honey from *A. cerana* was harvested with cut the honey cells (Figure 3) and squeezed to separate wax and honey. Afterward, honey was measured production by using a digital scale and stored in the refrigerator.

### 142 Production of saps from coconut and sugar palm

143 The production of sap from coconut was measured for a year and also based on dept interview with farmers, while the sugar palm sap based on the previously studied was used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The production of coconut and sugar palm saps per hectare was calculated from the sap production per tree multiplied by the number of trees in a one hectare area. After three months of beekeeping, honey from both treatments sugar palm and coconut saps were harvested to measure the honey production from the use of ten liters sap, and then honey production was measured by cylinder glass

### 149 Data analysis

150 The data on honey quality, production potency of honey from sugar palm and coconut saps, honey production, and production of saps were analyzed by using descriptive analysis (Steel et al. 1997).

## 152 RESULTS AND DISCUSSION

### 153 Moisture content of honey

154 Honey is composed of water as the second largest of honey constituents, ranging from 15 to 21 g/100 g, depending on the plant species as the nectar source which is affected by the botanical origin. Furthermore, honey moisture is also affected by honey maturity level, processing postharvest, and storage conditions (Da Silva et al. 2016). The honey moisture affects the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the temperature and humidity depending on the season (rainy and dry seasons). Honey moisture can increase during

160 postharvest processing such as storage conditions, because honey is hygroscopic that can absorb the moisture in the air (Da  
161 Silva et al. 2016; Karabagias et al. 2014).

162 A recent study showed that the honey moisture from the bee *A. cerana*, produced by sugar palm and coconut saps and  
163 their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted by the Indonesian  
164 national standard (SNI), where the moisture for beekeeping honey, including the bee *A. cerana* and *A. mellifera*, does not  
165 exceed 22% (National Standardization Agency of Indonesia 2018) and is higher compared to the international standard  
166 which Codex Alimentarius regulated is not exceed 20% (Thrasylvoulou et al. 2018). The variation of honey moisture of the  
167 bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm and coconut,  
168 however our study has not been measured. The higher moisture content requires a long time for ripening of honey, and the  
169 bees start the process of decreasing honey moisture when they take nectar from plant flowers or saps as the raw material to  
170 produce honey. Furthermore, a small portion of moisture content has been evaporated in the honey sack before being  
171 transferred to the other bee which is working in the hive. This transfer is rapid depending on the temperature, colony  
172 strength, and nectar availability (Da Silva et al. 2016).

173  
174 **Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CP1	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

175 Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0);  
176 coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm  
177 pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar  
178 palm pollen (SCP1).

179  
180 The honey production process is started with the foragers collecting nectar from the plant flowers or extrafloral nectar  
181 and then stored in the honey stomach. After that, the foragers will transfer the nectar that has been collected to the other  
182 bees who are working to process the nectar into honey in their mouth, then put it in the honey stomach and then transfer it  
183 to other bees several times until honey is ripening. A considerable amount of water will be evaporated in this process,  
184 which continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes  
185 (Balasubramanyam 2021; Zhang et al. 2021). The honey moisture content in our study differed from Wang et al. (2021)  
186 that honey moisture from the bee *A. cerana* which is collected from 42 different honeycombs from China ranges from  
187 17.03 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana*  
188 from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) also reported that the  
189 honey moisture produced by the *A. mellifera* bee by using sugar palm and coconut saps ranges from 19.34 to 20.94%. The  
190 different honey moisture content has been reported to be affected by the different geographical origins, impacts the  
191 different plant types that can be grown in each region, different environmental conditions (temperature and humidity), and  
192 also different bee species, which impact the different ability to evaporate water in the honey.

### 193 Reducing sugar and sucrose contents of honey

194 Sugars in honey are composed of monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in  
195 small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars  
196 in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerbiose, maltotriose,  
197 maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

198 A recent study showed that the honey reducing sugar from the bee *A. cerana* was beekeeping by using sugar palm and  
199 coconut saps, and their combination as the nectar source to produce honey ranges from 62.78 to 68.37 % (Table 1). This  
200 honey reducing sugar is acceptable by the SNI for treatments SP0, CP0, CP1, and SCP1 but not acceptable for treatments  
201 SCP0, and SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of Indonesia  
202 2018). This sugar is produced by the mechanism of invertase enzyme activity that change the sap sucrose into simple  
203 sugars. It is known that this enzyme is responsible for converting of sucrose into glucose and fructose. These sugars are  
204 included in the reducing sugar group and the main component in honey. In the honey maturity process, the sucrose is break  
205 down by the invertase enzyme into simple sugars simultaneously, and water will be evaporated to increase the reduced  
206 sugar content. In addition, enzymes secreted by the worker bees can also break down the carbohydrate into simple sugars.  
207 Furthermore, another enzyme in honey is the diastase enzyme that breaks down starch into simple sugars (Da Silva et al.  
208 2016). The honey reducing sugar in our study (Table 1) differed from what was reported by Erwan et al. (2020), that honey  
209 reducing sugar from the bee *A. mellifera* which was produced by extrafloral nectar (sugar palm and coconut saps) ranges  
210 from 60.15 to 73.69%. The different reducing sugar may be affected by the different bee species, which impacts their  
211 ability to evaporate water in honey, especially when they convert the complex sugars into simple sugars and different  
212 seasons when the study is related to temperature and humidity environmental.

213 The honey sucrose content from the bee *A. cerana* in our study ranges from 1.44 to 3.42% (Table 1) and acceptable by  
214 SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency of  
215 Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed  
216 5% for blossom and honeydew honey (Thrasylvoulou et al. 2018). Naturally, sucrose present in honey in our study  
217 originated from sugar palm and coconut saps. The low honey sucrose content in our study is caused by the honey  
218 harvested in mature condition characterized by honey cells that have been covered by wax. Furthermore, the invertase  
219 enzyme which is produced by the worker bees actively breaks down sucrose from saps into simple sugars. There are two  
220 types of invertase enzymes that are produced by the worker bees, namely glucoinvertase which converts sucrose into  
221 glucose and fructoinvertase, which converts sucrose into fructose. These enzymes are mostly derived from the bee's  
222 secretion and only a small portion from the nectar, while the honeydew from the insect's secretion mostly contains  
223 invertase enzymes (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) differed from Erwan et al.  
224 (2020), that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut  
225 saps) is ranging from 4.21 to 4.40%.

226 The honey sucrose content is a very important parameter to evaluate the maturity of honey to identify manipulation,  
227 where the high levels may indicate adulterations by adding several sweeteners such as cane sugar or refined beet sugar. In  
228 addition, indicating the early harvest, where sucrose is not completely transformed into fructose and glucose, the bees feed  
229 artificially for a prolonged time using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013; Escuredo et al. 2013;  
230 Tornuk et al. 2013). Honey is a sugar solution that is supersaturated and unstable so it's easy to crystallize. The honey  
231 crystallization is affected by the concentration of glucose, fructose, and water. Fructose is the dominant sugar present in  
232 honey from *A. mellifera* was produced by several plants as the nectar source that workers use to produce honey such as  
233 eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey was produced by  
234 *Brassica napus*. Rape honey is higher in glucose and lower in fructose which impacts its rapid crystallization (Escuredo et  
235 al. 2014). The sugars content present in honey is dependent on the geographical origins which impacts on the different  
236 plant types that can grow in each region and impacts the different sugars content from the nectar, which is produced by the  
237 nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016; Escuredo et al. 2014; Tornuk  
238 et al. 2013). Furthermore, the sugar content in honey is influenced by climate (season, temperature, and humidity),  
239 processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014; Tornuk et al. 2013).

#### 240 Diastase enzyme activity and hydroxymethylfurfural (HMF) of honey

241 A recent study showed that the diastase enzyme activity from the bee *A. cerana* honey produced by the sugar palm and  
242 coconut saps ranges from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with a minimum of 3 DN  
243 for beekeeping honey including the bee *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018),  
244 and also acceptable by the international standard has been regulated by Codex Alimentarius with the minimum 3 DN  
245 (Thrasylvoulou et al. 2018). One of the honey characteristics is that it contains enzymes originating from the bees, pollen,  
246 and nectar from plant flowers, but mostly enzymes are added by the bees when they are convert nectar into honey (Da  
247 Silva et al. 2016; Thrasylvoulou et al. 2018). The honey diastase enzyme activity in our study (Table 2) differed from what  
248 was reported by Erwan et al. (2020) that the diastase enzyme activity of honey from the bee *A. mellifera* was produced by  
249 extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

250 Diastases are divided into  $\alpha$ - and  $\beta$ -amylases, the natural enzymes present in honey. The  $\alpha$ -amylase separates the starch  
251 chain randomly in the center to produce dextrin, while the  $\beta$ -amylase separates the maltose in the end chain. The nectar  
252 source influences diastase enzyme content in honey (floral and extrafloral nectars) to produce honey and honey  
253 geographical origins, which impacts the different chemical composition of the nectar can be produced by the plants which  
254 is impact on the honey chemical composition especially diastase enzyme activity. In addition, the bee species are also  
255 influencing the activity diastase because it's related to the distance, and the flowers plant numbers that can be visited by  
256 the foragers when they are collecting nectar and pollen used to produce honey and bee bread (Da Silva et al. 2016).

257 Generally, the diastase enzyme has the role of breaking down complex sugars into simple sugars. In addition, this  
258 enzyme is role to digesting starch into maltose (disaccharide) and maltotriose (trisaccharide) which are sensitive to heat or  
259 thermolabile. Thus, this condition can be used to evaluate the overheating and preservation degree of honey (Da Silva et al.  
260 2016). Furthermore, diastase activity is also used to evaluate honey age related to storage time and temperature because the  
261 diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and  
262 Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed from Wu et al.  
263 (2020) for multifloral honey produced by the *A. cerana cerana* from the Hainan province (China) was 6.70 Göthe.  
264 Furthermore, it also differed from Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling Mountains  
265 (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activities of honey from *A. cerana* were reported by  
266 previous researchers are influenced by the different plant types as the nectar source to produce honey, different sugar  
267 content, and different geographical origin.

268 Furthermore, the HMF of *A. cerana* honey produced by the sugar palm and coconut saps in our study ranges from 2.24  
269 to 5.81 mg/kg (Table 2). This HMF indicates that honey from our study in fresh condition and acceptable by SNI for  
270 beekeeping honey, including from *A. cerana* and *A. mellifera*, not exceed 40 mg/kg (National Standardization Agency of  
271 Indonesia 2018) and also acceptable by the international standard regulated by Codex Alimentarius is not to exceed 40

272 mg/kg for blossom and honeydew honey (Thrasyvoulou et al. 2018). After harvesting, fresh honey generally contains a  
 273 low HMF ranges from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is the result of the degradation of honey  
 274 monosaccharides, especially fructose and glucose, under acid conditions and accelerated by heating. This reaction produce  
 275 levulinic and formic acids (Da Silva et al. 2016).

276  
 277

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CP1	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

278 Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0);  
 279 coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm  
 280 pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar  
 281 palm pollen (SCP1).  
 282

283 Hydroxymethylfurfural is formed after the honey is removed from the comb or when the wax cover is opened and the  
 284 advanced processing like heating process. The increase of the HMF content occurs in honey with the acidity and is  
 285 accelerated by the heating process. However, the HMF content is also influenced by sugars content, organic acids  
 286 presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF  
 287 can also be formed at low temperatures, acidic conditions, and sugar dehydration reactions. Therefore, the higher HMF  
 288 content's impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The HMF of honey from the *A.*  
 289 *cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana*  
 290 *cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The  
 291 different HMF content of honey from *A. cerana* reported by previous researchers are influenced by the different plant  
 292 types as the nectar source to produce honey, different sugars content, and different geographical origin.

### 293 Acidity of honey

294 Free acidity is one of the important parameters to evaluate honey deterioration which is characterized by the presence  
 295 of the organic acids in equilibrium with internal esters, lactone and several inorganic ions such as sulfates, chlorides, and  
 296 phosphates (Da Silva et al. 2016). This study showed that the honey acidity from *A. cerana* produced by the sugar palm  
 297 and coconut saps ranges from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is  
 298 acceptable by SNI not to exceed 50 ml NaOH/kg for the beekeeping honey including *A. cerana* and *A. mellifera*.  
 299 Furthermore, it is also acceptable by the international standard has been regulated by the Codex Alimentarius is not to  
 300 exceed 50 meq/kg for blossom and honeydew honeys (Thrasyvoulou et al. 2018).

301 The sour taste of honey originated from several organic and inorganic acids, where the dominant organic acid present  
 302 in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase which is added by the  
 303 bees when they convert nectar into honey, so that it can protect the nectar until honey maturity. This protection mechanism  
 304 is caused by inhibiting of microorganisms activity in honey (Da Silva et al. 2016). This inhibit mechanism includes the  
 305 combination of several factors, such as low moisture and the presence of hydrogen peroxide which is produced by the  
 306 enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of the cell wall  
 307 resulting in a change in cytoplasmic membrane permeability (Nainu et al. 2021; Pasiyas et al. 2018).

308 The total acidity content in honey is a small quantity. Still, the presence in honey is very important because it can  
 309 influence the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity indicates the  
 310 fermentation process occurs when some reducing sugar is break down into acetic acid. Honey acidity content is related to  
 311 the yeast number where they break down some reducing sugar into ethanol, and if the reaction with the oxygen is formed,  
 312 the acetic acid which is increasing the honey acidity. Therefore, the higher acidity values may indicate the sugars  
 313 fermentation process into organic acids. Honey acidity is affected by several factors such as different content of organic  
 314 acids, different geographical origins, and the season when honey is harvested (Da Silva et al. 2016; Tornuk et al. 2013).  
 315 The honey acidity from the bee *A. cerana* in our study (Table 2) differed from previous studied by Wu et al. (2020) for *A.*  
 316 *cerana cerana* honey is 0.80 mol/kg and Guerzou et al. (2021) ranges from 11 to 47 meq/kg for Algerian honey.  
 317 Furthermore, it is differed from Erwan et al. (2020) that honey acidity from the bee *A. mellifera* was produced by  
 318 extrafloral nectar (sugar palm and coconut saps) ranges from 22.00 to 43.00 ml NaOH/kg. The different acidity reported  
 319 previously with our study is affected by the different plant types as the nectar source to produce honey, honey pH,  
 320 geographical origin, and organic acids compound; however our study has not measured the organic acid compound and  
 321 honey pH.



322 **Honey production potency from the sugar palm and coconut saps**

323 Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized  
324 **contributing to** communities' income. Generally, the main **product** from the coconut (*Cocos nucifera* L.) was harvested as  
325 **coconut** fruit to **advance the** process into coconut oil and copra. **These** commodities have a high price, **but producing**  
326 coconut oil and copra are high risk for the farmers because they are just **preparing raw materials**. Therefore, the utilizing of  
327 the sap can be produced by the coconut and sugar palm were also potency feed for the bees was used as the nectar source  
328 to produce honey. Sugar palm and coconut saps are the feed **potential studied** by Erwan et al. (2021b) that the coconut and  
329 sugar palm saps can **increase** the number of honey and bee bread **cells** of the bee *A. cerana*. Furthermore, **it is** also reported  
330 that sugar palm and coconut are improving the productivity of the bee *A. cerana* such as **increasing** the brood cells number,  
331 colony weight, **and honey** production (Erwan et al. 2022). In addition, the saps from coconut and sugar palm are usually  
332 used **by farmers** to produce **sugar using** a traditional process.

333 The coconut plants can **produce 12** stalks in a year, **and one stalk** can produce sap of 90 liters. **Thus**, one coconut plant  
334 can **produce 1,080** liters of sap. Furthermore, if the farmers have one hectare **of land planted** by 100 coconut plants  
335 (distance 10 m × 10 m), so **they can produce about** 108,000 liters of coconut sap. To produce 1 kg of honey **requires**  
336 coconut sap for about 7 liters and in a year **84 liters are required to** produce 12 kg of honey. Thus, honey potency in a year  
337 from 100 hectares **of land** can be calculated as follows: 10,800,000 liters of sap divided by 84 liters of sap and multiplied  
338 by 12 kg of honey and obtained 1,542,857,14 kg/year (1,542.857 tons/year) or equivalent with 128.571 tons/month in 100  
339 hectares of the land. Based on the sap production showing that the coconut plants have a big potency to produce honey.  
340 This potency was also supported by the harvest area of coconut in West Lombok (Nusa Tenggara Province, Indonesia) was  
341 10,629.36 hectares (Department of Agricultural and Plantations 2021).

342 Sugar palm **plants** can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be **tapped not to**  
343 **exceed 4 months**. Wahyuni et al. (2021) reported that the production of sugar palm sap per **plant ranges** from 8 to 22  
344 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year).  
345 Furthermore, if in one hectare of **the** plantation we have 100 sugar palm **plants**, **the** distance for **planting** is 10 m × 10 m, so  
346 can be obtained of sap for 115,000 liters.

347 **The field** investigation showed **that producing** 1 kg of honey from the sugar palm **sap required about** 10 liters and in a  
348 **year, it is required about** 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm sap in a year  
349 from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and multiplied by 12 kg,  
350 so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833 tons/month in 100 hectares  
351 area. This potency indicate that the sugar palm sap has a big potency to produce honey which is supported by the report  
352 data from the Department of Agricultural and Plantations (2021) that the sap production, sap productivity, and harvest area  
353 for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46 tones, 304.80  
354 quintals/hectare, and 188.52, respectively, in the year of 2021. **Therefore, it** can be concluded that **honey** is produced by  
355 the bee *A. cerana* from sugar palm and coconut saps as the feed have **at** quality **that is acceptable** by Indonesian national  
356 standard, **and the** international standard has been regulated by the Codex Alimentarius. Honey potency production from the  
357 coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571 tons/month, **while**  
358 **sugar palm** can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

359 **ACKNOWLEDGEMENTS**

360 **We thank all** beekeepers and farmers **who support** and **permit** our teams to conduct this study in North Duman Village,  
361 Lingsar Sub-district, West Lombok, Indonesia.

362 **REFERENCES**

- 363 Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas  
364 22: 5205-5210. <https://doi.org/10.13057/biodiv/d221159>.
- 365 **Agussalim, Agus A. 2022. Production of honey, pot-pollen and propolis production from Indonesian stingless bee *Tetragonula laeviceps* and the**  
366 **physicochemical properties of honey: A review. Livest Res Rural Dev 34(8), Article #66. <http://www.lrrd.org/lrrd34/8/3466alia.html>.**
- 367 Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*,  
368 from different regions. Livest Res Rural Dev 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/aguss31091.html>.
- 369 Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta.  
370 Bul Peternak 42(1): 50-56. <https://doi.org/10.21059/buletinpetermak.v42i1.28294>.
- 371 Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bul  
372 Peternak 41(4): 448-460. <https://doi.org/10.21059/buletinpetermak.v41i4.13593>.
- 373 AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin  
374 Franklin Station, Washington D.C.
- 375 Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis Cerana Indica*. Int J Biol Innov 03: 271-277.  
376 <https://doi.org/10.46505/ijbi.2021.3204>.
- 377 Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323.  
378 <https://doi.org/10.1016/j.foodchem.2015.09.051>.

379 Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan  
380 Perkebunan Provinsi NTB, Mataram. [Indonesian].

381 Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci  
382 Educ 1: 1-7. <https://doi.org/10.29303/jossed.v1i1.482>.

383 Erwan, Franti, L.D., Purnamasari, D.K., Muhsinin, M., Agussalim, A., 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from  
384 *Apis cerana* from different regions in North Lombok Regency, Indonesia. J Trop Anim Prod 22: 35-41.  
385 <https://doi.org/10.21776/ub.jtapro.2021.022.01.5>

386 Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification.  
387 Livest Res Rural Dev 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.

388 Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and  
389 pollen) in West Lombok, Indonesia. Livest Res Rural Dev 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>.

390 Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization  
391 phenomenon. Food Chem 149: 84-90. <https://doi.org/10.1016/j.foodchem.2013.10.097>.

392 Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic  
393 area. Food Chem 138: 851-856. <https://doi.org/10.1016/j.foodchem.2012.11.015>.

394 Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of  
395 physicochemical properties of Algerian honey. Resources 10: 94. <https://doi.org/10.3390/resources10100094>.

396 Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York, pp. 51-68. DOI  
397 10.1007/978-3-642-16422-4\_3.

398 Karabagias IK, Badeka A, Kontakos S, Karabournioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to  
399 their geographical origin based on volatiles, physicochemical parameters and chemometrics. Food Chem 146: 548-557.  
400 <https://doi.org/10.1016/j.foodchem.2013.09.105>.

401 Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça Miguel M, Cristina Figueiredo A. 2022. Quality assessment of  
402 Portuguese monofloral honeys. Physicochemical parameters as tools in botanical source differentiation. Food Res Int 157: 111362.  
403 <https://doi.org/10.1016/j.foodres.2022.111362>.

404 Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*,  
405 *Apis dorsata* and *Apis mellifera*. BMC Complement Altern Med 13: 1-12.

406 Nainu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special  
407 focus on anticancer, antibacterial, antiviral, and antiparasitic properties. Antibiotics 10: 822. <https://doi.org/10.3390/antibiotics10070822>.

408 National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.

409 Pasiás IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and  
410 quality parameters. Food Chem 242: 513-518. <https://doi.org/10.1016/j.foodchem.2017.09.083>.

411 Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the  
412 epidemiological situation in apiaries varying in the level of colony losses. J Apic Sci 58: 107-132. <https://doi.org/10.2478/JAS-2014-0027>.

413 Puscas A, Hosu A, Cimpoi C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control  
414 honey adulteration. J Chromatogr A 1272: 132-135. <https://doi.org/10.1016/j.chroma.2012.11.064>.

415 Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of *Apis*. In: Hepburn HR, Radloff SE (Eds.), Honeybees of Asia. Springer, New York. pp.  
416 1-22. DOI 10.1007/978-3-642-16422-4\_1.

417 Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa  
418 Penida, and Sumbawa. Bee World 96: 45-49. <https://doi.org/10.1080/0005772x.2018.1564497>.

419 Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.

420 Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from  
421 *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. Biodiversitas 22: 4687-4693. <https://doi.org/10.13057/biodiv/d221062>.

422 Thrasyvoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. J  
423 Apic Res 57: 88-96. <https://doi.org/10.1080/00218839.2017.1411181>.

424 Tornuk F, Karaman S, Ozturk I, Toker OS, Tastemur B, Sagdic O, Dogan M, Kayacier A. 2013. Quality characterization of artisanal and retail Turkish  
425 blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. Ind Crops Prod 46: 124-131.  
426 <https://doi.org/10.1016/j.indcrop.2012.12.042>.

427 Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. Media Sains Indonesia, Tangerang.

428 Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the  
429 antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. Food Chem 337: 127774.  
430 <https://doi.org/10.1016/j.foodchem.2020.127774>.

431 Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*,  
432 *Apis dorsata* and *Lepidotrigona flavibasis*. LWT - Food Sci Technol 134: 110225. <https://doi.org/10.1016/j.lwt.2020.110225>.

433 Yücel Y, Sultanoglu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food  
434 Biosci 1: 16-25. <https://doi.org/10.1016/j.fbio.2013.02.001>.

435 Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process:  
436 The case of rape honey. Foods 10: 2882. <https://doi.org/10.3390/foods10112882>.



erwan apis &lt;apiserwan@gmail.com&gt;

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**[biodiv] Editor Decision**

2 pesan

**Smujo Editors** <smujo.id@gmail.com>

2 Oktober 2022 pukul 13.21

Kepada: Erwan &lt;apiserwan@gmail.com&gt;, Agussalim &lt;agussalim@mail.ugm.ac.id&gt;

Erwan, Agussalim:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Honey quality from the bee Apis cerana, honey potency produced by coconut and sugar palm saps".

Our decision is: Revisions Required

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[Biodiversitas Journal of Biological Diversity](#)**B-01-SEP-KDW.doc**

1972K

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**erwan apis** <apiserwan@gmail.com>

2 Oktober 2022 pukul 13.33

Kepada: Smujo Editors &lt;smujo.id@gmail.com&gt;

Dear Editor in Chief Biodiversitas

Thanks very much for the information, but we inform you that in the attached file we can not found the comments for our paper because the attached file is the same with the revision file that has been uploaded in the Biodiversitas System. Can you help me explain or send the comments again for our paper ?

[Kutipan teks disembunyikan]

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Best Regards,

Dr. Ir. Erwan, M.Si.

Faculty of Animal Science, University of Mataram, Indonesia



erwan apis &lt;apiserwan@gmail.com&gt;

---

**[biodiv] Editor Decision**

3 pesan

**Ayu Astuti** <smujo.id@gmail.com>

12 November 2022 pukul 07.14

Kepada: ERWAN &lt;apiserwan@gmail.com&gt;, AGUSSALIM &lt;agussalim@mail.ugm.ac.id&gt;

ERWAN, AGUSSALIM:

We have reached a decision regarding your submission to Biodiversitas Journal of Biological Diversity, "Honey quality from the bee Apis cerana, honey potency produced by coconut and sugar palm saps".

Our decision is to: Accept Submission

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[Biodiversitas Journal of Biological Diversity](#)**erwan apis** <apiserwan@gmail.com>

12 November 2022 pukul 19.44

Kepada: Ayu Astuti &lt;smujo.id@gmail.com&gt;

Dear Editor in Chief Biodiversitas

Thanks very much for the information

[Kutipan teks disembunyikan]

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Best Regards,

Dr. Ir. Erwan, M.Si.

Faculty of Animal Science, University of Mataram, Indonesia

**erwan apis** <apiserwan@gmail.com>

12 November 2022 pukul 19.57

Kepada: Ayu Astuti &lt;smujo.id@gmail.com&gt;

Dear Editor in Chief Biodiversitas

We have been check the copyedited in the system and we found some mistake for example in **Universitas Mataram** should be **University of Mataram**, the references not have DOI, so DOI we have been deleted and the references are [Agussalim, Agus A. 2022. Production of honey, pot-pollen and propolis production from Indonesian stingless bee \*Tetragonula laeviceps\* and the physicochemical properties of honey: A review. Livest Res Rural Dev 34 \(8\): 66.](#) [Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, \*Tetragonula laeviceps\*, from different regions. Livest Res Rural Dev 31 \(6\): 91.](#)

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erwan apis &lt;apiserwan@gmail.com&gt;

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**[biodiv] New notification from Biodiversitas Journal of Biological Diversity**

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**DEWI NUR PRATIWI** <smujo.id@gmail.com>  
Balas Ke: Ahmad Dwi Setyawan <editors@smujo.id>  
Kepada: Erwan <apiserwan@gmail.com>

9 November 2022 pukul 16.11

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You have been added to a discussion titled "Uncorrected Proof" regarding the submission "Honey quality from the bee Apis cerana, honey potency produced by coconut and sugar palm saps".

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Ahmad Dwi Setyawan

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**erwan apis** <apiserwan@gmail.com>  
Kepada: Ahmad Dwi Setyawan <editors@smujo.id>

9 November 2022 pukul 16.24

Dear Editor In Chief Biodiversitas

Thanks very much for the information and we will check and revise if any correction

[Kutipan teks disembunyikan]

--

Best Regards,

Dr. Ir. Erwan, M.Si.  
Faculty of Animal Science, University of Mataram, Indonesia

---

**erwan apis** <apiserwan@gmail.com>  
Kepada: Ahmad Dwi Setyawan <editors@smujo.id>

10 November 2022 pukul 18.21

Dear Editor in Chief Biodiversitas

We have been making corrections for our paper and the green color as the mark of correct revision.  
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[Kutipan teks disembunyikan]



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**erwan apis** <apiserwan@gmail.com>  
Kepada: Ahmad Dwi Setyawan <editors@smujo.id>

16 November 2022 pukul 13.05

Dear Editor in Chief Biodiversitas

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# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,✉</sup>, AGUS SALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram. Jl. Majapahit No. 62, Mataram 83125, West Nusa Tenggara, Indonesia. Tel.: +62-370-633603, Fax.: +62-370-640592, ✉email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada. Jl. Fauna 3, Bulaksumur, Sleman 55281, Yogyakarta, Indonesia

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**Abstract.** Erwan, Agussalim. 2022. Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps. *Biodiversitas* 23: 5854-5861. One of the big problems when keeping honeybees is the limited sustainable feed, especially in the rainy season. The objectives of this study were to evaluate the honey quality from the bee *Apis cerana* based on the chemical composition and honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* was divided into six treatments consisting of sugar palm sap without sugar palm pollen, coconut sap without sugar palm pollen, coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen, sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* was moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.33 mL NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1542.857 tons/year and 1150 tons/year, respectively. It can be concluded that the quality of *A. cerana* honey, produced by the sugar palm and coconut saps, is acceptable by the Indonesian national and international standards. The sugar palm and coconut saps have big potential as bee feed, especially for the bee *A. cerana*.

**Keywords:** *Apis cerana*, coconut, honey, sugar palm pollen

## INTRODUCTION

The honeybee of *Apis cerana* is one of the bees from the *Apis* genus, which includes the local bee which is spread in some regions in Indonesia, including Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Hepburn and Radloff 2011; Radloff et al. 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by beekeepers using traditional hives (for example, using a coconut log hive) and semi-modern hives (box hives without nest frames) to produce honey. Furthermore, several regions have been practicing the beekeeping of the bee *A. cerana*, has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives or use box hives but is not completed by the honey frame like the beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis. However, their production is lower compared to the bee *A. mellifera* (Schouten et al. 2019; Agussalim and Agus 2022).

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation of feed is a very serious problem that has been faced by beekeepers because they have no area used to plant several plants which are used as the feed source to produce the honeybees' products. Honeybee feeds are

divided into two types, namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral, which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which are collected by using all body parts and then deposited in the corbicula (Agussalim et al. 2017, 2018; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the forager's role as the pollinator agent by transporting pollen from the anther to the pistil so that the pollination process occurs, this process is continuously done by the foragers until their honey stomach is full of nectar and their corbicula has been deposited by the pollen. This pollination impacts the increase of the plant's productivity (Pohorecka et al. 2014; Supeno et al. 2021).

One of the strategies to produce sustainable honey from the bee *A. cerana* is by using sap from the plants such as sugar palm and coconut. Several studies have been conducted by using sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed could enhance the production of honey cells and bee bread cells. However, using sap from coconut and sugar palms can increase the honey and bee bread cells compared to the control group without sap as the feed (multi-floral nectar). Furthermore, Erwan et al. (2022) also reported using sugar palm and coconut saps which are each added with sugar palm pollen, can improve the bee *A.*



*cerana* productivity, such as increasing honey production, brood cell number, and colony weight. In addition, another study showed that the use of extrafloral nectar namely sugar palm (*Arenga pinnata*) and coconut (*Cocos nucifera*) saps as the *A. mellifera* bee feed which is resulting the honey chemical composition (reducing sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian national standard and the international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, studies about the chemical composition of honey from the bee *A. cerana* produced from the sugar palm sap, coconut sap, and their honey potency production from both sap sugar palm and coconut have yet to be studied. Therefore, the objectives of this study were to evaluate the honey quality based on the chemical composition of the bee *A. cerana* honey potency produced by the coconut and sugar palm saps.

## MATERIALS AND METHODS

### Study area

This research has been conducted in the North Duman Village (8°32'10" S 116°09'32" E), Lingsar Sub-district, West Lombok, West Nusa Tenggara Province, Indonesia. In this research, we used thirty *A. cerana* colonies divided

into six treatments and every five colonies per treatment as the replication. The saps used in our study were obtained from the stalk of coconut (*Cocos nucifera*) and sugar palm (*Arenga pinnata*) and the pollen source from the sugar palm (Figure 1). The stalks of coconut and sugar palm were cut and then put in a plastic bottle which was used to store the sap secreted by their stalks. The treatments in our study were sugar palm sap without added by sugar palm pollen (SP0), coconut sap without added sugar palm pollen (CP0), coconut sap of 50% + sugar palm sap of 50% without added sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added sugar palm pollen (SCP1).

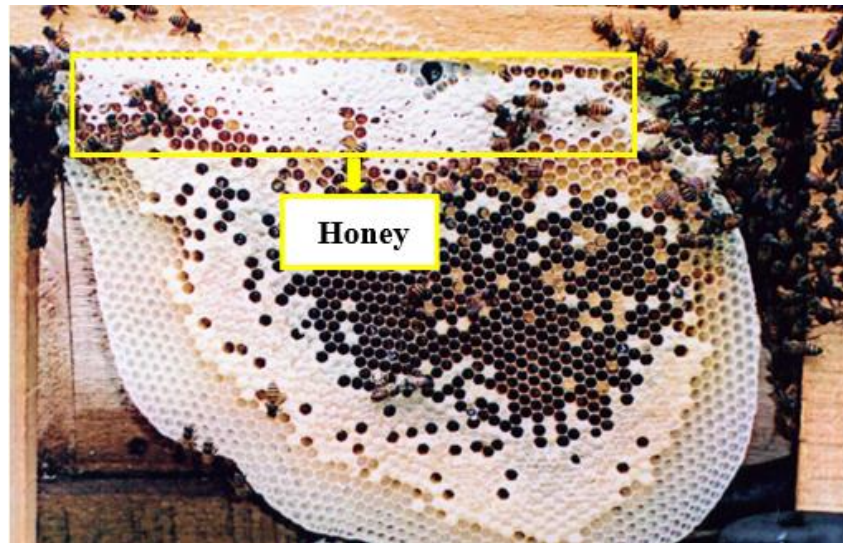
The technique used to give sugar palm and coconut saps and sugar palm pollen (Figure 2) was according to the previous method has been reported by Erwan et al. (2021b, 2022) briefly as follows: fresh coconut and sugar palm saps were given to the bee *A. cerana* by using a plastic plate and split bamboo was completed by 4 to 5 twigs for foragers perch. The plastic plate and split bamboo was placed one meter from the box hives, while the sugar palm pollen was hung beside and above the box hives. The distance of 600 meters to place the colony to avoid the foragers collecting pollen and sap from the other treatments.



**Figure 1.** Coconut sap (*left*), sugar palm sap (*center*), and sugar palm pollen (*right*)



**Figure 2.** Technique to given the sugar palm and coconut saps (*left*) and sugar palm pollen (*right*) (Erwan et al. 2021b, 2022)



**Figure 3.** Honey from *Apis cerana* was produced from the sugar palm and coconut saps

## Procedures

### *Honey quality*

Honey from the *A. cerana* (Figure 3) was harvested after beekeeping for three months using coconut and sugar palm saps. Honey from the five hives in one treatment group was composited into one honey sample and then used to analysis of their chemical composition. Honey quality from the *A. cerana* was evaluated based on the chemical composition consisting of moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and acidity. The moisture content was analyzed by using a proximate analysis based on the method from the Association of Official Agricultural Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed using a Layne-Enyon method and sucrose content was analyzed by a Luff Schoorl method, described by AOAC (2005). Diastase enzyme activity, HMF, and free acidity were analyzed based on the harmonized methods of the international honey commission (Machado et al. 2022).

### *Honey production from sugar palm and coconut saps*

Sugar palm and coconut saps every ten liters were used to measure the honey production from the bee *A. cerana* for three months of beekeeping. The sugar palm and coconut saps were placed on the plastic plate in front of the box hives at a distance of one meter. In addition, the honey production without using sugar palm and coconut saps was measured for one year of beekeeping, which calculates the contribution of sugar palm and coconut saps in honey production. Honey from *A. cerana* was harvested with cut the honey cells (Figure 3) and squeezed to separate wax and honey. Afterward, honey was measured production by using a digital scale and stored in the refrigerator.

### *Production of saps from coconut and sugar palm*

The production of sap from coconut was measured for a year and also based on dept interviews with farmers, while the sugar palm sap based on the previously studied was

used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The production of coconut and sugar palm saps per hectare was calculated from the sap production per tree multiplied by the number of trees in a one-hectare area. After three months of beekeeping, honey from both treatments, sugar palm and coconut saps, were harvested to measure the honey production from the use of ten liters sap, and then honey production was measured by cylinder glass

## Data analysis

The data on honey quality, production potency of honey from sugar palm and coconut saps, honey production, and production of saps were analyzed by using descriptive analysis (Steel et al. 1997).

## RESULTS AND DISCUSSION

### **Moisture content of honey**

Honey is composed of water as the second largest of honey constituents, ranging from 15 to 21g/100 g, depending on the plant species as the nectar source, which is affected by the botanical origin. Furthermore, honey moisture is also affected by honey maturity level, processing postharvest, and storage conditions (Da Silva et al. 2016). The honey moisture affects the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific gravity, and conservation (Escuredo et al. 2013; Da Silva et al. 2016). In addition, honey moisture is also affected by the temperature and humidity depending on the season (rainy and dry seasons). Honey moisture can increase during postharvest processing, such as storage conditions because honey is hygroscopic that can absorb the moisture in the air (Karabagias et al. 2014; Da Silva et al. 2016).

**Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *Apis cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CP1	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

Notes: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1)

A recent study showed that the honey moisture from the bee *A. cerana*, produced by sugar palm and coconut saps and their combination ranged from 20.76 to 21.80% (Table 1). This honey moisture content is accepted by the Indonesian national standard (SNI), where the moisture for beekeeping honey, including the bee *A. cerana* and *A. mellifera*, does not exceed 22% (National Standardization Agency of Indonesia 2018) and is higher compared to the international standard which Codex Alimentarius regulated is not exceeded 20% (Thrasyvoulou et al. 2018). The variation of honey moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm and coconut, however, our study has not been measured. The higher moisture content requires a long time for the ripening of honey, and the bees start the process of decreasing honey moisture when they take nectar from plant flowers or saps as the raw material to produce honey. Furthermore, a small portion of moisture content has been evaporated in the honey sack before being transferred to the other bee, which is working in the hive. This transfer is rapid depending on the temperature, colony strength, and nectar availability (Da Silva et al. 2016).

The honey production process is started with the foragers collecting nectar from the plant flowers or extrafloral nectar and then stored in the honey stomach. After that, the foragers will transfer the nectar that has been collected to the other bees who are working to process the nectar into honey in their mouth, then put it in the honey stomach and then transfer it to other bees several times until honey is ripening. A considerable amount of water will be evaporated in this process, which continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes (Balasubramanyam 2021; Zhang et al. 2021). The honey moisture content in our study differed from Wang et al. (2021), that honey moisture from the bee *A. cerana*, which is collected from 42 different honeycombs from China, ranges from 17.03 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana* from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) also reported that the honey moisture produced by the *A. mellifera* bee by using sugar palm and coconut saps ranges from 19.34 to 20.94%. The different honey moisture content has been reported to be affected by the different geographical origins, impacts

the different plant types that can be grown in each region, different environmental conditions (temperature and humidity), and also different bee species, which impact the different ability to evaporate water in the honey.

### Reducing sugar and sucrose contents of honey

Sugars in honey are composed of monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerobiose, maltotriose, maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

A recent study showed that the honey-reducing sugar from the bee *A. cerana* was beekeeping by using sugar palm and coconut saps, and their combination as the nectar source to produce honey ranges from 62.78 to 68.37% (Table 1). This honey-reducing sugar is acceptable by the SNI for treatments SP0, CP0, CP1, and SCP1 but not acceptable for treatments SCP0, and SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that changes the sap sucrose into simple sugars. It is known that this enzyme is responsible for converting sucrose into glucose and fructose. These sugars are included in the reducing sugar group and the main component in honey. In the honey maturity process, the sucrose is broken down by the invertase enzyme into simple sugars simultaneously, and water will be evaporated to increase the reduced sugar content. In addition, enzymes secreted by the worker bees can also break down the carbohydrate into simple sugars. Furthermore, another enzyme in honey is the diastase enzyme that breaks down starch into simple sugars (Da Silva et al. 2016). The honey-reducing sugar in our study (Table 1) differed from what was reported by Erwan et al. (2020), that honey-reducing sugar from the bee *A. mellifera* which was produced by extrafloral nectar (sugar palm and coconut saps) ranges from 60.15 to 73.69%. The different reducing sugar may be affected by the different bee species, which impacts their ability to evaporate water in honey, especially when they convert the complex sugars

into simple sugars and different seasons when the study is related to temperature and humidity environmental.

The honey sucrose content from the bee *A. cerana* in our study ranges from 1.44 to 3.42% (Table 1) and acceptable by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018) and also accepted by the international standard has been regulated by Codex Alimentarius is not exceed 5% for blossom and honeydew honey (Thrasylvoulou et al. 2018). Naturally, sucrose present in honey in our study originated from sugar palm and coconut saps. The low honey sucrose content in our study is caused by the honey harvested in a mature condition characterized by honey cells that have been covered by wax. Furthermore, the invertase enzyme which is produced by the worker bees actively breaks down sucrose from saps into simple sugars. There are two types of invertase enzymes that are produced by the worker bees, namely glucoinvertase, which converts sucrose into glucose and fructoinvertase, which converts sucrose into fructose. These enzymes are mostly derived from the bee's secretion and only a small portion from the nectar, while the honeydew from the insect's secretion mostly contains invertase enzymes (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) differed from Erwan et al. (2020), that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) ranging from 4.21 to 4.40%.

The honey sucrose content is a very important parameter to evaluate the maturity of honey to identify manipulation, where the high levels may indicate adulterations by adding several sweeteners such as cane sugar or refined beet sugar. In addition, indicating the early harvest, where sucrose is not completely transformed into fructose and glucose, the bees feed artificially for a prolonged time using a sucrose syrup (Escuredo et al. 2013; Puscas et al. 2013; Tornuk et al. 2013; Da Silva et al. 2016). Honey is a sugar solution that is supersaturated and unstable, so it's easy to crystallize. The honey crystallization is affected by the concentration of glucose, fructose, and water. Fructose is the dominant sugar present in honey from *A. mellifera* was produced by several plants as the nectar source that workers use to produce honey, such as eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey was produced by *Brassica napus*. Rape honey is higher in glucose and lowers in fructose which impacts its rapid crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins, which impacts the different plant types that can grow in each region and impacts the different sugars content from the nectar, which is produced by the nectary gland of plant flowers (Tornuk et al. 2013; Escuredo et al. 2014; Da Silva et al. 2016; Agussalim et al. 2019; Agus et al. 2021). Furthermore, the sugar content in honey is influenced by climate (season, temperature, and humidity), processing (heating process), and storage time (Tornuk et al. 2013; Escuredo et al. 2014; Da Silva et al. 2016).

### Diastase enzyme activity and hydroxymethylfurfural (HMF) of honey

A recent study showed that the diastase enzyme activity from the bee *A. cerana* honey produced by the sugar palm and coconut saps ranges from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with a minimum of 3 DN for beekeeping honey, including the bee *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018), and also acceptable by the international standard has been regulated by Codex Alimentarius with the minimum 3 DN (Thrasylvoulou et al. 2018). One of the honey characteristics is that it contains enzymes originating from the bees, pollen, and nectar from plant flowers, but mostly enzymes are added by the bees when they convert nectar into honey (Da Silva et al. 2016; Thrasylvoulou et al. 2018). The honey diastase enzyme activity in our study (Table 2) differed from what was reported by Erwan et al. (2020) that the diastase enzyme activity of honey from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

Diastases are divided into  $\alpha$ - and  $\beta$ -amylases, the natural enzymes present in honey. The  $\alpha$ -amylase separates the starch chain randomly in the center to produce dextrin, while the  $\beta$ -amylase separates the maltose in the end chain. The nectar source influences diastase enzyme content in honey (floral and extrafloral nectars) to produce honey and honey geographical origins, which impacts the different chemical compositions of the nectar that can be produced by the plants, which impacts the honey chemical composition, especially diastase enzyme activity. In addition, the bee species are also influencing the activity diastase because it's related to the distance and the flowers plant numbers that can be visited by the foragers when they are collecting nectar and pollen used to produce honey and bee bread (Da Silva et al. 2016).

Generally, the diastase enzyme has the role of breaking down complex sugars into simple sugars. In addition, this enzyme is a role in digesting starch into maltose (disaccharide) and maltotriose (trisaccharide), which are sensitive to heat or thermolabile. Thus, this condition can be used to evaluate the overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore, diastase activity is also used to evaluate honey age-related to storage time and temperature because the diastase activity may be reduced when heating above 60°C and longtime storage (Yücel and Sultanoğlu 2013; Da Silva et al. 2016). The honey diastase activity from the bee *A. cerana* in our study (Table 2) differed from Wu et al. (2020) for multifloral honey produced by the *A. cerana* cerana from the Hainan province (China) was 6.70 Göthe. Furthermore, it also differed from Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling Mountains (China) ranged from 22.05 to 35.67 Göthe. The different diastase activities of honey from *A. cerana* were reported by previous researchers and are influenced by the different plant types as the nectar source to produce honey, different sugar content, and different geographical origin.

Furthermore, the HMF of *A. cerana* honey produced by the sugar palm and coconut saps in our study ranges from

2.24 to 5.81 mg/kg (Table 2). This HMF indicates that honey from our study in fresh condition and acceptable by SNI for beekeeping honey, including from *A. cerana* and *A. mellifera*, does not exceed 40 mg/kg (National Standardization Agency of Indonesia 2018) and is also acceptable by the international standard regulated by Codex Alimentarius is not to exceed 40 mg/kg for blossom and honeydew honey (Thrasyvoulou et al. 2018). After harvesting, fresh honey generally contains a low HMF ranging from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is the result of the degradation of honey monosaccharides, especially fructose and glucose, under acid conditions and accelerated by heating. This reaction produces levulinic and formic acids (Da Silva et al. 2016).

Hydroxymethylfurfural is formed after the honey is removed from the comb or when the wax cover is opened and the advanced processing like heating process. The increase of the HMF content occurs in honey with acidity and is accelerated by the heating process. However, the HMF content is also influenced by sugar content, organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF can also be formed at low temperatures, acidic conditions, and sugar dehydration reactions. Therefore, the higher HMF content's impact on the honey color is darker (Tornuk et al. 2013; Da Silva et al. 2016). The HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* reported by previous researchers are influenced by the different plant types as the nectar source to produce honey, different sugar content, and different geographical origin.

### Acidity of honey

Free acidity is one of the important parameters to evaluate honey deterioration which is characterized by the presence of the organic acids in equilibrium with internal esters, lactone, and several inorganic ions such as sulfates, chlorides, and phosphates (Da Silva et al. 2016). This study showed that the honey acidity from *A. cerana* produced by the sugar palm and coconut saps ranges from 26.00 to 36.33 mL NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is acceptable by SNI not to exceed 50

mL NaOH/kg for the beekeeping honey, including *A. cerana* and *A. mellifera*. Furthermore, it is also acceptable by the international standard has been regulated by the Codex Alimentarius is not to exceed 50 meq/kg for blossom and honeydew honey (Thrasyvoulou et al. 2018).

The sour taste of honey originated from several organic and inorganic acids, where the dominant organic acid present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase, which is added by the bees when they convert nectar into honey so that it can protect the nectar until honey maturity. This protection mechanism is caused by inhibiting of microorganisms' activity in honey (Da Silva et al. 2016). This inhibit mechanism includes the combination of several factors, such as low moisture and the presence of hydrogen peroxide, which is produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of the cell wall resulting in a change in cytoplasmic membrane permeability (Pasiyas et al. 2018; Nainu et al. 2021).

The total acidity content in honey is a small quantity. Still, the presence of honey is very important because it can influence the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity indicates the fermentation process occurs when some reducing sugar is broken down into acetic acid. Honey acidity content is related to the yeast number where they break down some reducing sugar into ethanol, and if the reaction with the oxygen is formed, the acetic acid which is increasing the honey acidity. Therefore, the higher acidity values may indicate the sugars fermentation process into organic acids. Honey acidity is affected by several factors, such as different content of organic acids, different geographical origins, and the season when honey is harvested (Tornuk et al. 2013; Da Silva et al. 2016). The honey acidity from the bee *A. cerana* in our study (Table 2) differed from previous studied by Wu et al. (2020) for *A. cerana cerana* honey is 0.80 mol/kg, and Guerzou et al. (2021) ranges from 11 to 47 meq/kg for Algerian honey. Furthermore, it differed from Erwan et al. (2020) that honey acidity from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) ranging from 22.00 to 43.00 mL NaOH/kg. The different acidity reported previously with our study is affected by the different plant types as the nectar source to produce honey, honey pH, geographical origin, and organic acids compound; however, our study has not measured the organic acid compound and honey pH.

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *Apis cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (mL NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CPI	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

Notes: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CPI); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1)

### Honey production potency from the sugar palm and coconut saps

Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized, contributing to communities' income. Generally, the main product from the coconut (*Cocos nucifera*) was harvested as coconut fruit to advance the process into coconut oil and copra. These commodities have a high price but producing coconut oil and copra are high risk for the farmers because they are just preparing raw materials. Therefore, the utilizing of the sap can be produced by the coconut and sugar palm was also potency feed for the bees was used as the nectar source to produce honey. Sugar palm and coconut saps are the feed potential studied by Erwan et al. (2021b) that the coconut and sugar palm saps can increase the number of honey and bee bread cells of the bee *A. cerana*. Furthermore, it is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*, such as increasing the number of brood cells number, colony weight, and honey production (Erwan et al. 2022). In addition, the saps from coconut and sugar palms are usually used by farmers to produce sugar using a traditional process.

The coconut plants can produce 12 stalks in a year, and one stalk can produce sap of 90 liters. Thus, one coconut plant can produce 1080 liters of sap. Furthermore, if the farmers have one hectare of land planted by 100 coconut plants (distance 10×10 m), so they can produce about 108,000 liters of coconut sap. To produce 1 kg of honey requires coconut sap for about 7 liters and in a year, 84 liters are required to produce 12 kg of honey. Thus, honey potency in a year from 100 hectares of land can be calculated as follows: 10,800,000 liters of sap divided by 84 liters of sap and multiplied by 12 kg of honey and obtained 1,542,857,14 kg/year (1542.857 tons/year) or equivalent with 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

Sugar palm plants can be tapped to collect sap for about 5 to 6 months in one stalk but generally can be tapped not to exceed 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant ranges from 8 to 22 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1500 liters/plant/year (average is 1150 liters/plant/year). Furthermore, if in one hectare of the plantation we have 100 sugar palm plants, the distance for planting is 10×10 m, so can be obtained of sap for 115,000 liters.

The field investigation showed that producing 1 kg of honey from the sugar palm sap required about 10 liters and, in a year, it required about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm sap in a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and multiplied by 12 kg, so obtained 1,150,000 kg of honey per year (1150 tons of honey) or equivalent with 95.833

tons/month in 100 hectares area. This potency indicates that the sugar palm sap has a big potency to produce honey which is supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. Therefore, it can be concluded that honey is produced by the bee *A. cerana* from sugar palm and coconut saps as the feed have at a quality that is acceptable by Indonesian national standards, and the international standard has been regulated by the Codex Alimentarius. Honey potency production from the coconut sap in 100 hectares area can produce honey of 1542.857 tons/year or equivalent with 128.571 tons/month, while sugar palm can produce honey of 1150 tons/year or equivalent with 95.833 tons/month.

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### REFERENCES

- Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas 22: 5205-5210. DOI: 10.13057/biodiv/d221159.
- Agussalim, Agus A. 2022. Production of honey, pot-pollen and propolis production from Indonesian stingless bee *Tetragonula laeviceps* and the physicochemical properties of honey: A review. Livest Res Rural Dev 34 (8): 66.
- Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*, from different regions. Livest Res Rural Dev 31 (6): 91.
- Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglihar Gunungkidul Yogyakarta. Bull Anim Sci 42 (1): 50-56. DOI: 10.21059/buletinpeternak.v42i1.28294.
- Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bull Anim Sci 41 (4): 448-460. DOI: 10.21059/buletinpeternak.v41i4.13593.
- AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin Franklin Station, Washington DC.
- Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis cerana indica*. Intl J Biol Innov 3: 271-277. DOI: 10.46505/ijbi.2021.3204.
- Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323. DOI: 10.1016/j.foodchem.2015.09.051.
- Department of Agricultural and Plantations. 2021. Rekapitulasi Produksi, Luas Panen, dan Produktivitas Aren Provinsi NTB. Dinas Pertanian dan Perkebunan Provinsi NTB, Mataram. [Indonesian]
- Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci Educ 1: 1-7. DOI: 10.29303/jossed.v1i1.482.
- Erwan, Franti LD, Purnamasari DK, Muhsinin M, Agussalim A. 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from *Apis cerana* from different regions in North Lombok Regency, Indonesia. J Trop Anim Prod 22: 35-41. DOI: 10.21776/ub.jtapro.2021.022.01.5.

- Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification. *Livest Res Rural Dev* 33: 121.
- Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia. *Livest Res Rural Dev* 34: 25.
- Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization phenomenon. *Food Chem* 149: 84-90. DOI: 10.1016/j.foodchem.2013.10.097.
- Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic area. *Food Chem* 138: 851-856. DOI: 10.1016/j.foodchem.2012.11.015.
- Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of physicochemical properties of Alergian honey. *Resources* 10: 94. DOI: 10.3390/resources1010094.
- Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (eds). *Honeybees of Asia*. Springer, New York.
- Karabagias IK, Badeka A, Kontakos S, Karaboumioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to their geographical origin based on volatiles, physicochemical parameters and chemometrics. *Food Chem* 146: 548-557. DOI: 10.1016/j.foodchem.2013.09.105.
- Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça MM, Cristina FA. 2022. Quality assessment of Portuguese monofloral honeys: Physicochemical parameters as tools in botanical source differentiation. *Food Res Intl* 157: 111362. DOI: 10.1016/j.foodres.2022.111362.
- Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*, *Apis dorsata* and *Apis mellifera*. *BMC Complement Altern Med* 13: 43. DOI: 10.1186/1472-6882-13-43.
- Nainu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special focus on anticancer, antibacterial, antiviral, and antiparasitic properties. *Antibiotics* 10: 822. DOI: 10.3390/antibiotics10070822.
- National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta. [Indonesia]
- Pasias IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and quality parameters. *Food Chem* 242: 513-518. DOI: 10.1016/j.foodchem.2017.09.083.
- Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the epidemiological situation in apiaries varying in the level of colony losses. *J Apic Sci* 58: 107-132. DOI: 10.2478/JAS-2014-0027.
- Puscas A, Hosu A, Cimpoiu C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control honey adulteration. *J Chromatogr A* 1272: 132-135. DOI: 10.1016/j.chroma.2012.11.064.
- Radloff SE, Hepburn HR, Engel MS. 2011. The Asian species of *Apis*. In: Hepburn HR, Radloff SE (eds). *Honeybees of Asia*. Springer, New York.
- Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa Penida, and Sumbawa. *Bee World* 96: 45-49. DOI: 10.1080/00057772x.2018.1564497.
- Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.
- Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. *Biodiversitas* 22: 4687-4693. DOI: 10.13057/biodiv/d221062.
- Thrasivoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolis V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. *J Apic Res* 57: 88-96. DOI: 10.1080/00218839.2017.1411181.
- Tornuk F, Karaman S, Ozturk I, Tokar OS, Tastemur B, Sagdic O, Dogan M, Kayacier A. 2013. Quality characterization of artisanal and retail Turkish blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. *Ind Crops Prod* 46: 124-131. DOI: 10.1016/j.indcrop.2012.12.042.
- Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. *Media Sains Indonesia*, Tangerang.
- Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. *Food Chem* 337: 127774. DOI: 10.1016/j.foodchem.2020.127774.
- Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*, *Apis dorsata* and *Lepidotrigona flavibasis*. *LWT - Food Sci Technol* 134: 110225. DOI: 10.1016/j.lwt.2020.110225.
- Yücel Y, Sultanoğlu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. *Food Biosci* 1: 16-25. DOI: 10.1016/j.fbio.2013.02.001.
- Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process: The case of rape honey. *Foods* 10: 2882. DOI: 10.3390/foods10112882.

# Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN<sup>1,\*</sup>, AGUSSALIM<sup>2</sup>

<sup>1</sup>Faculty of Animal Science, University of Mataram, Jl. Majapahit No. 62, Mataram-83125, Indonesia.  
Tel./fax. +62370-633603/+62370-640592, \*email: apiserwan@gmail.com

<sup>2</sup>Faculty of Animal Science, Universitas Gadjah Mada, Jl. Fauna 3, Bulaksumur, Yogyakarta-55281, Indonesia

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**Abstract.** Erwan, Agussalim. 2022. Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps. *Biodiversitas* 23: xxxx. One of the big problems when keeping honeybees is the limited of sustainable feed, especially in the rainy season. The objectives of this study were to evaluate the honey quality from the bee *A. cerana* based on the chemical composition, and honey potency produced by the coconut and sugar palm saps. This study using thirty colonies of the bee *A. cerana* was divided into six treatments consisting of sugar palm sap without sugar palm pollen; coconut sap without sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% without sugar palm pollen; sugar palm sap was added by sugar palm pollen; coconut sap was added by sugar palm pollen; coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen. The chemical composition of honey from the *A. cerana* were moisture (20.76 to 21.80%), reducing sugar (62.78 to 68.37%), sucrose (1.44 to 3.42%), diastase enzyme activity (5.17 to 9.04 DN), hydroxymethylfurfural (2.24 to 5.81 mg/kg), and acidity (26.00 to 36.33 ml NaOH/kg). Honey potency produced by the coconut and sugar palm saps in 100 hectares area produces honey was 1,542.857 tons/year and 1,150 tons/year, respectively. It can be concluded that the quality of *A. cerana* honey, produced by the sugar palm and coconut saps, is acceptable by the Indonesian national and international standards. The sugar palm and coconut saps have a big potential as the bee feed especially for the bee *A. cerana*.

**Keywords:** *Arenga pinnata*, beekeeping, *Cocos nucifera* L., extrafloral nectar, multifloral nectar

## INTRODUCTION

The honeybee of *A. cerana* is one of the bees from the *Apis* genus which includes the local bee which is spread in some regions in Indonesia, including Kalimantan, Sumatera, Java, Bali, Lombok, Sumbawa, Sulawesi, Papua, and Seram (Radloff et al. 2011; Hepburn and Radloff 2011). In Indonesia, beekeeping of the bee *A. cerana* has been practiced by beekeepers using traditional hives (for example using a coconut log hive) and semi-modern hives (box hives without nest frames) to produce honey. Furthermore, several regions have been practicing the beekeeping of the bee *A. cerana* has been reported by Schouten et al. (2019) are Riau, North Sumatera, Lampung, Banten, Java, Yogyakarta region, Bali, and Lombok. However, the beekeeping of *A. cerana* is mostly using traditional hives or use box hives but is not completed by the honey frame like the beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis. However, their production is lower compared to the bee *A. mellifera* (Agussalim and Agus 2022; Schouten et al. 2019).

One of the problems faced by the beekeepers in Indonesia is the limited of feed sustainability as the raw material to produce honey, bee bread, and royal jelly. The limitation feed is a very serious problem that has been faced by beekeepers because they have no area used to plant several plants which are used as the feed source to produce the honeybees' products. Honeybee feeds are

divided into two types, namely nectar and pollen, where nectar is obtained by the foragers from the plant flowers (nectar floral) and nectar extrafloral, which is obtained by the foragers from stalk and leaf of plants (Agussalim et al. 2018, 2017). Pollen is obtained by the foragers from plant flowers which is collected by using all body parts and then deposited in the corbicula (Agussalim et al. 2018, 2017; Erwan et al. 2021a). When collecting nectar and pollen from the plant flowers, the foragers role as the pollinator agent by transporting pollen from the anther to pistil so that the pollination process occurs. This process is continuously done by the foragers until their honey stomach is full of nectar and their corbicula has been deposited by the pollen. This pollination impacts on the increasing the plants productivity (Pohorecka et al. 2014; Supeno et al. 2021).

One of the strategies to produce sustainable honey from the bee *A. cerana* is by using sap from the plants such as sugar palm and coconut. Several studies have been conducted by using sugar palm and coconut saps as the *A. cerana* feed. Erwan et al. (2021b) reported that the feed combination of coconut sap and sugar palm pollen as the *A. cerana* feed could enhance the production of honey cells and bee bread cells. However, the use of sap from coconut and sugar palm can increase the honey and bee bread cells compared to the control group without sap as the feed (multi-floral nectar). Furthermore, Erwan et al. (2022) also reported using sugar palm and coconut saps which are each added with sugar palm pollen can improve the bee *A. cerana* productivity, such as increasing honey production,



brood cell number, and colony weight. In addition, another study showed that the use of extrafloral nectar namely sugar palm (*Arenga pinnata*) and coconut (*Cocos nucifera* L.) saps as the *A. mellifera* bee feed which is resulting the honey chemical composition (reducing sugar, sucrose, acidity, moisture, and diastase enzyme activity) which are acceptable by Indonesian national standard and the international standard has been regulated by Codex Alimentarius (Erwan et al. 2020). However, studies about the chemical composition of honey from the bee *A. cerana* produced from the sugar palm sap, coconut sap, and their honey potency production from both sap sugar palm and coconut have yet to be studied. Therefore, the objectives of this study were to evaluate the honey quality based on the chemical composition of the bee *A. cerana*, honey potency produced by the coconut and sugar palm saps.

## MATERIALS AND METHODS

### Study area

This research has been conducted in the North Duman Village (8°32'10" S 116°09'32" E), Lingsar Sub-district, West Lombok (West Nusa Tenggara Province, Indonesia). In this research, we used thirty *A. cerana* colonies were divided into six treatments and every five colonies per treatment as the replication. The saps used in our study

were obtained from the stalk of coconut (*Cocos nucifera* L.) and sugar palm (*Arenga pinnata*) and the pollen source from the sugar palm (Figure 1). The stalks of coconut and sugar palm were cut and then put in a plastic bottle which was used to store the sap secreted by their stalks. The treatments in our study were sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CP1); coconut sap of 50% + sugar palm sap of 50% was added sugar palm pollen (SCP1).

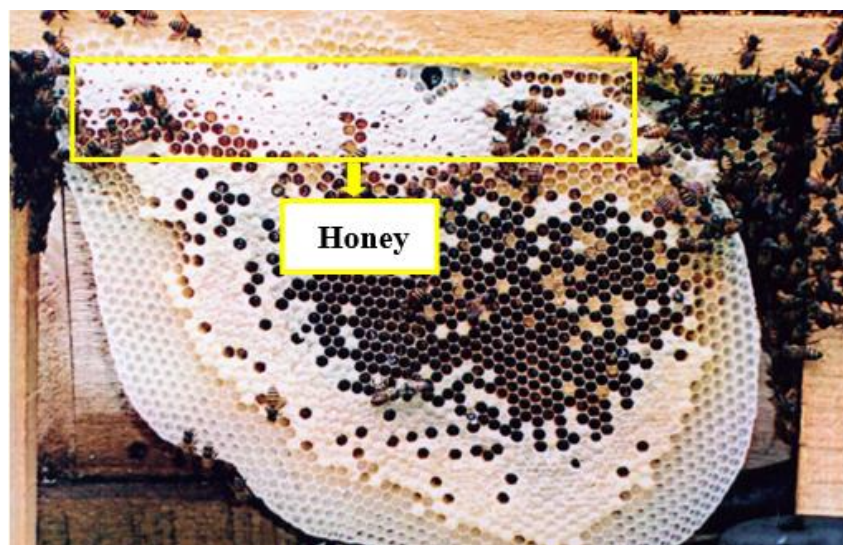
The technique was used to give sugar palm and coconut saps and sugar palm pollen (Figure 2) was according to the previous method has been reported by Erwan et al. (2022, 2021b) briefly as follows: fresh coconut and sugar palm saps were given to the bee *A. cerana* by using a plastic plate and split bamboo was completed by 4 to 5 twigs for foragers perch. The plastic plate and split bamboo was placed one meter from the box hives, while the sugar palm pollen was hung besides and above of the box hives. The distance of 600 meters to place the colony to avoid the foragers collecting pollen and sap from the other treatments.



**Figure 1.** Coconut sap (left), sugar palm sap (center), and sugar palm pollen (right)



**Figure 2.** Technique to given the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)



**Figure 3.** Honey from *A. cerana* was produced from the sugar palm and coconut saps

## Procedures

### Honey quality

Honey from the *A. cerana* (Figure 3) was harvested after beekeeping for three months using coconut and sugar palm saps. Honey from the five hives in one treatment group was composited into one honey sample and then used to analysis of their chemical composition. Honey quality from the *A. cerana* was evaluated based on the chemical composition consisting of moisture, reducing sugar, sucrose, diastase enzyme activity, hydroxymethylfurfural (HMF), and acidity. The moisture content was analyzed by using a proximate analysis based on the method from the Association of Official Agricultural Chemists (AOAC) (AOAC 2005). Reducing sugar was analyzed using a Layne-Enyon method and sucrose content was analyzed by a Luff Schoorl method, described by AOAC (2005). Diastase enzyme activity, HMF, and free acidity were analyzed based on the harmonized methods of the international honey commission (Machado et al. 2022).

### Honey production from sugar palm and coconut saps

Sugar palm and coconut saps every ten liters were used to measure the honey production from the bee *A. cerana* for three months of beekeeping. The sugar palm and coconut saps were placed on the plastic plate in front of the box hives at a distance of one meter. In addition, the honey production without using sugar palm and coconut saps was measured for one year of the beekeeping, which calculates the contribution of sugar palm and coconut saps in honey production. Honey from *A. cerana* was harvested with cut the honey cells (Figure 3) and squeezed to separate wax and honey. Afterward, honey was measured production by using a digital scale and stored in the refrigerator.

### Production of saps from coconut and sugar palm

The production of sap from coconut was measured for a year and also based on dept interview with farmers, while the sugar palm sap based on the previously studied was

used to calculate the production per hectare area and was also obtained from the deep interview with the farmers. The production of coconut and sugar palm saps per hectare was calculated from the sap production per tree multiplied by the number of trees in a one hectare area. After three months of beekeeping, honey from both treatments sugar palm and coconut saps were harvested to measure the honey production from the use of ten liters sap, and then honey production was measured by cylinder glass

## Data analysis

The data on honey quality, production potency of honey from sugar palm and coconut saps, honey production, and production of saps were analyzed by using descriptive analysis (Steel et al. 1997).

## RESULTS AND DISCUSSION

### Moisture content of honey

Honey is composed of water as the second largest of honey constituents, ranging from 15 to 21 g/100 g, depending on the plant species as the nectar source which is affected by the botanical origin. Furthermore, honey moisture is also affected by honey maturity level, processing postharvest, and storage conditions (Da Silva et al. 2016). The honey moisture affects the physical properties such as crystallization, viscosity, flavor, color, taste, solubility, specific gravity, and conservation (Da Silva et al. 2016; Escuredo et al. 2013). In addition, honey moisture is also affected by the temperature and humidity depending on the season (rainy and dry seasons). Honey moisture can increase during postharvest processing such as storage conditions, because honey is hygroscopic that can absorb the moisture in the air (Da Silva et al. 2016; Karabagias et al. 2014).

**Table 1.** The moisture, reducing sugar, and sucrose contents of honey from the bee *A. cerana*

Treatments	Moisture (%)	Reducing sugar (%)	Sucrose (%)
SP0	21.60	65.24	2.86
CP0	20.76	68.37	1.96
SCP0	21.40	64.55	2.51
SP1	21.80	62.78	3.42
CPI	21.58	65.37	1.72
SCP1	20.98	67.33	1.44

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CPI); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

A recent study showed that the honey moisture from the bee *A. cerana*, produced by sugar palm and coconut saps and their combination was ranging from 20.76 to 21.80% (Table 1). This honey moisture content is accepted by the Indonesian national standard (SNI), where the moisture for beekeeping honey, including the bee *A. cerana* and *A. mellifera*, does not exceed 22% (National Standardization Agency of Indonesia 2018) and is higher compared to the international standard which Codex Alimentarius regulated is not exceed 20% (Thrasylvoulou et al. 2018). The variation of honey moisture of the bee *A. cerana* in our study may be caused by the different moisture content of both saps from sugar palm and coconut, however our study has not been measured. The higher moisture content requires a long time for ripening of honey, and the bees start the process of decreasing honey moisture when they take nectar from plant flowers or saps as the raw material to produce honey. Furthermore, a small portion of moisture content has been evaporated in the honey sack before being transferred to the other bee which is working in the hive. This transfer is rapid depending on the temperature, colony strength, and nectar availability (Da Silva et al. 2016).

The honey production process is started with the foragers collecting nectar from the plant flowers or extrafloral nectar and then stored in the honey stomach. After that, the foragers will transfer the nectar that has been collected to the other bees who are working to process the nectar into honey in their mouth, then put it in the honey stomach and then transfer it to other bees several times until honey is ripening. A considerable amount of water will be evaporated in this process, which continues with the help of wing fans that can regulate the air humidity for about 15 to 20 minutes (Balasubramanyam 2021; Zhang et al. 2021). The honey moisture content in our study differed from Wang et al. (2021) that honey moisture from the bee *A. cerana* which is collected from 42 different honeycombs from China ranges from 17.03 to 18.44%, 18.65% for *A. cerana cerana* from Hainan province, China (Wu et al. 2020), and 16.99% for *A. cerana* from Borneo (Malaysian honey) (Moniruzzaman et al. 2013). Furthermore, Erwan et al. (2020) also reported that the honey moisture produced by the *A. mellifera* bee by using sugar palm and coconut saps ranges from 19.34 to 20.94%. The different honey moisture content has been reported to be affected by the different geographical origins, impacts the different plant types that can be grown in each region, different

environmental conditions (temperature and humidity), and also different bee species, which impact the different ability to evaporate water in the honey.

### Reducing sugar and sucrose contents of honey

Sugars in honey are composed of monosaccharides for about 75%, disaccharides are 10 to 15%, and other sugars in small amounts. Honey sugars are responsible as the energy source, hygroscopic, viscosity, and granulation. Several sugars in honey have been reported such as glucose, fructose, sucrose, trehalose, rhamnose, isomaltose, nigerobiose, maltotriose, maltotetraose, melezitose, melibiose, maltulose, nigerose, raffinose, palatinose, erlose and others (Da Silva et al. 2016).

A recent study showed that the honey reducing sugar from the bee *A. cerana* was beekeeping by using sugar palm and coconut saps, and their combination as the nectar source to produce honey ranges from 62.78 to 68.37% (Table 1). This honey reducing sugar is acceptable by the SNI for treatments SP0, CP0, CPI, and SCP1 but not acceptable for treatments SCP0, and SP1 (Table 1), where the minimum reducing sugar is 65% (National Standardization Agency of Indonesia 2018). This sugar is produced by the mechanism of invertase enzyme activity that change the sap sucrose into simple sugars. It is known that this enzyme is responsible for converting of sucrose into glucose and fructose. These sugars are included in the reducing sugar group and the main component in honey. In the honey maturity process, the sucrose is break down by the invertase enzyme into simple sugars simultaneously, and water will be evaporated to increase the reduced sugar content. In addition, enzymes secreted by the worker bees can also break down the carbohydrate into simple sugars. Furthermore, another enzyme in honey is the diastase enzyme that breaks down starch into simple sugars (Da Silva et al. 2016). The honey reducing sugar in our study (Table 1) differed from what was reported by Erwan et al. (2020), that honey reducing sugar from the bee *A. mellifera* which was produced by extrafloral nectar (sugar palm and coconut saps) ranges from 60.15 to 73.69%. The different reducing sugar may be affected by the different bee species, which impacts their ability to evaporate water in honey, especially when they convert the complex sugars into simple sugars and different seasons when the study is related to temperature and humidity environmental.

The honey sucrose content from the bee *A. cerana* in our study ranges from 1.44 to 3.42% (Table 1) and acceptable by SNI is not exceed 5% for the beekeeping honey including *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018) and also accepted by the International standard has been regulated by Codex Alimentarius is not exceed 5% for blossom and honeydew honey (Thrasylvoulou et al. 2018). Naturally, sucrose present in honey in our study originated from sugar palm and coconut saps. The low honey sucrose content in our study is caused by the honey harvested in mature condition characterized by honey cells that have been covered by wax. Furthermore, the invertase enzyme which is produced by the worker bees actively breaks down sucrose from saps into simple sugars. There are two types of invertase enzymes that are produced by the worker bees, namely glucoinvertase which converts sucrose into glucose and fructoinvertase, which converts sucrose into fructose. These enzymes are mostly derived from the bee's secretion and only a small portion from the nectar, while the honeydew from the insect's secretion mostly contains invertase enzymes (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) differed from Erwan et al. (2020), that honey sucrose content from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 4.21 to 4.40%.

The honey sucrose content is a very important parameter to evaluate the maturity of honey to identify manipulation, where the high levels may indicate adulterations by adding several sweeteners such as cane sugar or refined beet sugar. In addition, indicating the early harvest, where sucrose is not completely transformed into fructose and glucose, the bees feed artificially for a prolonged time using a sucrose syrup (Da Silva et al. 2016; Puscas et al. 2013; Escuredo et al. 2013; Tornuk et al. 2013). Honey is a sugar solution that is supersaturated and unstable so it's easy to crystallize. The honey crystallization is affected by the concentration of glucose, fructose, and water. Fructose is the dominant sugar present in honey from *A. mellifera* was produced by several plants as the nectar source that workers use to produce honey such as eucalyptus, acacia, bramble, lime, chestnut, sunflower, and from honeydew, except in rape honey was produced by *Brassica napus*. Rape honey is higher in glucose and lower in fructose which impacts its rapid crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which impacts on the different plant types that can grow in each region and impacts the different sugars content from the nectar, which is produced by the nectary gland of plant flowers (Agus et al. 2021; Agussalim et al. 2019; Da Silva et al. 2016; Escuredo et al. 2014; Tornuk et al. 2013). Furthermore, the sugar content in honey is influenced by climate (season, temperature, and humidity), processing (heating process), and storage time (Da Silva et al. 2016; Escuredo et al. 2014; Tornuk et al. 2013).

### Diastase enzyme activity and hydroxymethylfurfural (HMF) of honey

A recent study showed that the diastase enzyme activity from the bee *A. cerana* honey produced by the sugar palm and coconut saps ranges from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with a minimum of 3 DN for beekeeping honey including the bee *A. cerana* and *A. mellifera* (National Standardization Agency of Indonesia 2018), and also acceptable by the international standard has been regulated by Codex Alimentarius with the minimum 3 DN (Thrasylvoulou et al. 2018). One of the honey characteristics is that it contains enzymes originating from the bees, pollen, and nectar from plant flowers, but mostly enzymes are added by the bees when they are convert nectar into honey (Da Silva et al. 2016; Thrasylvoulou et al. 2018). The honey diastase enzyme activity in our study (Table 2) differed from what was reported by Erwan et al. (2020) that the diastase enzyme activity of honey from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) is ranging from 16.48 to 17.12 Schade unit.

Diastases are divided into  $\alpha$ - and  $\beta$ -amylases, the natural enzymes present in honey. The  $\alpha$ -amylase separates the starch chain randomly in the center to produce dextrin, while the  $\beta$ -amylase separates the maltose in the end chain. The nectar source influences diastase enzyme content in honey (floral and extrafloral nectars) to produce honey and honey geographical origins, which impacts the different chemical composition of the nectar can be produced by the plants which is impact on the honey chemical composition especially diastase enzyme activity. In addition, the bee species are also influencing the activity diastase because it's related to the distance, and the flowers plant numbers that can be visited by the foragers when they are collecting nectar and pollen used to produce honey and bee bread (Da Silva et al. 2016).

Generally, the diastase enzyme has the role of breaking down complex sugars into simple sugars. In addition, this enzyme is role to digesting starch into maltose (disaccharide) and maltotriose (trisaccharide) which are sensitive to heat or thermolabile. Thus, this condition can be used to evaluate the overheating and preservation degree of honey (Da Silva et al. 2016). Furthermore, diastase activity is also used to evaluate honey age related to storage time and temperature because the diastase activity may be reducing when heating above 60°C and longtime storage (Da Silva et al. 2016; Yücel and Sultanoğlu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed from Wu et al. (2020) for multifloral honey produced by the *A. cerana cerana* from the Hainan province (China) was 6.70 Göthe. Furthermore, it also differed from Wang et al. (2021) that the diastase activity of *A. cerana* honey from Qinling Mountains (China) is ranging from 22.05 to 35.67 Göthe. The different diastase activities of honey from *A. cerana* were reported by previous researchers are influenced by the different plant types as the nectar source to produce honey, different sugar content, and different geographical origin.

Furthermore, the HMF of *A. cerana* honey produced by the sugar palm and coconut saps in our study ranges from

2.24 to 5.81 mg/kg (Table 2). This HMF indicates that honey from our study in fresh condition and acceptable by SNI for beekeeping honey, including from *A. cerana* and *A. mellifera*, not exceed 40 mg/kg (National Standardization Agency of Indonesia 2018) and also acceptable by the international standard regulated by Codex Alimentarius is not to exceed 40 mg/kg for blossom and honeydew honey (Thrasylvoulou et al. 2018). After harvesting, fresh honey generally contains a low HMF ranges from 0 to 4.12 mg/kg honey. Hydroxymethylfurfural is the result of the degradation of honey monosaccharides, especially fructose and glucose, under acid conditions and accelerated by heating. This reaction produce levulinic and formic acids (Da Silva et al. 2016).

**Hydroxymethylfurfural** is formed after the honey is removed from the comb or when the wax cover is opened and the advanced processing like heating process. The increase of the HMF content occurs in honey with the acidity and is accelerated by the heating process. However, the HMF content is also influenced by sugars content, organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In addition, HMF can also be formed at low temperatures, acidic conditions, and sugar dehydration reactions. Therefore, the higher HMF content's impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* reported by previous researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and different geographical origin.

### Acidity of honey

Free acidity is one of the important parameters to evaluate honey deterioration which is characterized by the presence of the organic acids in equilibrium with internal esters, lactone and several inorganic ions such as sulfates, chlorides, and phosphates (Da Silva et al. 2016). This study showed that the honey acidity from *A. cerana* produced by the sugar palm and coconut saps ranges from 26.00 to 36.33 ml NaOH/kg (Table 2). The acidity of *A. cerana* honey in our study is acceptable by SNI not to exceed 50 ml NaOH/kg for the beekeeping honey including *A. cerana*

and *A. mellifera*. Furthermore, it is also acceptable by the international standard has been regulated by the Codex Alimentarius is not to exceed 50 meq/kg for blossom and honeydew honeys (Thrasylvoulou et al. 2018).

The sour taste of honey originated from several organic and inorganic acids, where the dominant organic acid present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase which is added by the bees when they convert nectar into honey, so that it can protect the nectar until honey maturity. This protection mechanism is caused by inhibiting of microorganisms activity in honey (Da Silva et al. 2016). This inhibit mechanism includes the combination of several factors, such as low moisture and the presence of hydrogen peroxide which is produced by the enzyme glucose-oxidase can inhibit the metabolism activity in the microbe cell through the destruction of the cell wall resulting in a change in cytoplasmic membrane permeability (Nainu et al. 2021; Pasiyas et al. 2018).

The total acidity content in honey is a small quantity. Still, the presence in honey is very important because it can influence the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity indicates the fermentation process occurs when some reducing sugar is break down into acetic acid. Honey acidity content is related to the yeast number where they break down some reducing sugar into ethanol, and if the reaction with the oxygen is formed, the acetic acid which is increasing the honey acidity. Therefore, the higher acidity values may indicate the sugars fermentation process into organic acids. Honey acidity is affected by several factors such as different content of organic acids, different geographical origins, and the season when honey is harvested (Da Silva et al. 2016; Tornuk et al. 2013). The honey acidity from the bee *A. cerana* in our study (Table 2) differed from previous studied by Wu et al. (2020) for *A. cerana cerana* honey is 0.80 mol/kg and Guerzou et al. (2021) ranges from 11 to 47 meq/kg for Algerian honey. Furthermore, it is differed from Erwan et al. (2020) that honey acidity from the bee *A. mellifera* was produced by extrafloral nectar (sugar palm and coconut saps) ranges from 22.00 to 43.00 ml NaOH/kg. The different acidity reported previously with our study is affected by the different plant types as the nectar source to produce honey, honey pH, geographical origin, and organic acids compound; however, our study has not measured the organic acid compound and honey pH.

**Table 2.** The diastase enzyme activity, hydroxymethylfurfural, and acidity of honey from the bee *A. cerana*

Treatments	Diastase enzyme activity (DN)	Hydroxymethylfurfural (mg/kg)	Acidity (ml NaOH/kg)
SP0	7.57	5.78	36.33
CP0	5.17	5.04	26.00
SCP0	9.04	4.75	28.60
SP1	6.86	4.77	29.68
CPI	8.51	5.81	28.26
SCP1	6.85	2.24	30.61

Abbreviations: sugar palm sap without added by sugar palm pollen (SP0); coconut sap without added by sugar palm pollen (CP0); coconut sap of 50% + sugar palm sap of 50% without added by sugar palm pollen (SCP0); sugar palm sap was added by sugar palm pollen (SP1); coconut sap was added by sugar palm pollen (CPI); coconut sap of 50% + sugar palm sap of 50% was added by sugar palm pollen (SCP1).

### Honey production potency from the sugar palm and coconut saps

Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized contributing to communities' income. Generally, the main product from the coconut (*Cocos nucifera* L.) was harvested as coconut fruit to advance the process into coconut oil and copra. These commodities have a high price, but producing coconut oil and copra are high risk for the farmers because they are just preparing raw materials. Therefore, the utilizing of the sap can be produced by the coconut and sugar palm was also potency feed for the bees was used as the nectar source to produce honey. Sugar palm and coconut saps are the feed potential studied by Erwan et al. (2021b) that the coconut and sugar palm saps can increase the number of honey and bee bread cells of the bee *A. cerana*. Furthermore, it is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana* such as increasing the brood cells number, colony weight, and honey production (Erwan et al. 2022). In addition, the saps from coconut and sugar palm are usually used by farmers to produce sugar using a traditional process.

The coconut plants can produce 12 stalks in a year, and one stalk can produce sap of 90 liters. Thus, one coconut plant can produce 1,080 liters of sap. Furthermore, if the farmers have one hectare of land planted by 100 coconut plants (distance 10 m × 10 m), so they can produce about 108,000 liters of coconut sap. To produce 1 kg of honey requires coconut sap for about 7 liters and in a year 84 liters are required to produce 12 kg of honey. Thus, honey potency in a year from 100 hectares of land can be calculated as follows: 10,800,000 liters of sap divided by 84 liters of sap and multiplied by 12 kg of honey and obtained 1,542,857,14 kg/year (1,542.857 tons/year) or equivalent with 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

Sugar palm plants can be tapped to collect sap for about 5 to 6 months in one stalk, but generally can be tapped not to exceed 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant ranges from 8 to 22 liters/plant or 300 to 400 liters/season (3 to 4 months) or 800 to 1,500 liters/plant/year (average is 1,150 liters/plant/year). Furthermore, if in one hectare of the plantation we have 100 sugar palm plants, the distance for planting is 10 m × 10 m, so can be obtained of sap for 115,000 liters.

The field investigation showed that producing 1 kg of honey from the sugar palm sap required about 10 liters and in a year, it is required about 120 liters to produce 12 kg of honey. Thus, the honey potency from the sugar palm sap in a year from the 100 hectares of the sugar palm field is 11,500,000 liters which was divided by 120 liters and

multiplied by 12 kg, so is obtained 1,150,000 kg of honey per year (1,150 tons of honey) or equivalent with 95.833 tons/month in 100 hectares area. This potency indicate that the sugar palm sap has a big potency to produce honey which is supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. Therefore, it can be concluded that honey is produced by the bee *A. cerana* from sugar palm and coconut saps as the feed have at quality that is acceptable by Indonesian national standard, and the international standard has been regulated by the Codex Alimentarius. Honey potency production from the coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with 128.571 tons/month, while sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

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### REFERENCES

- Agus A, Agussalim, Sahlan M, Sabir A. 2021. Honey sugars profile of stingless bee *Tetragonula laeviceps* (Hymenoptera: Meliponinae). Biodiversitas 22: 5205-5210. DOI: 10.13057/biodiv/d221159.
- Agussalim, Agus A. 2022. Production of honey, pot-pollen and propolis production from Indonesian stingless bee *Tetragonula laeviceps* and the physicochemical properties of honey: A review. Livest Res Rural Dev 34 (8), Article #66. <http://www.lrrd.org/lrrd34/8/3466alia.html>.
- Agussalim, Agus A, Nurliyani, Umami N. 2019. The sugar content profile of honey produced by the Indonesian Stingless bee, *Tetragonula laeviceps*, from different regions. Livest Res Rural Dev 31(6): Article #91. <http://www.lrrd.org/lrrd31/6/aguss31091.html>.
- Agussalim, Agus A, Umami N, Budisatria IGS. 2018. The type of honeybees forages in district of Pakem Sleman and Nglipar Gunungkidul Yogyakarta. Bul Peternak 42 (1): 50-56. DOI: 10.21059/buletinpeternak.v42i1.28294.
- Agussalim, Agus A, Umami N, Budisatria IGS. 2017. Variation of honeybees forages as source of nectar and pollen based on altitude in Yogyakarta. Bul Peternak 41 (4): 448-460. DOI: 10.21059/buletinpeternak.v41i4.13593.
- AOAC. 2005. Official Method of Association of Official Analytical Chemist. 18<sup>th</sup> Edition. Association of Official Analytical Chemist. Benjamin Franklin Station, Washington D.C.
- Balasubramanyam MV. 2021. Factors influencing the transformation of nectar to honey in *Apis cerana indica*. Intl J Biol Innov 03: 271-277. DOI: 10.46505/ijbi.2021.3204.
- Da Silva PM, Gauche C, Gonzaga LV, Costa ACO, Fett R. 2016. Honey: Chemical composition, stability and authenticity. Food Chem 196: 309-323. DOI: 10.1016/j.foodchem.2015.09.051.
- Department of Agricultural and Plantations. 2021. Rekapitulasi produksi, luas panen, dan produktivitas aren Provinsi NTB. Dinas Pertanian dan Perkebunan Provinsi NTB, Mataram. [Indonesian].
- Erwan E, Harun M, Muhsinin M. 2020. The honey quality of *Apis mellifera* with extrafloral nectar in Lombok West Nusa Tenggara Indonesia. J Sci Sci Educ 1: 1-7. DOI: 10.29303/jossed.v1i1.482.

- Erwan, Franti LD, Purnamasari DK, Muhsinin M, Agussalim A. 2021a. Preliminary study on moisture, fat, and protein contents of bee bread from *Apis cerana* from different regions in North Lombok Regency, Indonesia. *J Trop Anim Prod* 22: 35-41. DOI: 10.21776/ub.jtapro.2021.022.01.5
- Erwan, Muhsinin M, Agussalim. 2021b. Enhancing honey and bee bread cells number from Indonesian honeybee *Apis cerana* by feeding modification. *Livest Res Rural Dev* 33: Article #121. <http://www.lrrd.org/lrrd33/10/33121apist.html>.
- Erwan, Supeno B, Agussalim. 2022. Improving the productivity of local honeybee (*Apis cerana*) by using feeds coconut sap and sugar palm (sap and pollen) in West Lombok, Indonesia. *Livest Res Rural Dev* 34: Article #25. <http://www.lrrd.org/lrrd34/4/3425apis.html>
- Escuredo O, Dobre I, Fernández-González M, Seijo MC. 2014. Contribution of botanical origin and sugar composition of honeys on the crystallization phenomenon. *Food Chem* 149: 84-90. DOI: 10.1016/j.foodchem.2013.11.097.
- Escuredo O, Míguez M, Fernández-González M, Seijo MC. 2013. Nutritional value and antioxidant activity of honeys produced in a European Atlantic area. *Food Chem* 138: 851-856. DOI: 10.1016/j.foodchem.2012.11.015.
- Guerzou M, Aouissi HA, Guerzou A, Burlakovs J, Doumandji S, Krauklis AE. 2021. From the beehives: Identification and comparison of physicochemical properties of Alergian honey. *Resources* 10: 94. DOI: DOI: 10.3390/resources10100094.
- Hepburn HR, Radloff SE. 2011. Biogeography. In: Hepburn HR, Radloff SE (eds). *Honeybees of Asia*. Springer, New York. DOI 10.1007/978-3-642-16422-4\_3.
- Karabagias IK, Badeka A, Kontakos S, Karabourmioti S, Kontominas MG. 2014. Characterisation and classification of Greek pine honeys according to their geographical origin based on volatiles, physicochemical parameters and chemometrics. *Food Chem* 146: 548-557. DOI: 10.1016/j.foodchem.2013.09.105.
- Machado AM, Tomás A, Russo-Almeida P, Duarte A, Antunes M, Vilas-Boas M, Graça Miguel M, Cristina Figueiredo A. 2022. Quality assessment of Portuguese monofloral honeys. Physicochemical parameters as tools in botanical source differentiation. *Food Res Intl* 157: 111362. DOI: 10.1016/j.foodres.2022.111362.
- Moniruzzaman M, Khalil I, Sulaiman SA, Gan SH. 2013. Physicochemical and antioxidant properties of Malaysian honeys produced by *Apis cerana*, *Apis dorsata* and *Apis mellifera*. *BMC Complement Altern Med* 13: 43.
- Nainu F, Masyita A, Bahar MA, Raihan M, Prova SR, Mitra S, Emran TB, Simal-Gandara J. 2021. Pharmaceutical prospects of bee products: Special focus on anticancer, antibacterial, antiviral, and antiparasitic properties. *Antibiotics* 10: 822. DOI: 10.3390/antibiotics10070822.
- National Standardization Agency of Indonesia. 2018. Indonesian National Standard for Honey. Badan Standarisasi Nasional, Jakarta.
- Pasias IN, Kiriakou IK, Kaitatzis A, Koutelidakis AE, Proestos C. 2018. Effect of late harvest and floral origin on honey antibacterial properties and quality parameters. *Food Chem* 242: 513-518. DOI: 10.1016/j.foodchem.2017.09.083.
- Pohorecka K, Bober A, Skubida M, Zdańska D, Torój K. 2014. A comparative study of environmental conditions, bee management and the epidemiological situation in apiaries varying in the level of colony losses. *J Apic Sci* 58: 107-132. DOI: 10.2478/JAS-2014-0027.
- Puscas A, Hosu A, Cimpoiu C. 2013. Application of a newly developed and validated high-performance thin-layer chromatographic method to control honey adulteration. *J Chromatogr A* 1272: 132-135. DOI: 10.1016/j.chroma.2012.11.064.
- Radloff SE, Hepburn HR, Engel MS. 2011. The Asian Species of *Apis*. In: Hepburn HR, Radloff SE (eds). *Honeybees of Asia*. Springer, New York. DOI 10.1007/978-3-642-16422-4\_1.
- Schouten C, Lloyd D, Lloyd H. 2019. Beekeeping with the Asian honey bee (*Apis cerana javana* Fabr) in the Indonesian islands of Java, Bali, Nusa Penida, and Sumbawa. *Bee World* 96: 45-49. DOI: 10.1080/0005772x.2018.1564497.
- Steel RGD, Torrie JH, Zoberer DA. 1997. Principles and Procedures of Statistics a Biometrical Approach. 3<sup>rd</sup> Edition. McGraw-Hill Inc., New York.
- Supeno B, Erwan, Agussalim. 2021. Enhances production of coffee (*Coffea robusta*): The role of pollinator, forages potency, and honey production from *Tetragonula* sp. (*Meliponinae*) in central Lombok, Indonesia. *Biodiversitas* 22: 4687-4693. DOI: 10.13057/biodiv/d221062.
- Thrasivoulou A, Tananaki C, Goras G, Karazafiris E, Dimou M, Liolios V, Kanelis D, Gounari S. 2018. Legislation of honey criteria and standards. *J Apic Res* 57: 88-96. DOI: 10.1080/00218839.2017.1411181.
- Tornuk F, Karaman S, Ozturk I, Toker OS, Tastemur B, Sagdic O, Dogan M, Kayaci A. 2013. Quality characterization of artisanal and retail Turkish blossom honeys: Determination of physicochemical, microbiological, bioactive properties and aroma profile. *Ind Crops Prod* 46: 124-131. DOI: 10.1016/j.indcrop.2012.12.042.
- Wahyuni N, Asfar AMIT, Asfar AMIA, Asrina, Isdar. 2021. Vinegar Nira Aren. *Media Sains Indonesia*, Tangerang.
- Wang Y, Gou X, Yue T, Ren R, Zhao H, He L, Liu C, Cao W. 2021. Evaluation of physicochemical properties of Qinling *Apis cerana* honey and the antimicrobial activity of the extract against *Salmonella Typhimurium* LT2 in vitro and in vivo. *Food Chem* 337: 127774. DOI: 10.1016/j.foodchem.2020.127774.
- Wu J, Duan Y, Gao Z, Yang X, Zhao D, Gao J, Han W, Li G, Wang S. 2020. Quality comparison of multifloral honeys produced by *Apis cerana cerana*, *Apis dorsata* and *Lepidotrigona flavibasis*. *LWT - Food Sci Technol* 134: 110225. DOI: 10.1016/j.lwt.2020.110225.
- Yücel Y, Sultanoğlu P. 2013. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. *Food Biosci* 1: 16-25. DOI: 10.1016/j.fbio.2013.02.001.
- Zhang GZ, Tian J, Zhang YZ, Li SS, Zheng HQ, Hu FL. 2021. Investigation of the maturity evaluation indicator of honey in natural ripening process: The case of rape honey. *Foods* 10: 2882. DOI: 10.3390/foods10112882.



erwan apis &lt;apiserwan@gmail.com&gt;

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