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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^{1,*}, AGUSSALIM²

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

*email: apiserwan@gmail.com

²Faculty 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 α - and β -amylases which are the natural enzymes present in honey. The α -amylase is separate
200 the starch chain randomly in the central to produce dextrin, while the β -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.

243 Acidity of honey

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

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

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

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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**EDITOR DECISION: KOMENTAR DARI REVIEWER A
TERHADAP ARTIKEL DAN ARTIKEL HASIL
KOMENTAR DARI REVIEWER A
(27 SEPTEMBER 2022)**

[biodiv] Editor Decision

Smujo Editors <smujo.id@gmail.com>

27 September 2022 pukul 10.02

Kepada: Erwan <apiserwan@gmail.com>, Agussalim <agussalim@mail.ugm.ac.id>

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

Reviewer A:Recommendation: Revisions Required

Biodiversitas Journal of Biological Diversity

A-12166-Article Text-1060789-1-4-20220909(1).doc

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Round 1 Round 2 Round 3 Round 4 Round 5

Round 2 Status
A review is overdue.

Notifications

[biodiv] Editor Decision	2022-09-27 03:03 AM
[biodiv] Editor Decision	2022-10-02 06:21 AM
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[biodiv] Editor Decision	2022-11-18 09:34 AM

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Reviewer's Attachments Q Search

 1062246-1 , 12166-Article Text-1060789-1-4-20220909(1).doc	September 26, 2022
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erwan apis <apiserwan@gmail.com>

[biodiv] Editor Decision

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Kepada: Smujo Editors <smujo.id@gmail.com>

29 September 2022 pukul 22.10

Dear Editor in Chief Biodiversitas

Thanks very much for the information and we will revise according to reviewer comments and submit to the system as soon as possible

[Kutipan teks disembunyikan]

--

Best Regards,

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

**ARTIKEL HASIL KOMENTAR DARI REVIEWER A
(27 SEPTEMBER 2022)**

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 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

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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).

Commented [I21]: Please add the picture of both saps sugar palm and coconut, sugar palm pollen, and honey from *A. cerana*

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 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% (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, 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* 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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sugars are included in reducing sugar group and as the main component present in honey. In 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 break down the carbohydrate into simple sugars. Furthermore, other enzyme present in honey is diastase enzyme that role to break down starch into simple sugars (Da Silva et al. 2016). The honey reducing sugar in our study (Table 1) was differed to 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 ranging from 60.15 to 73.69%. The different reducing sugar may be affected by the different bee species which is impact on the different their ability to evaporate water present in honey especially when they are convert the complex sugars into simple sugars and different season when done the study which are related to temperature and humidity environmental.

The honey sucrose content from the bee *A. cerana* in our study is ranging 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 is originated from sugar palm and coconut saps. The low of honey sucrose content in our study is caused the honey which is harvested in mature condition that characterized by honey cells have been covered by the wax. Furthermore, the invertase enzyme which is produced by the worker bees is actively break down of sucrose from saps into simple sugars. There are two types of invertase enzymes which are produced by the worker bees, namely glucoinvertase which is converts sucrose into glucose and fructoinvertase which is 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 is mostly contain invertase enzyme (Da Silva et al. 2016). The honey sucrose content in our study (Table 1) was differed 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 identifying manipulation, where the high levels may be indicated adulterations by adding the several sweeteners such cane sugar or refined beet sugar. In addition, also indicating the early of harvest, where sucrose is not completed transformed into fructose and glucose, the bees feeding artificial in 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 sugar solution that is supersaturated and unstable so it's easy to crystallize. The honey crystallization is affected by 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 which 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 lower in fructose which is impact on the rapidly crystallization (Escuredo et al. 2014). The sugars content present in honey is dependent on the geographical origins which is impact on the different plant types 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, 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).

189 Diastase enzyme activity and hydroxymethylfurfural of honey

The recent study showed that the diastase enzyme activity from the bee *A. cerana* honey was produced by the sugar palm and coconut saps was ranging from 5.17 to 9.04 DN (Table 2). This enzyme activity is acceptable by SNI with the 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 international standard has been regulated by Codex Alimentarius with the minimum 3 DN (Thrasylvoulou et al. 2018). One of the honey characteristics is contain enzymes which is originate 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 to 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 is divided into α - and β -amylases which are the natural enzymes present in honey. The α -amylase is separate the starch chain randomly in the central to produce dextrin, while the β -amylase to separate the maltose in the end chain. Diastase enzyme content in honey is influenced by nectar source (floral and extrafloral nectars) to produce honey and honey geographical origins which are impact on 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 is also influencing the activity diastase because it's related to the distance and the flowers plant numbers can be visited by the foragers when they are collecting nectar and pollen were using to produce honey and bee bread (Da Silva et al. 2016).

Generally, diastase enzyme is role to break down the complex sugars into simple sugars. This enzyme is role to digest 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

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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 is
 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

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

230
 231
 232 Hydroxymethylfurfural is formed after honey removed from the comb or when the wax covers was opened and the
 233 advanced processing like heating process. The increasing of the HMF content is occur sin honey with the high acidity and
 234 accelerated by the heating process. However, the HMF content also sinfluenced by several factors such as sugars content,
 235 organic acids presence, pH, moisture content, water activity, and the plant types as the nectar source (floral source). In
 236 addition, HMF is also can be formed at the low temperatures, acidic condition, and sugars dehydration reactions.
 237 Therefore, the higher of HMF content is impact on the honey color is darker (Da Silva et al. 2016; Tornuk et al. 2013). The
 238 HMF of honey from the *A. cerana* in our study (Table 2) was differed to previously reported by Wu et al. (2020) for
 239 multifloral honey of *A. cerana cerana* from China is 3.80 mg/kg and 1.69 mg/kg for *A. cerana* honey from Qinling
 240 Mountains, China is 1.69 mg/kg. The different HMF content of honey from *A. cerana* were reported by previously
 241 researchers are influenced by the different plant types as the nectar source to produce honey, different sugars content, and
 242 different geographical origin.

243 Acidity of honey

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

251 The sour taste of honey originated from the several of organic and inorganic acids, where the dominant of organic acid
 252 present in honey is gluconic acid. This organic acid is produced by the enzyme activity of glucose-oxidase which is added
 253 by the bees when they are convert a nectar into honey, so can protecting a nectar until honey maturity. This protecting
 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
 258 The acidity total content in honey is small quantity, but the present in honey is very important because can influencing
 259 the honey stability on the microorganisms, taste or flavor, and aroma of honey. The high acidity is indicating the
 260 fermentation process had been occurred when some reducing sugar is break down into acetic acid. Honey acidity content is
 261 related to the yeast number where them is break down some reducing sugar into ethanol and if it's reaction with the
 262 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.

309 ACKNOWLEDGEMENTS

310 We thank to all beekeepers and farmers which are support and permitting our teams to conduct this study in North
311 Duman Village, Lingsar Sub-district, West Lombok, Indonesia.

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ARTIKEL HASIL PERBAIKAN KOMENTAR DARI REVIEWER A

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

ERWAN^{1,*}, AGUSSALIM²

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

*email: apiserwan@gmail.com

²Faculty 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 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)

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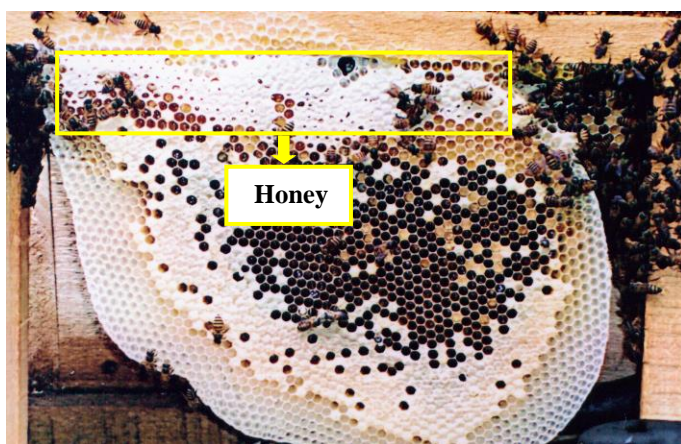


Figure 2. Technique to given the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)

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).



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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 α - and β -amylases which are the natural enzymes present in honey. The α -amylase separates
252 the starch chain randomly in the central to produce dextrin, while the β -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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**EDITOR DECISION: KOMENTAR KEDUA DARI REVIEWER A
TERHADAP ARTIKEL DAN ARTIKEL HASIL
KOMENTAR KEDUA DARI REVIEWER A
(1 NOVEMBER 2022)**

[biodiv] Editor Decision

Smujo Editors <smujo.id@gmail.com>

1 November 2022 pukul 10.35

Kepada: Erwan <apiserwan@gmail.com>, Agussalim <agussalim@mail.ugm.ac.id>

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

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

Biodiversitas Journal of Biological Diversity

 **A-12166-Article Text-1062944-1-4-20221004.doc**
2024K



erwan apis <apiserwan@gmail.com>

[biodiv] Editor Decision

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

1 November 2022 pukul 13.26

Dear Editor in Chief Biodiversitas

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

[Kutipan teks disembunyikan]

--

Best Regards,

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

ARTIKEL HASIL KOMENTAR KEDUA DARI REVIEWER A

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

ERWAN^{1,*}, AGUSSALIM²

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

*email: apiserwan@gmail.com

²Faculty 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* wasere divided into six treatments consistings 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, isare 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 hHoneybee of *A. cerana* is one of the bees from the *Apis* genus, which-is 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-a beekeeping of *A. mellifera*. The bee *A. cerana* can produce honey, bee bread, royal jelly, and propolis. H-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 atthe very serious problem that hasve 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 areis 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-sustainablehity 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 couldan enhance the production of honey cells and bee bread cells. However, the use of sap from coconut and sugar palm can increaseing 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 improve 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 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 a 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 give 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 collecting pollen and sap from the other treatments.



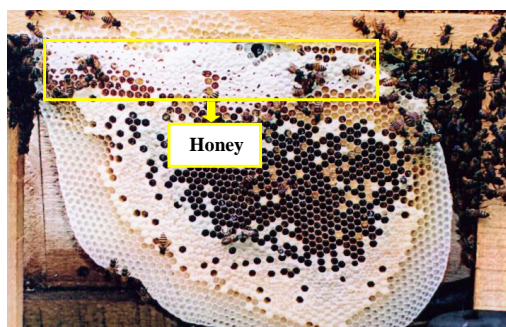
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108 **Figure 2.** Technique to given the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)

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 in 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 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 ~~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 (rainy and dry seasons), and~~ ~~the~~ 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).

~~A~~ ~~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 is~~ 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 ~~the 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 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).

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~~ ~~H~~ honey production process is started ~~with from~~ 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 it~~ to other bees ~~for~~ several times until honey is ripening. A considerable amount of water will be evaporated in this process, ~~which 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 from to reported by~~ Wang et al. (2021) that honey moisture from the bee *A. cerana*, which is collected from 42 different honeycombs from China ~~ranges is ranging~~ 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 is impacts on~~ the different plant types ~~that~~ can be grown ~~in~~ in each region, different environmental conditions (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 ~~of 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).

~~A~~ ~~The~~ recent study showed that the ~~honey~~ reducing sugar from the bee *A. cerana* ~~was~~ ~~ere~~ 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 convertions~~ 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 ~~reduced~~ 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 ~~role to breaks~~ down starch into simple sugars (Da Silva et al. 2016). The honey-reducing sugar in our

study (Table 1) ~~was differed from what wast~~ 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 use~~ ~~which-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 grow ~~th~~ 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).

246 Diastase enzyme activity and hydroxymethylfurfural (HMF) of honey

247 ~~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 wast~~ 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.

257 Diastases ~~are~~ divided into α - and β -amylases, ~~which-are~~ the natural enzymes present in honey. The α -amylase ~~separates~~ the starch chain randomly in the center ~~fra~~ to produce dextrin, while the β -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).

265 Generally, ~~the~~ diastase enzyme ~~has theis~~ role ~~of to~~ breaking down complex sugars into simple sugars. ~~In addition, r~~ 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, ~~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 Sultanoglu 2013). The honey diastase activity from the bee *A. cerana* in our study (Table 2) was differed ~~to-reported-by~~ 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 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 (Thrasyvoulou 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 was 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* 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). This 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 (Thrasyvoulou 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 the nectar until honey maturity. This protection mechanism is caused by the inhibition 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 influence 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 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

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

332 Honey production potency from the sugar palm and coconut saps

333 Coconut and sugar palm plants have a good prospect to be developed because almost part of the plants can be utilized
334 which can contribute to communities' income. Generally, the main production from the coconut (*Cocos nucifera* L.)
335 was harvested as coconut fruit to advance the process into coconut oil and copra. These commodities have a high price, but
336 producing coconut oil and copra are high risk for the farmers because they are just preparing raw materials. Therefore, the
337 utilizing of the sap can be produced by the coconut and sugar palm were also potency feed for the bees was used as the
338 nectar source to produce honey. Sugar palm and coconut saps are the feed potential which is studied by Erwan et al.
339 (2021b) that the coconut and sugar palm saps can increase the number of honey cells and bee bread cells of the bee *A.*
340 *cerana*. Furthermore, it is also reported that sugar palm and coconut are improving the productivity of the bee *A. cerana*,
341 such as increasing the brood cells number, colony weight, and the honey production (Erwan et al. 2022). In addition, the
342 saps from coconut and sugar palms are usually used by the farmers to produce sugar by using a traditional process.

343 The coconut plants can produce 12 stalks in a year, and in one stalk can produce sap of 90 liters; thus, in one coconut
344 plant can produce 1,080 liters of sap. Furthermore, if the farmers have one hectare of the land which are planted by 100
345 coconut plants (distance 10 m × 10 m), so they can be produced for about 108,000 liters of coconut sap. To produce 1 kg
346 of honey requires coconut sap for about 7 liters, and in a year 84 liters are required to produce 12 kg of honey. Thus,
347 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
348 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
349 128.571 tons/month in 100 hectares of the land. Based on the sap production showing that the coconut plants have a big
350 potency to produce honey. This potency was also supported by the harvest area of coconut in West Lombok (Nusa
351 Tenggara Province, Indonesia) was 10,629.36 hectares (Department of Agricultural and Plantations 2021).

352 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
353 exceed 4 months. Wahyuni et al. (2021) reported that the production of sugar palm sap per plant is ranging from 8 to 22
354 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).
355 Furthermore, if in one hectare of the plantation, we have 100 sugar palm plants, with the distance for planting is 10 m ×
356 10 m, so can be obtained of sap for 115,000 liters.

357 The field investigation showed that to produce 1 kg of honey from the sugar palm sap is required for about 10 liters,
358 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
359 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
360 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
361 tons/month in 100 hectares area. This potency indicates that the sugar palm sap has a big potency to produce honey which
362 is supported by the report data from the Department of Agricultural and Plantations (2021) that the sap production, sap
363 productivity, and harvest area for sugar palm plants in West Lombok (West Nusa Tenggara Province, Indonesia) are 57.46
364 tones, 304.80 quintals/hectare, and 188.52, respectively, in the year of 2021. Therefore, it can be concluded that honey is
365 produced by the bee *A. cerana* from sugar palm and coconut saps as the feed have the quality which that is acceptable
366 by Indonesian national standard, and the international standard has been regulated by the Codex Alimentarius. Honey
367 potency production from the coconut sap in 100 hectares area can produce honey of 1,542.857 tons/year or equivalent with
368 128.571 tons/month, while in sugar palm can produce honey of 1,150 tons/year or equivalent with 95.833 tons/month.

Commented [Rev3]: Please add the references for these data.

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**ARTIKEL HASIL PERBAIKAN KOMENTAR KEDUA DARI
REVIEWER A**

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

ERWAN^{1,*}, AGUSSALIM²

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

*email: apiserwan@gmail.com

²Faculty 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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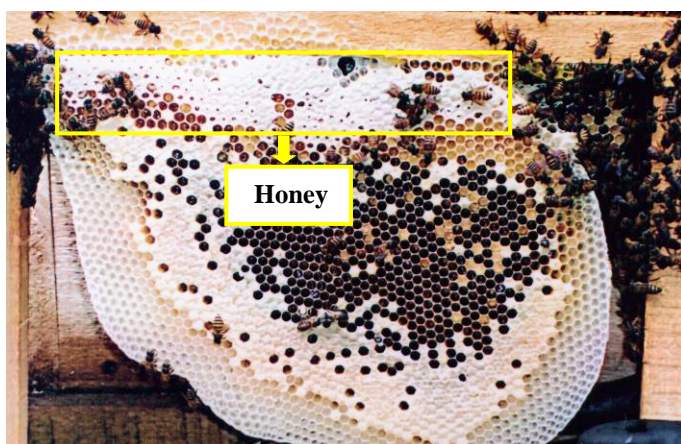


Figure 2. Technique to give the sugar palm and coconut saps (left) and sugar palm pollen (right) (Erwan et al. 2022, 2021b)

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 (Thrasyvoulou 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 (Thrasyvoulou 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; Thrasyvoulou 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 α - and β -amylases, the natural enzymes present in honey. The α -amylase separates the starch
251 chain randomly in the center to produce dextrin, while the β -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 (Thrasylvoulou 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 (Thrasylvoulou 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.

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Dear Editor In Chief Biodiversitas

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

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Best Regards,

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

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ERWAN

Faculty of Animal Science, Universitas Mataram.
Jl. Majapahit No. 62, Mataram-83125, Indonesia.
Tel./fax. +62370-633603/+62370-640592
email: apiserwan@gmail.com

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

ERWAN^{1,✉}, AGUS SALIM²

¹Faculty of Animal Science, Universitas Mataram, Jl. Majapahit No. 62, Mataram-83125, Indonesia.

Tel./fax. +62370-633603/+62370-640592, ✉email: apiserwan@gmail.com

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

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Abstract. Erwan, Agus Salim. 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 36.35 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*.

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).

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 (mult-ifloral 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)

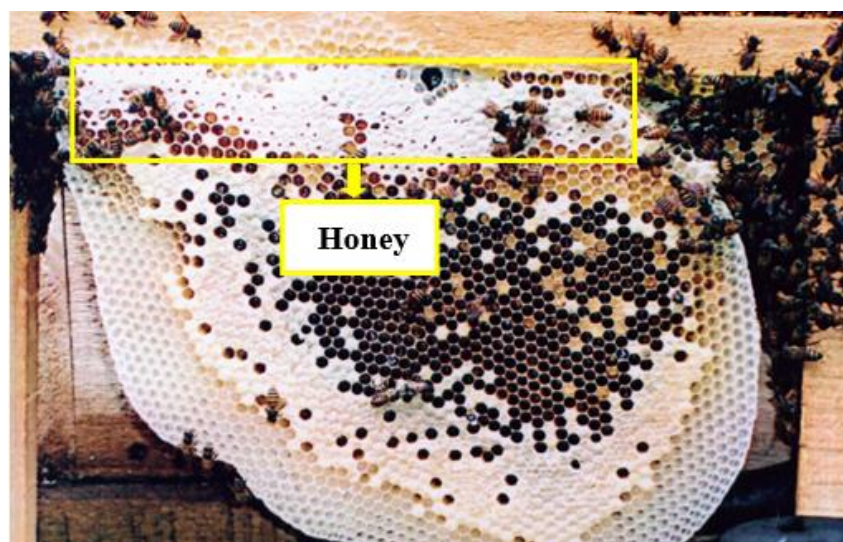


Figure 3. Honey from *A. cerana* was produced from the sugar palm and coconut saps

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
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).

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, 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 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 α - and β -amylases, the natural enzymes present in honey. The α -amylase separates the starch chain randomly in the center to produce dextrin, while the β -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

(Thrasivoulou 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 (Thrasivoulou 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
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).

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

ERWAN^{1,*}, AGUSSALIM²

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

²Faculty 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)

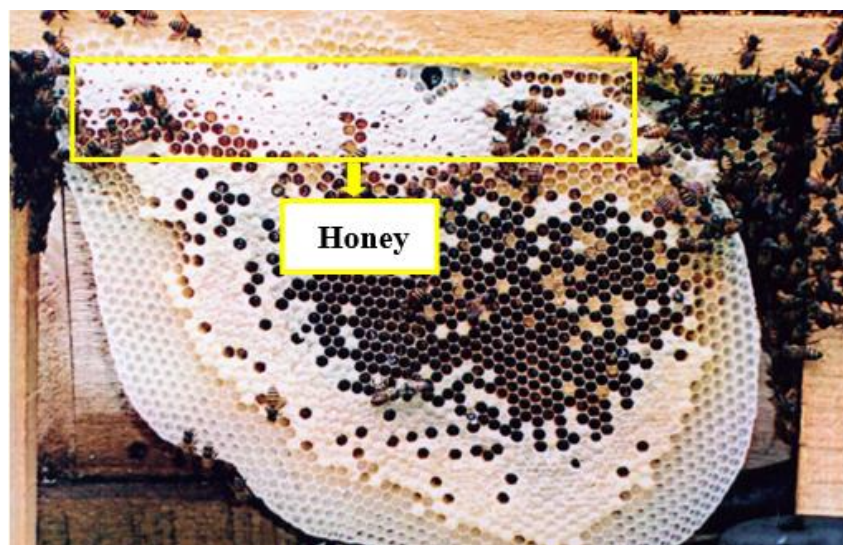


Figure 3. Honey from *A. cerana* was produced from the sugar palm and coconut saps

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 α - and β -amylases, the natural enzymes present in honey. The α -amylase separates the starch chain randomly in the center to produce dextrin, while the β -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 (Thrasyvoulou 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 (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 (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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(12 NOVEMBER 2022)**



erwan apis <apiserwan@gmail.com>

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Ayu Astuti <smujo.id@gmail.com>

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Our decision is to: Accept Submission

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erwan apis <apiserwan@gmail.com>

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erwan apis <apiserwan@gmail.com>
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Thanks very much for the information

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Best Regards,

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Faculty of Animal Science, University of Mataram, Indonesia

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erwan apis <apiserwan@gmail.com>

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erwan apis <apiserwan@gmail.com>
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[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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Honey quality from the bee *Apis cerana*, honey potency produced by coconut and sugar palm saps

ERWAN^{1,*}, AGUSSALIM²

¹Faculty 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

²Faculty 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)

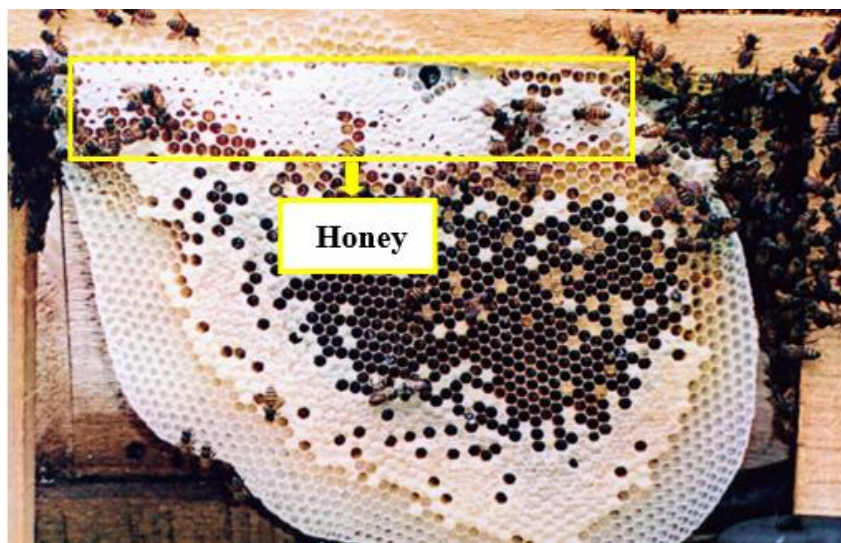


Figure 3. Honey from *Apis cerana* was produced from the sugar palm and coconut saps

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 α - and β -amylases, the natural enzymes present in honey. The α -amylase separates the starch chain randomly in the center to produce dextrin, while the β -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
CP1	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 (CP1); 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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