

The Effect of Tempe Benguk (*Mucuna pruriens L.*) Feed as a Substitute for Tepungsari on the Performance of Day Age of Work Bees (*Apis mellifera L.*)

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Abstract— The purpose of this study was to determine the level of administration of tempe benguk paste on the appearance of *Apis mellifera L.* worker bees at the age of one day. This research was conducted in Mojokerto Regency, East Java Province from 10 September 2021 to 05 Oktober 2021. The research method was experimental using a Completely Randomized Design (CRD) with 6 treatments and 4 replications. The data were analyzed using analysis of variance and if there was a significant effect between treatments, then it was continued to be tested with Duncan's Multiple Distance Test (UJBD). Tempe was treated as follows: P0 (0%), P1 (5%), P2 (10%), P3 (15%), P4 (20%) and P5 (25%). The variables observed were body weight, body length and wing length of worker bees. The research materials were 24 colonies of *Apis mellifera* bee colonies and tempe benguk paste. The results showed that there was no significant effect of the addition of benthed tempe paste as a substitute for pollen on body weight, body length and wing length of worker bees ($P > 0.05$). Furthermore, Treatment P2 (10%) had the highest body weight, body length and wing length (110 mg; 13.23 mm and 9.15 mm). So, it can be concluded that the best addition of tempe benguk as a pollen substitute for the performance of *Apis mellifera* bees to produce honey is 10%.

Keywords— Worker bees, substitute feed, tempe benguk paste.

I. INTRODUCTION

Apis mellifera bee is one type of bee that has long been cultivated because it can produce honey that is beneficial to humans. These bees are usually bred in several studs placed in plantation areas that have a flowering cycle every year. Honey bees can also produce products of high economic value such as royal jelly, propolis, pollen, and bee venom. Honey bees need food for their growth and development needs. Sarwono (2001) added that feed is one of the factors that can affect the growth and development of bee colonies. Flowering plants are the availability of food sources that can be utilized by bees. The availability of feed resources will also determine the number of offspring that can be maintained at a productive age for the survival of the bee colony.

Honey bees need food to survive in the form of pollen, nectar, and royal jelly obtained by sucking from flowering plants. Nectar is a sweet liquid produced by flowering plants. Pollen is the male reproductive organ in flowers. Nectar is a source of energy for bees while pollen or pollen is a source of

protein, fat, a little carbohydrate and minerals for bees. Budiwijono (2012) added that nectar contains 3-87% carbohydrates such as sucrose, fructose and glucose. Crude protein content in pollen varies between 8 – 40% or an average of 23%. Protein is used by young bees to produce the structural elements of muscles, glands and other tissues. Pollen is also used in the production of royal jelly.

The famine season is an obstacle in honey bee cultivation because it can disrupt the flower development cycle so that the nectar and pollen produced by flowering plants decreases. Bees who lack food cause colonies to become weak, the number of colonies to decrease, and production to decrease. Provision of substitute feed is one way that can be done to overcome the shortage of bee feed sources. Sulistyorini (2006) stated that honey beekeepers in developed countries have used a variety of pollen substitute products known as pollen substitutes during winter and autumn, when there are no flowers or when there is a shortage of flowers. Winston, et al., (1983) added that pollen substitute as honey bee feed can also be made by breeders using local ingredients with several requirements to be liked by honey bees and can increase the productivity of honey bee colonies.

Legumes have 20–48% protein, so they are recommended as one of the main ingredients for mixing feed substitutes. Disadvantages of nuts in the use of protein are difficult to digest, lack of some essential amino acids and anti-nutritional factors. Raw bean (*Mucuna pruriens L.*) has a protein content of 24–31.44%, fat content 4.1-14.39%, crude fiber 6.71%, calcium 1.5%, metabolic energy 2925 kcal/kg and carbohydrate content 41.79-64.88% (Fadhilla, Solah, Angkasa (2018). Tempe is a traditional fermented food made from wet and cooked benguk beans inoculated with a fungus usually derived from *Rhizopus oligosporus*. Kiers, et al., (2003) added that the important function of fermentation in the tempe process is the synthesis of enzymes, fermentation can also reduce or eliminate anti-nutrient elements. Overall, the nutritional quality of fermented products is increasing. Tempe molds produce digestive enzymes so protein, fat, and The carbohydrates in tempeh become more easily digested in the body of young bees. The fermentation process that occurs in tempeh functions to convert complex macromolecular

compounds found in benguk (such as proteins, fats, and carbohydrates) into simpler compounds such as peptides, amino acids, fatty acids and monosaccharides (Bastian, Ishak, Tawali and Bilang, 2013). Furthermore, Widowati (2013) stated that it is recommended that substitute pollen has a particle size below 500 m so that it can be eaten by bees. One alternative to processing tempe products that extend the shelf-life and usability of tempeh is to make tempe paste. Tempe paste whose size and nutritional content resembles that of pollen can increase the productivity of honey bees.

II. MATERIALS AND METHODS

A. Research Material

The study was carried out in Cendoro Village, Dawarblandog District, Mojokerto Regency, East Java from September 10, 2021 to October 5, 2021. The material used in this study was a colony of *Apis mellifera* honey bees with 24 colony boxes (*setup*) with a total of 4 combs. (*frames*). Each hive contains 24,625 worker bees. Each hive is taken 5 day old worker bees which are still fresh without being preserved first. Colonies obtained from honey bee farm CV. Kembang Joyo. The substitute feed comes from peanut benguk tempeh which is ground with a mixture of natural pollen and honey. The raw materials used are obtained from the Dinoyo market, Malang. Equipment used for beekeeping include: colony box (*setup*), comb (*frame*), feeder frame (feeder frame), stationery, and camera. The tools for making feed substitutes are transparent paper, pestle, plastic trays, solets and scales. The equipment used for testing include: analytical scales, calipers and tweezers.

B. Research Methods

The method used in this research is the experimental method. The treatment that was tried was bean tempe benguk paste mixed with honey. Each treatment contains 75% honey.

Finally the treatment given was as follows: P0 = Tepungsari 25% + Tempe Benguk Paste 0%, P1 = Tepungsari 20% + Tempe Benguk Paste 5%, P2 = Tepungsari 15% + Tempe Benguk Paste 10%, P3 = Tepungsari 10% + Tempe Benguk Paste 15%, P4 = Tepungsari 5% + Tempe Benguk Paste 20% and P5 = Tepungsari 0% + Tempe Benguk Paste 25%

This study used a completely randomized design (CRD) experimental model. The linear model is as follows:

Information:

$$Y_{ij} = \mu + T_i + \epsilon_{ij}$$

Y_{ij} = Observation value in the 1-6th treatment and 1-4

μ = General mean

T_i = Effect of treatment to 1-6

ϵ_{ij} = Error (error) in treatment 1-6 and repetition 1-4

i = Treatment

j = Deuteronomy

C. Observation Variable

a. Body weight of the worker bee *Apis mellifera*

Measurement of body weight of a day old *Apis mellifera* worker bee carried out using an analytical balance.

b. The Body Length of the *Apis mellifera* Worker Bee

The length of a day-old worker bee was measured using a caliper with an accuracy of 1 millimeter (mm).

c. *Apis mellifera* Worker Bee Wings

Measurements using a caliper with an accuracy of 0.1 millimeters (mm).

III. RESULTS AND DISCUSSION

The results of the study and analysis of the various effects of treatment on the average body weight, body length and wing length. The average research results for each treatment can be seen in Table I.

TABLE I. Average Body Weight, Body Length and Wing Length of Day-old Worker Bees

Treatment	Body Weight (mg/tail)	Body Length (mm/tail)	Wing Length (mm/tail)
P ₀	106,25 ± 4,7	13,16 ± 0,08	9,11 ± 0,02
P ₁	108,75 ± 8,5	13,18 ± 0,08	9,12 ± 0,02
P ₂	110,00 ± 8,1	13,23 ± 0,04	9,15 ± 0,09
P ₃	103,75 ± 4,7	13,13 ± 0,07	9,10 ± 0,04
P ₄	102,50 ± 2,8	13,10 ± 0,07	9,08 ± 0,02
P ₅	101,25 ± 2,5	13,08 ± 0,04	9,06 ± 0,02

Body Weight

The body weight of the worker bee determines its ability to carry out the activities needed for colony development. The large body weight of the worker bees means that the worker bees can transport large amounts of nectar and pollen and suck nectar faster than smaller bees so that the colony will grow stronger because of the need for nutrients that are available in more quantities (Arianne, 2007). The results of the analysis of variance showed that the addition of artificial pollen made from tempeh bean benguk paste had no significant effect ($P > 0.05$) on the body weight value of day-old worker bees. The average body weight measurement results of day-old worker bees can be seen in Table I.

The average body weight of day-old worker bees ranged from 101.25-110.00 mg. This is presumably because feed consumption in P2 tends to be higher than P5. According to the results of research by Roulston and Cane (2002), it is known that body weight will increase if the feed consumed during larvae also increases. The larvae's diet was royal jelly derived from young worker bees and its secretion was affected by protein consumption, indicating that the nutrients of artificial pollen were well absorbed by the bees. Kuntadi (2008) added that the protein content of honey bees in the range of 60% is very high. In this condition honey bees become stronger and have resistance to disease attacks, live longer, and have a higher ability to find food. On the other hand, the bee's body protein can also decrease by up to 30%,

which is when there is a lack of pollen or under stress conditions that can make bees more susceptible to disease and shorter lifespans.

The provision of substitute pollen with a certain percentage has an effect on the texture, aroma and color of the feed given so that it affects feed consumption. The substitute flour for benguk beans has a sticky texture because it is given in the form of a paste mixed with honey and natural pollen. This is in accordance with Somerville (2000) which states that substitute pollen can be given in the form of a paste, which is a mixture of various compositions of substitute pollen which is then added with honey to form a paste with a good consistency. The color of the artificial feed given is yellow due to the presence of natural pollen from the corn plant which is mixed according to the formulation. P2 is more effectively used as bee feed to increase body weight than P5. The body weight obtained at the time of the study was in accordance with Winston (1987) that the average body weight of the newly released worker bees was in the normal range of 81 mg – 151 mg. It is indicated that bees can use feed consumption efficiently to increase their body weight.

Factors that can affect the body weight of worker bees that have just been born or have just left the cell are cell size, size and age of nurse bees, colony population, nectar and pollen obtained, and disease and season (Winston, 1987). If the colony is in a larval state of lack of food, namely when nectar and pollen are scarce, the colony is susceptible to disease, and the small population will result in the adult bees being produced will be small and their development will be disrupted (Arianne, 2007). Worker bees, the larger their physical size, the more productive they are in their activities, for example in gathering feed, making nests and even maintaining colonies (Febriana, Mahajoeno and Listyawati, 2003).

Body Length

Body length can predict honey bee production, because the main factor in the amount of nectar collected by honey bees is the capacity of the honey bag. The capacity of the honey bag depends on the body size of the worker bees (Novita, Saepudin and Sutriyono, 2013). The results of the analysis of variance showed that the addition of artificial pollen made from tempeh bean benguk paste had no significant effect ($P > 0.05$) on the body length value of day-old worker bees. The average body length measurement of day-old worker bees can be seen in Table I.

The average body length of day-old worker bees ranged from 13.08 to 13.23 mm. The difference in bee body length is thought to be caused by differences in texture, smell and color of each type of paste (P0, P1, P2, P3, P4, and P5). The low P5 body length was caused by the unpleasant aroma of the benthic tempeh paste, which had an unpleasant smell and no added pollen. The factor that most determines the attractiveness of pollen to bees is smell, and not because of the high nutritional content of pollen, age, water content, or color (Minarti, 2010). Worker bees select pollen based on the smell and physical appearance of the pollen grains. The size of the pollen in question is to be in accordance with the means of

transporting bees (Winston, 1987). Honey bees are indicated to be sensitive to sweet, sour, salty and bitter tastes and can distinguish tastes like humans (Febretrisiana, 2006). The average body length obtained during the study according to the statement of Febriana, Mahajoeno and Listyawati (2003) stated that the body length of bees that had just come out of the cell had an average range of 11.5 – 14.1 mm for worker bees, 15.0 – 17, 5 mm male bee, 18.0 – 20.0 mm queen bee.

The length and shape of the body in honey-producing bees that are very quickly influenced by plant species because the body is adapted to extract nectar from various types of plants that are the source of bee nectar. Bush plants contain a lot of pollen and to meet the needs of nectar as a source of carbohydrates by feeding artificial honey. Tepungsari is needed for the development of the body parts of the *Apis mellifera* honey bee because the increase in the length of the bee's body requires protein. The increase in bee body length will not be optimal because the pollen needs are not met (Sihombing, 1997). Feed, temperature and environment are also important factors that can affect the life of honey bees. Temperature can affect honeybee life activities (foraging for food, breeding and caring for offspring) directly or indirectly (Winarno, 1981).

Wing Length

The relatively small size of the wings causes the spread of the pygmy bee. The limitation of flight in foraging activities has an impact on the development of the colony. The wing size of worker bees has generally been considered an adaptation for foraging activities and exploiting flower resources (Jasmi, 2013). The results of the analysis of variance showed that the addition of artificial pollen made from tempeh bean benguk paste had no significant effect ($P > 0.05$) on the wing length of day-old worker bees. The average results of measuring the wing length of day-old worker bees can be seen in Table I.

The results of the analysis of variance showed that there was no significant difference between the six treatments. The average wing length of day-old worker bees ranged from 9.06-9.15 mm. Aroma is the most important aspect in the manufacture of feed. The aroma of the feed in P2 was more in line with the preferences of the bees compared to the aroma of the feed in P5. This is evidenced by the presence of leftover feed in P5, while in P2 there is no remaining feed. Therefore, the amount of digested feed from P2 tends to be higher than P5. The aroma produced is typical of benguk beans and the distinctive aroma of natural pollen. The distinctive aroma of natural pollen is sweet with the addition of honey which dominates as much as 75% in each treatment, giving rise to a sweet aroma and attracting the attention of honey bees to approach. The distribution and concentration of protein or amino acids in the honeybee's body is also influenced by physiological activity, diet, age, species strata and environmental conditions (Keller, Fluri and Imdorf, 2005). The protein content of the artificial pollen obtained is high, but it does not really affect the development of bees because of the inappropriate aroma of the feed. Average The wing length above is good according to Andereb, et al., (2012) which

states that the morphological character of worker honeybees has a wingspan of about 8.54-10.01 mm.

Sari, Jasmi and Pratiwi (2013) stated that in addition to feed factors, environmental factors also affect the life of bees. Air temperature can affect the metabolic processes in the body of bees. The temperature of 30°C – 33°C is a comfortable temperature for bees. Dwiyono, Jasmi and Safitri (2014) added that the air temperature drops by a few °C, the activity of the bees will decrease and the energy from the food they take is mostly used for tissue formation, especially muscle tissue. Muscle tissue in the chest will work together with nerve tissue to move the wings, legs, head and stomach.

IV. CONCLUSIONS AND SUGGESTIONS

Conclusion

The level of feeding substitute for tempe bentuk P2 as much as 10% in the diet of day-old worker bees gave the best treatment with a body weight value of 110 mg for a body length of 13.23 mm and a wing length of 9.15 mm.

Suggestion

Based on the results of the study, it is recommended to remove the unpleasant aroma in the bentuk tempe paste so that it resembles natural pollen and more homogenizes the mixture of honey, natural pollen and bentuk tempe.

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