Formulation of winged bean seeds as pollen substitute for outgrowth of honey bees (Apis mellifera L)

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Abstract. The availability of pollen in plants depends on the season. The rainy season becomes a limiting factor for honeybees to obtain a source of pollen because there are not many flowering plants this season. This causes the development of honey bee colonies to be inhibited, as pollen is the only source of protein for the naturally available bees that can affect the rate of reproduction and the life span of bees. The winged bean contains a high enough protein and amino acids that the bees require, so the winged beans can be used as artificial feed of pollen substitute. Winged bean seeds be processed into three types of processed, namely roasted winged bean seeds (TKS), boiled winged bean seeds (TKR), and fermented winged bean seeds (TKF). Winged bean seeds flour given to bees in paste form. Based on the observations obtained the results that the consumption of the bee's liked is roasted winged bean seeds, because it does not a bad odor. The smell is lost due to the roasting process. Protein content of fermented, boiled, and roasted of winged bean seeds was 6.46%; 7.36%; and 15.19%. While the fat content on fermented, boiled, and roasted of winged bean seeds were 8.35%; 8.31%; and 12.07%. This indicates that the most preferred type is roasted winged bean seeds with the highest protein and fat.

1. Introduction

Apiculture, the maintenance of honey bee colonies by humans, has faced a number of challenges in recent years. While our dependence on honey bees has vastly increased, 80% of global agricultural pollination services can be attributed to the European Honey Bee, Apis mellifera and 52 of the 115 leading global food commodities depend on honey bee pollination for either fruit or seed, managed colonies in both Europe and North America especially have declined [1]. The business of bee development can develop well when viewed from the natural potential of Indonesia, but the development of honey bees is decreasing. In many areas of the Kingdom, bees and beekeepers suffer from seasonal drought, which causes a shortage of bee forage [2]. These conditions drive many beekeepers to move their colonies from one area to another in search of better nectar and/or pollen sources and to avoid severe weather condition [3]. The reason is that there is insufficient nutrition for the growth of bees. Nutrients obtained by bees come from pollen proteins with a content of 2.5-61% [4-5]. Physiological and nutritional needs of workers, queens and drones differ somewhat honey bee colonies and the workers are responsible for the colonies’ productivity and health [6].

Pollen supplies are not always available at all times, availability depends on the season. Bee researchers from the Indonesian Institute of Sciences say that domestic honey supply is threatened to
shrink along with the expansion of widespread forests and conversion of agricultural land. This makes the distribution of flowers decrease, even though the flower is the producer of nectar or flower extract which is the bee feed. Flower fatigue occurs when the rainy season is prolonged. Based on annual data from the Ministry of Trade, the average import of honey is 2000-2300 tons per year [7].

Farmers usually provide additional food in the form of sugar water to overcome the problem of lack of nectar. Farmers in Indonesia still rarely provide substitute feed for pollen for honey bees when natural pollen is not sufficiently available in nature. The rainy season is also a limiting factor for honey bees to get pollen sources because there are not many plants that bloom this season. The development of honey bee colonies can be hampered if the problem of availability of pollen is not immediately addressed, and can cause great harm to farmers [8].

Many sources of protein are used as artificial pollen ingredients [9]. The protein content of old winged beans reaches 33.3-38.3%, which is almost the same as the protein content of soybean seeds around 39.8-42.8%. Winged beans are reported to contain amino acids that resemble soybeans. Besides that, winged productivity is higher than peanut or soybean plants [10], so that winged beans can be used as an alternative to substitute pollen.

2. Method
The research methods included making winged seed flour, testing the protein and fat content of winged seed flour, and the implementation of winged seed flour on bees to find out the bees' interest in winged seed flour with three variations of processed types. The equipment used is the bee box (stup) along with the combs and supports, pollen trap, queen blocker, queen lever, bee brush, smooker, mask, tweezers, scales, plastic bags and ovens. The ingredients used are winged beans with three different types of processing, namely roasted winged beans (BKS), boiled winged beans (BKR), and fermented winged beans (BKF).

The research was carried out using one bee box with seven combs. Feed given in the form of pasta with a ratio of 50 grams of winged bean flour + 100 grams of sugar water. Feed given in the form of paste, then observed bee attraction in the feed.

3. Result and Discussion

3.1. Nutrient content of winged seed flour
Tepungsari contains nutrients, namely charcoal, protein (in the form of essential amino acids), essential fatty acids, vitamins, minerals, enzymes and hormones that the body needs for the regeneration of tissue cells [11]. Analysis of protein content in artificial pollen was carried out by spectrophotometric method [12], while the analysis of fat content was carried out by the Soxhlet method [13]. The protein and fat content of each processed can be seen on Figure 1.

![Figure 1. Nutrient content of winged seed flour](attachment:image.png)

Based on the above results, that winged bean flour which has the highest protein content is winged seed flour which is processed by roasting. This is because the roasting process only takes place
at a temperature of 60-70°C for 20 minutes, so that a little protein is denatured due to roasting. This result is consistent with research conducted by [14] that red beans which are roasted for 20 minutes have a high protein content of 26%. The results obtained are also in accordance with the research conducted by [15] concerning the manufacture of mung bean seed flour through the revision that the protein content of roasted mung bean seeds is 27.16 w/w higher than oven green bean flour with a protein content of 26.99 w/w.

The protein content of boiled winged beans is lower than roasted winged beans. The boiling process greatly reduces the protein content of red pea with skin and without skin. In the fermentation process the protein with the lowest levels is produced, this is the result of too long oven processes which can cause denatured proteins [14]. Roasted winged beans have the highest fat content among the three types of processed. This is in accordance with the research of [14] that the fat content of red beans which is roasted for 20 minutes is the highest than the fat content in the boiling and steaming process.

Based on the results of the analysis of protein and fat content that processed with the highest protein and fat are roasted winged bean flour. Protein and fat are two important nutrients that are needed by honey bees [15], so roasted winged flour flour can be used as an alternative as artificial pollen that can be given to honey bees during the famine season.

3.2. Preference of honey bees to artificial pollen

There are five factors that must be considered in procuring substitutes, namely bee interest, availability of materials, prices, nutrition, and the presence or absence of toxic substances. Pollen substitute is a mixture of winged bean flour processed with sugar water, so the pasta mixture is obtained. The sweet taste generated by sugar water to attract honey bees while the paste form is intended so that bees can easily pick it up. The interest of honey bees to the feed given can be seen based on the consumption of honey bee on the artificial feed. Based on the preference test, data is obtained as shown in Figure 2.

Based on the observation that many of the processed bees taken are roasted winged beans, because of the 5 grams of winged bean flour paste which is given, as much as 2.1 grams of winged bean flour paste taken by worker bees. The consumption difference is influenced by external factors of the artificial pollen feed, namely the aroma of the food given. Flavored roasted seed flour has a distinctive aroma so the bees are attracted to the type of roasted processed. Clark et al [16] states that worker bees take pollen from flowers based on the color, aroma, and physical form of pollen grains.

The distinctive aroma of winged roasted bean flour is caused by the loss of the sweet smell of winged beans. The bad smell in winged beans due to the oxidation of fatty acids not saturated by the lipoxygenase enzyme and produces aldehyde and ketone compounds [17]. Lipoxygenase enzyme can be activated by roasting. As is the case, in making mung bean flour through roasting, the roasting
process can activate the lipoxygenase enzyme, thus reducing the odor more unpleasant than the green beans being oven [18].

4. Conclusion
Winged seeds that have been processed with three variations of processing are fermented, boiled and roasted winged beans having a protein content of 6.46%; 7.36%; and 15.19%. While the fat content in the fermented, boiled and roasted process were 8.35%; 8.31%; and 12.07%. The highest interest of honey bees is found in roasted winged bean flour with the highest protein and fat content among the three types of processed.

References
[1] Van E D and Meixner M D 2010 J. Invertebr. Pathol. 103 80
[2] Nuru A, Shenkte A G, Al-Ghamdi A A, Said H, Ansari J, Sammoud R and Touir A 2013 J. Food Agr. Environ. 11 2220
[3] Alqarni A S, Haman M A, Owayss A A and Engel M S 2011 ZooKeys 134 83
[4] Arruda V A S, Pereira A A S, Freitas U S, Barth O M and Almeida M L B 2013 J. Food Compos. Anal. 29 100
[5] Yang K, Wu D , Ye X Q, Liu D H, Chen J C and Sun P L 2013 J. Agric. Food Chem. 61 708
[6] Pradeepa S D, Bhat N S and Mutthuraju G P 2014 Current Biotica. 8 21
[7] Brodschneider R and Crailsheim K 2010 Apidologie. 41 278
[8] Febretisiana A 2006 Essay (Bogor: Bogor Agricultural University)
[9] Amoo I A, Adebayo and Oyelaye 2006 Afr. J. Food Agric. Nutr. Dev. 6 2
[10] Budijanto S, Azis B S and Wita M 2011 J. Food Technol. Ind. 23 165
[11] Minarti S 2010 J. Trop. Livest. 11 54
[12] Wijaya H, Nurhasnawati H and Jubaidah S 2016 Manuntung Sci. J. 2 111
[13] Angelia I O 2016 J Tech. 4 19
[14] Monoharapon E, Sandra J N and Laiyan D 2017 J. Agric. Technol. 6 21
[15] Kuntadi. 2008 J. For. Res. Nat. Conserv. 5 367
[16] Clarke D, Morley E and Robert D 2017 J. Comp Physiol. 203 737
[17] Wijaya C, Kardono L B S and Halim J M 2015 J. Food Technol. Appl. 4 112
[18] Pertiwi R P, Larasati A and Laili H 2018 Technol. Vocat. J. 41 89