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# Evaluation of Honey Production for Industry Purposes, The Case of Beekeeping with *Apis Mellifera* in Indonesia After The Covid-19 Pandemic

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***Keywords***
*Covid-19 Pandemic, Honey Production, Honey Price.*

**ABSTRACT**
The Indonesian beekeeping industry, grappling with diverse bee species, focuses on the sustainability of operations, particularly with the introduction of *Apis mellifera* during the early stages of the pandemic. This study explores post-pandemic *Apis mellifera* honey production in Indonesia, analyzing its impact on prices and business sustainability. Surveys and interviews were conducted with beekeepers in Java and Sumatra, primary islands with significant *A. mellifera* activities, along with data collection from other regions from January 2022 to October/November 2023. Monthly observations centered on honey production and prices for industrial purposes. The study uncovered two beekeeping systems: migratory in Java and stationery in Sumatra. Carpa honey from *Accacia crassicarpa plantation* emerged as a suitable industrial honey, displaying sustainable production, seasonality, and a large carpa area as bee forages, contributing to colony growth. Conversely, four Java honey types showed lower productivity, indicating a potential absence of honey seasons. Carpa honey prices ranged from IDR 25,200 to IDR 31,000 per kg, influenced by market size, production, competition, productivity, costs, and producer-consumer interactions. Despite a pandemic-induced surge in the honey market, sustaining high productivity and increasing colony numbers are crucial for long-term honey production sustainability.

## INTRODUCTION

The Covid-19 pandemic has hit the world since the beginning of 2020, including Indonesia. Asof December 2023, there were more than 700 million positive cases of Covid worldwide, with nearly 7 million deaths (WHO Corona Virus Dashboard, 2023). In Indonesia, positive Covid cases are approaching 7 million, with the death toll reaching 161,848 people. COVID-19 not only threatens human lives but also severely impacts the world economy due to various restrictions on transportation and human movement. Beekeeping is one of the activities affected by these restrictions, especially cultivation, which must move


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from place to place for production and pollination needs. However, amidst the existing difficulties, the COVID-19 pandemic has also brought blessings to beekeeping due to the soaring demand for beekeeping products, especially honey (Mohan et al., 2023).

Beekeeping has become essential to human life (Fels et al., 2019; Kritsky, 2017). This cannot be separated from the role and function of honeybees in supporting human daily living needs (Chanthayod et al., 2017). History records that humans have known and used honey for thousands of years as a food ingredient and medicine (Crane, 1999). The same product has become a world trade commodity with significant economic value. Honey and trade commodities for bee products have also expanded to other products such as royal jelly, propolis, bee pollen, beeswax, bee venom, and various derivative products (Polat et al., 2023). However, the pollination function is the most crucial role of honeybees for human life by maintaining food availability, environmental sustainability, and health (Aditya & Purwanto, 2023).

Apis mellifera is one of the few species of honeybees of the Apis genus that have been widely raised and developed throughout the world (Kumari et al., 2023) to produce honey andother things and to support the pollination needs of various food crops (Gupta et al., 2014). Indonesia has developed this type of bee native to Europe more seriously since the 1970s (Widiarti & Kuntadi, 2012). It is the largest honey producer after the forestbee, A. dorsata (Kahono et al., 2018).

Beekeeping with *A. mellifera* has developed rapidly on the island of Java, supported by excellent and diverse food sources in a very adequate area, both in areas managed by state-owned plantation companies, private companies, and community gardens. Types of food source plants include kapok (*Ceiba pentandra*), rubber (*Hevea brasiliensis*), rambutan (*Nephelium lappaceum*), calliandra (*Calliandra calothyrsus*). However, as the food source area decreases and other factors, such as pest attacks and climate change, the cultivation and production of A. *mellifera* honey in Java tend to decline (Kahono et al., 2018). Many attempts have been made todevelop *A. mellifera* outside Java. Still, most have failed, except for the last few years in acacia plantations in Sumatra, which have shown promising honey productivity.

The COVID-19 pandemic has had a significant impact on beekeeping in Indonesia. During the pandemic, beekeeping products have become highly sought after because they are believed tobe able to maintain and increase the body's immune system (Harianja et al., 2023; S. Elsadibah et al., 2023), which is very much needed to prevent transmission and speed up healing. As quoted by Indriani et al. (2022), Tempo Magazine reported that online honey sales increased 2 to 3 times during the pandemic. This development of the beekeeping industry in Indonesia is good upstream and downstream. It has increased greatly fast, especially in *A. mellifera* and stingless bees. Mellifera business is beautiful and involves lots of new perpetrators and new areas for developing the new bee business, specifically in Sumatra with the acacia plantation within the forest area in Jambi Province (Attia et al., 2022) and Riau (Pribadi et al., 2023).

Looking forward, Indonesia's beekeeping industry needs to develop various strategies for making honey to get broader access to the international market. This is necessary to channel domestic production, which has enormous potential at a time when the domestic market is still minimal. Therefore, studying and analyzing market trends in the field is necessary to strengthen Indonesia's beekeeping industry ecosystem. The study aims to understand and interpret the dynamics of *A. mellifera* honey production. This research is expected to show how production, processing, distribution, and consumption can influence each other and how external and internal factors can influence the dynamics (Pribadi et al., 2023).

## METHODS

**Research Approach**

The aim is to collect and understand the honey production dynamics in the market, focusing on *Apis mellifera* production. The surveys were conducted using direct interviews with beekeepers. The interview flow is guided by a list of questions (questionnaire).

**Time and Location**

The regions surveyed represent the largest honey-producing areas within Indonesia, namely Sumatra (Jambi and Riau provinces) and Java (West Java, Central Java, and East Java). Surveying was carried out in November 2023 in several districts/cities. The study took place in Java and represents a model of migratory beekeeping with honey products originating from several tree species as the main nectar and pollen sources, especially kapok, rambutan, and rubber. Sumatra represents a model of stationary beekeeping in acacia plantations as the only honey source. The following table shows the districts/cities that were selected as survey locations based on the presence of beekeepers related to *Apis mellifera*.

**Table 1. Survey Locations**

| Island | Province | Regency/City |
|---|---|---|
| Sumatra | Riau | Siak |
| | | Bengkalis |
| | Jambi | West Tanjung Jabung |
| | | Muaro Jambi |
| Java | West region | Bogor |
| | | Bekasi |
| | | South Tangerang |
| | | Sukabumi |
| | | Depok |
| | Central region | Temanggung |
| | | Sragen |
| | | Pati |
| | | Semarang |
| | | Kudus |
| | East region | Kediri |
| | | Malang |

**Data collection**

The chosen respondents were determined using a purposive sampling method based on certain criteria. Sampling was carried out randomly among several respondents using a snowballing system. Data collection was carried out through interviews with respondents face to face, guided by prepared questionnaires. Interviews with beekeepers focused on developments in production and selling prices of selected honey for industry purposes from 2022 to 2023. Data was collected every month.

**Data analysis**

***Data Tabulation***

Data from the questionnaires were tabulated, which included data on colony population, honey production, and the selling price of selected honey for industry purposes. Data was analyzed descriptively to describe honey production patterns, activities, and the price.

***Data Screening***

Screening data was intended to assess honey production, which met the qualifications for being a raw material for the industry. Screening was carried out using tabulated data on the output of each type of honey. The assessment is carried out based on the following parameters:

1. Honey production is relatively high and can be increased.
2. Honey production is relatively consistent, and it must be sustainable.

Focus Group Discussion (FGD)FGD is intended to:

1. Analyze honey production cost.
2. Determine the factors influencing the selling price.

## RESULTS

### Beekeeping System

Beekeeping practices in Sumatra differ from those in Java regarding how to keep and manage stationary apiaries (Sumatra) and migratory (Java). The system has been established to reach the availability of nectar and pollen according to the flowering calendar of bee forages. The migratory system in Java is usually done (1) to maintain colony population during the dearth period (off-season) by placing honeybee colonies close to pollen sources, mainly corn (*Zea mays*) and forms (*Accacia auriculiformis*) plantations and (2) to collect honey from various species of plants by placing honeybee colonies close to nectar plantation during each of their nectar flow (honey season). In off season, the colonies should be fed sugar syrup to compensate the absence of nectar. The flowering time and nectar secretion of honey plants in Java are seasonal over a relatively short period. Therefore, accurate timing of migration and selection of colony placement locations are critical to maximize the honey season and produce honey. During honey season, some plantations use pollen such as Kapok Randu (*Ceiba petandra*). Other trees have very limited or no pollen in their flowers (Table 2).

Table 2. List of beeforages as primary food source for beekeeping in Java and Sumatra

| Number | Beeforages | Food Source | | Beekeeping Location |
|---|---|---|---|---|
| | | Pollen | Nectar | |
| 1. | Kapok Randu (*Ceiba petandra*) | Yes | Yes | Central and East Java |
| 2. | Rambutan (*Nephelium lappaceum*) | No | Yes | West Java |
| 3. | Coffee (*Coffea* spp.) | Yes | Yes | Central and East Java |
| 4. | Rubber (*Hevea brasiliensis*) | No | Yes* | Java |
| 5. | Red caliandra (*Calliandra callothyrsus*) | No | Yes | Central and East Java |
| 6. | Mangium (*Accacia mangium*) | Yes** | Yes* | Jambi, Riau |
| 7. | Carpa (*Accacia crassicarpa*) | Yes** | Yes* | Jambi, Riau |
| 8. | Durian (*Durio zibhetinus*) | Yes** | Yes | Central and East Java |
| 9. | Manggo (*Mangifera indica*) | Yes** | Yes | Central and East Java |
| 10. | Sono (*Dalbergia latifolia*) | No | Yes | Central and East Java |
| 11. | Wadang (*Pterospermum javanicum*) | Yes** | Yes | East Java |
| 12. | Water spinach (*Ipomoea aquatica*) | No | Yes | East Java |
| 13. | Corn (*Zea mays*) | Yes | No | West, Central, East java |
| 14. | Sengon (*Paraserianthes falcataria*) | No | Yes | Central and East Java |
| 15. | Ploso (*Butea monosperma*) | Yes** | Yes | East Java |
| 16. | Wild morning glory (*Ipomea* sp.) | Yes** | Yes | East Java |
| 17. | Oil Palm Plantation (*Elaeis guinensis*) | Yes | No | Riau, Jambi |
| 18. | Formis (*Accaica auriculiformis*) | Yes | No | Central Java |
| 19. | Rosewood (*Dalbergia* spp.) | No | Yes | Central and East Java |

*** = Extra floral**

**= Minor source

The main honey produced by *A. mellifera* honeybee colonies in Java includes kapok, rambutan, and rubber honey. The harvest season for kapok honey is around May-July, rubber honey around August-

September, and rambutan honey around October-November. Several types of honey can be produced outside these months, including durian, coffee, calliandra, etc., but mostly in relatively small quantities. The location of these relatively minor honey sources is only found in certain areas, so it can only be accessed by local Beekeepers.

The Sumatra stationary system is a more accessible beekeeping system due to low costs for transporting the bees and providing sugar syrup. The nectar (extra flora) is sourced from carpa plantation (*Acacia crassicarpa*) within the age of less than 2. The pollen is coming from male flowers of oil palm plantation/OPP (*Elaeis guinensis*). The selected location for the hives should be in the range of the honeybees' foraging flight to reach carpa and OPP. Most respondents explained that they are delighted to keep the bees in the acacia plantation forest, even though they face some pests that are not easy to control, such as monkeys, honey bears, and bee-eater birds.

**Honey Production**

The respondents described the honey types as shown in Table 3. There are 14 monofloral honey types from Java and 2 monofloral honey types from Sumatra. The most demanding honey according to several respondents of beekeepers is carpa honey in Sumatra and kapok randu honey in Java. When we look at the preference percentages from very high to low, there are 5 monofloral honey types: Carpa, Kapok Randu, Rambutan, Rubber, Coffee, and Durian.

**Table 3. Beekeeper Preference on Honey Type**

| Number | Beeforages | % Preference | | Demand by beekeepers |
|---|---|---|---|---|
| | | Java | Sumatra | |
| 1. | Kapok Randu (*Ceiba petandra*) | 88 | - | High |
| 2. | Rambutan (*Nephelium lappaceum*) | 83 | - | High |
| 3. | Coffee (*Coffea* spp.) | 38 | - | Low |
| 4. | Rubber (*Hevea brasiliensis*) | 83 | - | High |
| 5. | Red caliandra (*Calliandra callothyrsus*) | 17 | - | Very low |
| 6. | Mangium (*Accacia mangium*) | - | 18 | Very low |
| 7. | Carpa (*Accacia crassicarpa*) | - | 100 | Very High |
| 8. | Durian (*Durio zibhetinus*) | 38 | - | Low |
| 9. | Manggo (*Mangifera indica*) | 17 | - | Very low |
| 10. | Sono (*Dalbergia latifolia*) | 17 | - | Very low |
| 11. | Wadang (*Pterospermum javanicum*) | 8 | - | Very low |
| 12. | Water spinach (*Ipomoea aquatica*) | 17 | - | Very low |
| 13. | Sengon (*Paraserianthes falcataria*) | 17 | - | Very low |
| 14. | Ploso (*Butea monosperma*) | 4 | - | Very low |
| 15. | Wild morning glory (*Ipomea* sp.) | 4 | - | Very low |
| 16. | Rosewood (*Dalbergia* spp.) | 17 | - | Very low |

Honey production in Jambi and Riau provinces is dominated by Carpa honey. It is produced from extra-floral nectar secreted by the nectariferous glands at the base of the leaves of the *A. crassicarpa* trees. The honey production period in acacia areas is relatively lengthy because the nectar secretion occurs continuously, especially in the dry season. In one year, the production period can be between 6-8 months continuously (dry season) with honey harvesting interval about 15-20 days and 4-6 months (rainy season) with harvesting interval at least 30 days. The honey harvesting period is between March and October if the local climates are favorable and are not hampered by high rainfall. That is why the productivity of *A. mellifera* in acacia plantation forest areas is relatively high, and it can be 68 kg/colony/year (Pribadi et al., 2023).

Regions with honey production in high demand in Java are Kapok Randu, Rambutan, Rubber,

Coffee, and Durian. The season for kapok randu honey is between May to July, rubber honey is between August to September, rambutan honey is between October to November and for durian and coffee honey is between September to October (Table 4). The colony productivity level is around 15 kg/colony/year. This productivity is relatively low and much lower than the productivity of colonies in Sumatra. The low honey productivity in Java is thought to be due to the increasingly high level of competition between beekeepers as the consequence of rapid declining area of beeforages with high depletion rates.

**Table 4. The Honey Season for The Main Species of Bee Forages in Indonesian**

| No. | Honey Season | Jan | Feb | Mar | Apr | May | Jun | Jul | Ags | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Carpa | | | | | | | | | | | | |
| 2 | Kapok Randu | | | | | | | | | | | | |
| 3 | Rubber | | | | | | | | | | | | |
| 4 | Rambutan | | | | | | | | | | | | |
| 5 | Coffee | | | | | | | | | | | | |
| 6 | Durian | | | | | | | | | | | | |

The productivity of major honey sources in Indonesia is described in Figure 1. Carpa is the highest honey source with an annual honey production of about 29 Kg/colony/year followed by kapok 5 kg/colony/year, rubber 6 kg/colony/year, rambutan 4 Kg/colony/year, durian 0.3 Kg/colony/year, and coffee 0.3 Kg/colony/year.

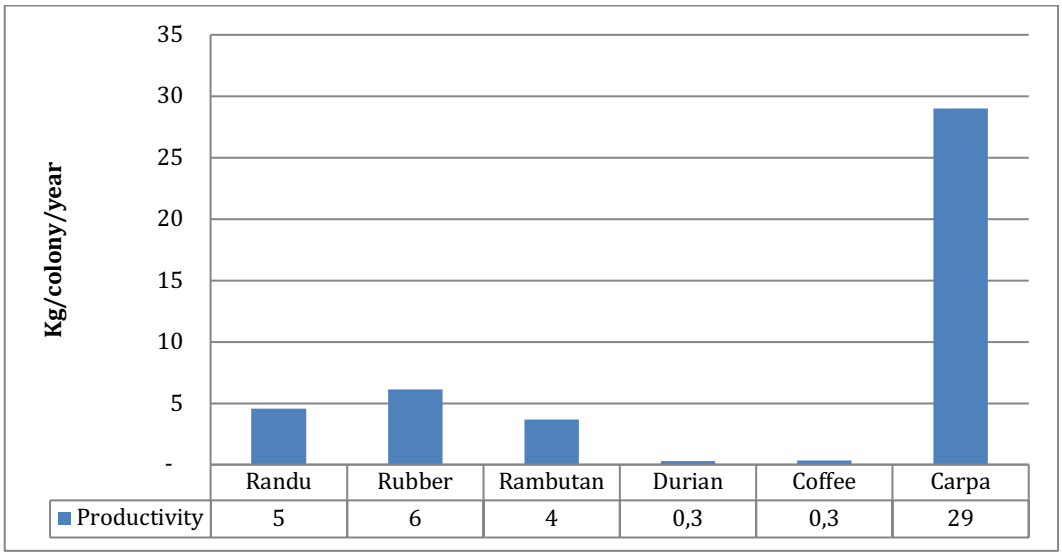



**Figure 1. Average Productivity of Major Honey Types in Indonesia**

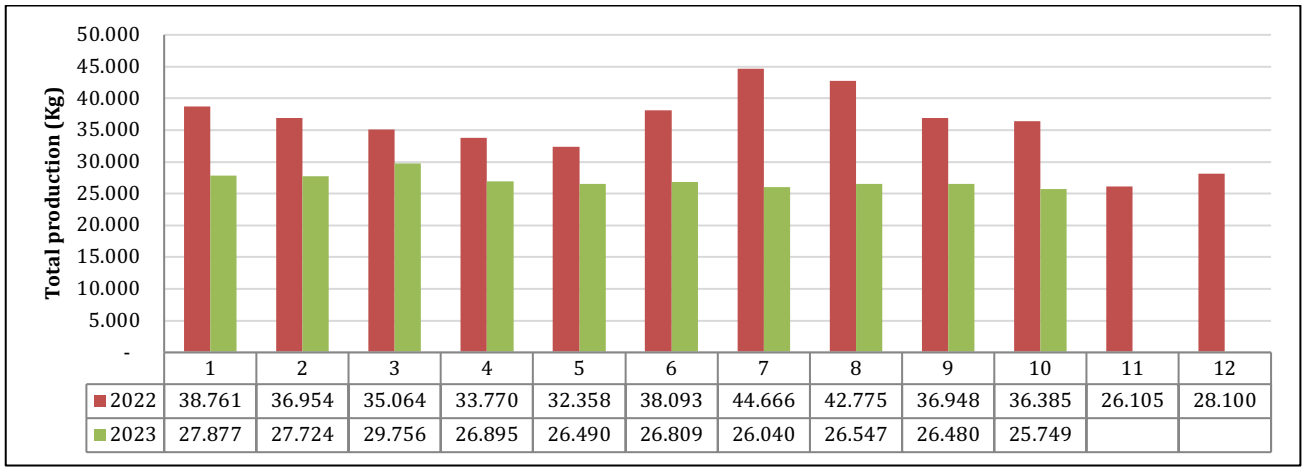
**Honey For Industry and Large-Scale Distribution**

After selecting the five primary honey sources to survey, the evaluation is subjected to the type of honey that matches for the industry purposes to understand the potential volume intake and its sustainability of production. Table 7 shows the proportion of honey intake for Indonesia's 5 major honey types. Carpa honey (66 %) is in the best position among honey types because of its honey season availability throughout the year and its growing trend in more expansive use. In contrast, all other honey types are in a downward trending position, and no honey production may occur.

**Table 5. Evaluation of the sustainability of five major honey types in Indonesian**

| No. | Honey | Colony Productivity (Kg/year) | Proportion (%) | Trend Area | Honey Season | Occurrence with no honey | Sustainability |
|---|---|---|---|---|---|---|---|
| 1 | Kapok | 5 | 10 | Down | May – July | Yes | no |
| 2 | Rubber | 6 | 14 | Down | Ags – Sept | Yes | no |
| 3 | Rambutan | 4 | 8 | Down | Oct – Nov | Yes | no |
| 4 | Durian | 0.3 | 1 | Down | Sept – Oct | Yes | no |
| 5 | Coffee | 0.3 | 1 | Down | Sept – Oct | Yes | no |
| 6 | Carpa | 29 | 66 | Up | Jan – Dec | No | yes |

Carpa honey is the superior honey for bulk processing and large-scale distribution which will continue to be in demand in the future of beekeeping in Indonesia, especially from the beekeepers from Java as more colonies are operating within Java and Sumatra. The production for carpa honey is described in Figures 2 and 3.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2022 | 38.761 | 36.954 | 35.064 | 33.770 | 32.358 | 38.093 | 44.666 | 42.775 | 36.948 | 36.385 | 26.105 | 28.100 |
| 2023 | 27.877 | 27.724 | 29.756 | 26.895 | 26.490 | 26.809 | 26.040 | 26.547 | 26.480 | 25.749 | | |

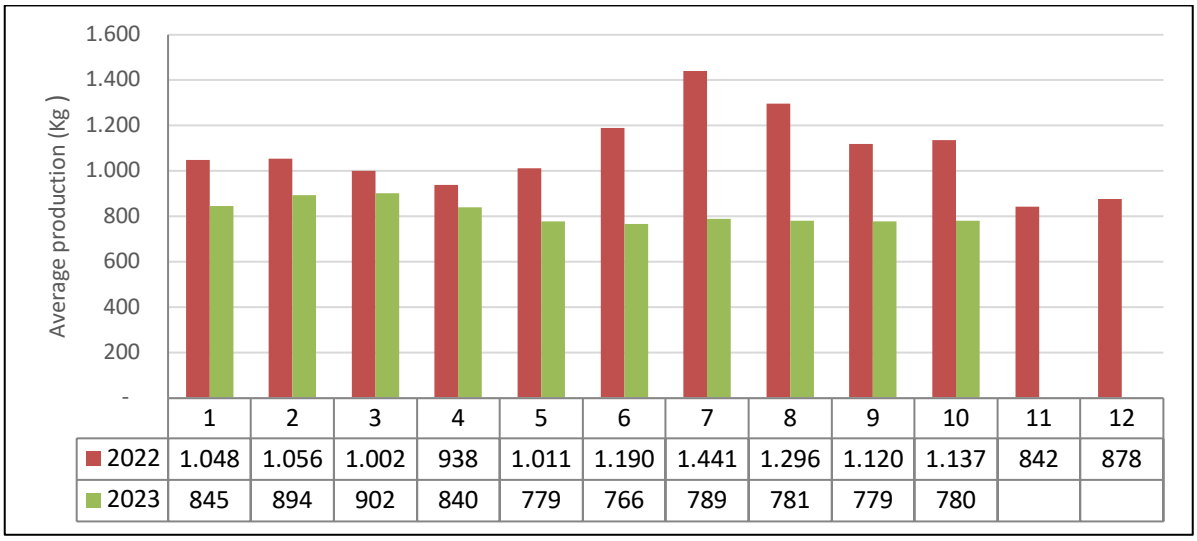
**Figure 2. Total monthly average of *Accacia crassicarpa* honey production produced by all Sumatran respondents of beekeepers (Riau and Jambi)**

Beekeeping with *A. mellifera* in acacia plantation forests can produce carpa honey throughout the year with an average fluctuating monthly production (Figure 2). Monthly honey production in 2022 ranged from 26 tons (lowest total production) to 44 tons (highest total production), or around 312 to 528 tons per year. Monthly honey production in 2023 ranged from 25 tons (lowest total production) to 30 tons (highest total production) or around 300 to 360 tons per year. On average, the total production of Sumatran carpa honey in 2022 and 2023 will be 428 tonnes and 304 tonnes, respectively. There was a decrease in production figures during 2023 compared to the previous year. This decrease is estimated to be due to a significant decrease in colony populations. Our respondents in Jambi and Riau had lost their colonies in total by 1,170 and 2,230, respectively, in 2023.

The average monthly honey production per Beekeeper in 2022 was also found to fluctuate, while in 2023, it tended to be flat (Figure 4). The pattern of average production figures per beekeeper differs from the cumulative production pattern of all respondents in Figure 2. The production pattern was relatively high at the beginning of the year (January) with total production of around 1.05 tons/beekeeper, then gradually decreased slightly until April, reaching an average of around 0.95 tons/Beekeeper. In May, average monthly production began to increase sharply, with the highest peak in

July. In the following months, the average monthly production began to decline, with the lowest production levels occurring in the last 2 months at the end of the year when rainfall became more intense in the rainy season. Throughout 2022, the highest average honey production figure per Beekeeper reached 1.45 tonnes in July and the lowest in October, around 0.85 tonnes.

Meanwhile, in 2023 the highest average monthly production figure only reached around 0.9 tonnes, which occured in March and the lowest occured in June around 0.68 tonnes. The average colony productivity figures in Jambi and Riau were 35.95 kg/colony/year and 22.1 kg/colony/year. Overall, the average colony productivity in Sumatra is 29 kg/colony/year.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2022 | 1.048 | 1.056 | 1.002 | 938 | 1.011 | 1.190 | 1.441 | 1.296 | 1.120 | 1.137 | 842 | 878 |
| 2023 | 845 | 894 | 902 | 840 | 779 | 766 | 789 | 781 | 779 | 780 | | |

**Figure 4. Monthly average of *Accacia crassicarpa* honey production per respondent of beekeeper from Riau and Jambi**

Carpa honey has a characteristic brownish color. Based on the Pfund Honey Color Guide, Carpa honey is in the amber color category with a color intensity of around 102 mm Pfund. In general, the content of carpa *honey* is not much different from honey, except that this honey has a relatively high free acid content (Ishak, 2018; Suhesti et al., 2023).

**Production Cost**

Table 1 shows the production cost of carpa honey derived from data from a prominent respondent who managed apiaries of *A. mellifera* honeybee colonies in Riau provinces and previously in Jambi. The production cost for 1 kg carpa honey is about IDR 20,877 with the condition of 400 hives per location per one worker, the neighbor apiary distance is 2 km away, with 60 kg of production per year per colony, and 5% production lost.

**Table 6. The Cost Production Calculation from The Focus Group Discussion**

| No. | Description | Unit name | Volume | Price Per Volume Unit (IDR*) | Total (4x5) |
|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 |
| I. | Cost | | | | |
| 1. | Workers | MP*) | 12 | 5,000,000 | 60,000,000 |
| 2. | Harvesting Works | HP*) | 16 | 2,400,000 | 38,400,000 |
| 3. | Fee for harvesting | Kg | 24,000 | 4,000 | 96,000,000 |
| 4. | Packaging | Kg | 24,000 | 1,400 | 33,600,000 |

| | | | | | |
|---|---|---|---|---|---|
| 5. | Materials, Fuel, and Supplies | Month | 12 | 2,000,000 | 24,000,000 |
| 6. | Monthly Equipment support | Month | 12 | 2,000,000 | 24,000,000 |
| 7. | Budget allocation for Bee colonies per year **) | Hives | 400 | 500,000 | 200,000,000 |
| | **Total Cost** | | | | 476,000,000 |
| II. | Honey Production Cost Calculation per Kg | | | | |
| 1. | Total production (5 kg/month x 12 month x 400 hives) | Kg | 24,000 | - | - |
| 2. | Production lost (5% x 24.000 Kg) | Kg | 1,200 | - | - |
| 3. | Net Production (24,000 Kg – 1,200 Kg) | Kg | 22,800 | - | - |
| | Honey Production Cost per Kg (IDR 476,000,000 : 22,800 Kg) | IDR | | | 20,877 |

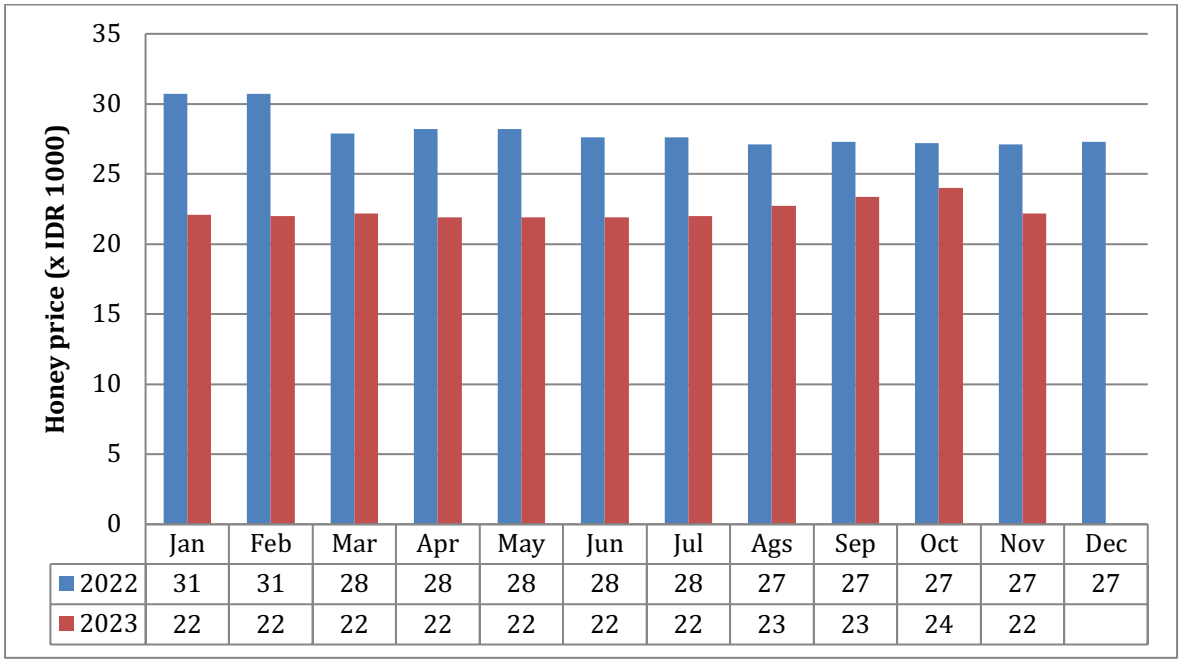
*) MP = Monthly Person
HP = Harvesting Person
IDR = Indonesian Rupiah

**) The economic price of the bee colony is IDR 1,500,000 with 3 years of economic usage

**Price**

The price of carpa honey at the beekeeper level was found to fluctuate. The study leads up to the end of the Covid-19 pandemic (2022) and after the Covid-19 pandemic (2023) and shows a downward trend. The result of the carpa honey price in the research locations (Riau and Jambi) is presented in Figure 1. Respondents reported prices exclusive of VAT. The price of honey varied between months. In 2022, the price tends to decrease from month to month, with an annual average of around IDR 27,000 to IDR 31,000 per kg and about IDR 28,000/Kg on average. Meanwhile, in 2023, the price of honey tends to be stable at a price in the range of IDR 22,000 to IDR 24,000 per kg, with an average price of IDR 22,400 per kg.

In general, the price of carpa honey until October 2023 is lower than the previous year's price. However, recently there has been a slight increase in prices as seen in the graph for October 2023. This increase is thought to be related to the re-emergence of cases of exposure to Covid 19, which are increasing again. This has an impact on growing demand for honey, and however, at the same time, acacia honey production is lower than the previous year, which has also caused prices to increase.




| | Jan | Feb | Mar | Apr | May | Jun | Jul | Ags | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2022 | 31 | 31 | 28 | 28 | 28 | 28 | 28 | 27 | 27 | 27 | 27 | 27 |
| 2023 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 23 | 23 | 24 | 22 | |

**Figure 1. The average monthly price of *Accacia crassicarpa* honey**

**Discussion**

Indonesia officially entered a COVID-19 pandemic emergency in early March 2020 after the President declared the Corona Virus Disease 2019 Public Health Emergency through Presidential Decree Number 11 of 2020. The COVID-19 pandemic lasted 3 years before it ceased and changed to endemic status in June 2023 (Presidential Decree number 17 of 2023). In the early days of Covid-19, demand for honey products increased sharply (Indriani et al., 2022), for at least 2 years. During the pandemic, interest in beekeeping increased significantly in anticipation of market demand and sharp increases in honey prices. This is recorded in this research as seen in Table 3 where new beekeepers dominate the beekeeper respondents in Sumatra with 3 to 5 years of experience, namely those who just started raising *A. mellifera* honeybees between 2019 to 2021. Interestingly, more than half of the respondents surveyed were non-local beekeepers. It shows a relatively significant shift of colonies from Java to Sumatra. Meanwhile, in Java, almost all farmer respondents were older beekeepers with more than 5 years of beekeeping experience.

Beekeeping with *A. mellifera* is substantially different from stationary beekeeping in Sumatra, and migratory beekeeping in Java, and such forms of beekeeping have an impact on production systems, production volumes, types of honey produced, and various accompanying aspects, including marketing patterns, commodity prices, etc. These differences are influenced by the local environment, especially the availability of bee forages, which is the primary support for colony development and sustainability.

As for the best type of honey for growing the industry, as shown in Tables 5 and 7, among the 15 honey type options, 5 major honey types are more favorable for beekeepers, but it is only 1 honey type (carpa honey) which is the best honey type for the industry. The production sustainability and the high quantity of carpa honey are keys to addressing *Accacia crassicarpa* use in Sumatra as the main honey source in Indonesia that can promote in managing the peat area as the eco-business ecosystem.

Beekeeping with *Acacia crassicarpa* in Sumatra can be developed on a large-scale basis given the availability of industrial forest plantations to produce wood and the nearby pulp and paper industry (APRIL, 2017). Throughout Sumatra, it is estimated that the area of planted forests is around 4 million

hectares, 65% of which are acacia plantations, most of which are in the provinces of Riau, Jambi, and South Sumatra (BPS 2022). Acacia provides extrafloral nectar secreted continuously from each young leaf (Kusuma et al., 2023). The nectar secretion volume of *A. crassicarpa* aged 12 and 50 months can produce nectar of 47.74 and 73.76 liters/ha/day (Pribadi et al. 2023). The high nectar secretion activity that lasts throughout the year makes acacia plants an excellent food source to support honey beekeeping, as shown by the results of this research. Beekeepers can produce honey all year round (Table 5, Figures 3 and 4). Production constraints are generally only due to high rainfall during the rainy season, either due to disruption of honeybee foraging activities or raindrops washing away nectar. Another obstacle is the attacks of thousands of bee-eater birds (*Merops* sp.), which have in recent years become a severe predatory pest that attacks apiaries in Riau and Jambi regions during the rainy season (personal communication with beekeeper).

Additionally, attacks by mites (*Varroa destructor* and *Tropilaelaps clareae*) continue to affect every bee colony throughout the year. The number of *A. mellifera* honeybee colonies in Riau and Jambi according to several beekeepers is around 45,000 colonies and 15,000, respectively (Gunarto, Budiman, Adi Pradana, personal communication). This represents a decrease from the previous number, namely in 2021, which reached 125,000 colonies in Riau and 45,000 colonies in Jambi.

The productivity of bee forage in Sumatra is generally high. This can be seen from the level of colony productivity in Sumatra, which averages around 29 kg/colony/year. This level of productivity is relatively high when compared with the level of colony productivity in Argentina, one of the largest honey exporting countries in the world and number 1 in South America, which nationally averages 25 kg/colony/year (Olate-Olave et al., 2021). Differences in the abundance of beeforages have a massive role in determining differences in colony productivity. According to Olate-Olave et al. (2021), citing Farrar (1937), productivity is determined by the quantity and duration of nectar flow.

During the Covid-19 pandemic, honey maintained a key role in society as a food supplement for immunomodulation. This occurred especially at the beginning of the pandemic when means of prevention and treatment were still scarce and difficult to obtain. At such times, honey was seen as an alternative means to help strengthen the body's immune system to prevent transmission and help speed up the healing process (Harianja et al., 2023; S. Elsadibah et al., 2023). Because of this, the demand for honey products has increased. As a comparison, a study in Tarakan, North Kalimantan, stated that during the COVID-19 pandemic, the demand for health supplements increased rapidly, growing by 300 to 800% (Lanuddin et al., 2023). *Apis mellifera* beekeepers in Jambi and Riau informed us that demand for honey is increasing rapidly.

From the results of our analysis through the FGD (Focus Group Discussion) forum, several factors were identified that influence the selling price of honey, one of which is the cost of production. However, the influence is classified as medium. Other factors that influence this are market size (high), productivity (medium), interaction with consumers (medium), psychology (medium), production abundance (low), and business competition (low). Thus, the average price of IDR 25,200 is the equilibrium level for the honey price in the market for industrial use. In personal communications during the interview and FGD sessions, the willingness to sell from beekeepers and buy from middlemen and processors were equally important. Such demand dynamics are also essential in the high season of honey production. Based on production cost data from one of the large beekeepers in Riau (Sunoto, personal communication), the production cost for acacia carpa honey is IDR 20,877 (Table 6). Thus, despite competition among beekeepers to sell their honey, they can still profit from their operations.

The results of this study illustrate that acacia carpa honey has the potential to expand honey distribution, enter further on an industrial scale, and expand to export markets. Several factors inherent

in the development and production patterns of carpa honey are supportive to industry growth if improvements and efficiency efforts are made. These factors are: (1) the production capacity of carpa honey is very large considering that the carpa plantation forest area in Indonesia is enormous, reaching 5 million hectares so that it can guarantee production volume requirements; (2) the production period for acacia honey can last throughout the year so that it can guarantee continuity, supply of honey raw materials, (3) the price of acacia honey is such that it may be able to compete in the international market as an export commodity. For this reason, improvements are needed in several areas, including colony management, apiary management, production management, marketing management, and increasing the capacity of beekeepers and other beekeeping businesses. Efficiency efforts in production and post-harvest management are no less important so that the prices formed can genuinely compete in national and international markets.

## CONCLUSION

The research concludes beekeeping with *Apis mellifera* in Indonesia may pose opportunities to become a more significant market participant in industrial honey production because the carpa honey (*Accacia crasicarpa*) from Sumatra region has high productivity, an upward trend in bee colony population, and the capacity for sustainable production. The price of carpa honey from the research period ranged from IDR 22,000 to IDR 31,000 with an average of IDR 25,200. The COVID-19 pandemic propelled demand and signaled readiness in the Indonesian honey industry, which can further be channeled through the production and promotion of carpa honey.

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