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Effect of Microwave and Oven Drying to the Drying Characteristics, and Quality of Stingless Bee (*Tetragonula biroi*) Pollens

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Abstract

Stingless bee pollens are good source of vitamins and minerals that can be collected from the surplus of bees. The effect of two drying methods on the drying characteristics, and nutritive value of the stingless bee pollens has been investigated. Microwave drying and oven drying were the methods applied in the study. Results revealed that microwave drying, outweighs oven drying almost in all drying parameters. In terms of the quality of stingless bee pollens, there was no significant difference found in the pH level of the microwave and oven dried samples except for the water activity. For the nutritive value of stingless bee pollens, oven drying showed higher beta carotene content compared to microwave drying but was found to be not statistically different to each other. On the other hand, microwave drying showed higher protein and vitamin E content but was also found to be not statistically different from each other.

Keywords: *drying, microwave, oven, pollen, stingless bee*

Introduction

Bee pollen is a rich source of essential nutrients and is regarded as one of nature's complete foods. It's rich in calcium, vitamins, minerals, and antioxidants, all of which are important to our health. It contains a lot of B vitamins, which are essential for brain health. Protein, one of the most valuable components of bee pollen, is essential for the development of healthy skin, bones, and muscles (Campos *et al*., 2008; Miranda *et al.*, 2020). Worker honeybees collect bee pollen when foraging. Honey supplies carbohydrates for honeybees, but bee pollen provide all of the nutrients that honey can't provide. Humans take advantage of the opportunity to collect excess bee pollen using pollen traps when pollen production peaks.

Honey has always been the main product from honeybees. Like honey, bee pollens can also be produced for human consumption and pharmaceuticals. Bee pollen is a perishable commodity and exposure of fresh bee pollens to moisture will promote deterioration. Because the bee pollen will be processed and stored as food or supplement, the need for an efficient drying technique is required to maintain the nutritive value of the product (Campos *et al*., 2010; Miranda *et al*., 2020).

After collection the bee pollens are normally stored in the freezer to prolong its shelf life. But considering that bee pollens will be packed dry in bottles, sachet or in capsules, drying is a better option. Drying of honeybee pollen is essential in improving storage life and meeting market requirement. The need for drying prevents mold formation and eventual deterioration.

*Bulacan Agricultural State College, Pinaod, San Ildefonso, Bulacan, Philippines

Air drying is not enough to meet market requirement and it can expose the product to contaminants therefore using dryers is essential. Also, the cold storage system throughout its distribution chain is not always available and dried pollen is currently the requirement for sales. Stingless bee pollens take around three weeks of air drying before the product is ready for sales. The amount of time to dry the product can cause delay in the marketability and longer exposure during air drying can cause food contamination. Drying time also influence power consumption as longer drying consumes more energy. This will result to higher production cost affecting the income of the bee producers or processors.

As fresh bee pollen contains a considerable amount of moisture, it can be a natural breeding ground for bacteria and fungi. Drying, which is a technique for preserving bee pollen, has been used for many years, but the study showed that dehydrating pollen causes the depletion of some of the vital nutrients in bee pollens (Campos *et al.*, 2008). Microwave drying, another form of dehydration, has been tested and stated to have less drying time compared to traditional drying without or less impact on the nutritional value of the product. In effect, this decreases energy demand while increasing output (Pereira de Melo & Almeida-Muradian, 2010; Miranda *et al.*, 2020). Therefore, the purpose of the study is to evaluate the properties and drying characteristics of stingless bee pollens dried using oven drying and microwave drying to determine the difference between the two drying methods. Specifically, to compare the drying time, moisture reduction rate, and recovery of microwave and oven drying and to evaluate the quality of the dried pollens in terms of pH, water activity, protein, vitamin E, and beta carotene.

Methodology

Preparation of Materials

Fresh stingless bee pollens were bought at a bee farm in Sorsogon City. The samples were kept refrigerated until they were ready to be processed. The frozen bee pollens were allowed to warm up to room temperature before being dried. The pollens were cleaned manually by extracting foreign materials such as dead bees and bee legs. To achieve homogeneity in the samples, the bee pollens were mixed.

Six 150 grams of stingless bee pollens were used to compare the microwave and oven drying. Both drying techniques were tested for their drying performance. The temperature of the oven dryer was set at 45 °C while the microwave dryer was set at 700W. Moisture content of the samples in both drying conditions were recorded with 30 minutes intervals (or as needed) until 7% moisture content was reached. Final weight of the sample with 7% moisture content was computed using (1) (PAES, 2010; Somerville, 2012; Miranda *et al*., 2020).

$$Wf = \frac{Wi\ (100\text{-}MCi)}{(100\text{-}MCf)} \qquad (1)$$

Where Wf is the final weight of the sample (g), Wi is the initial weight of the sample (g), MCi is the initial moisture content (%), and MCf is the final moisture content (%).

Comparison of Microwave drying and Oven drying

The microwave dryer by Miranda et al., (2020) and an oven dryer (MEMMERT) was used for the microwave drying, and oven drying of the stingless bee pollens, respectively. Microwave drying and oven drying methods were evaluated using the following parameters:

Moisture Reduction Rate

The moisture reduction rate of the microwave dryer was computed using (2) (Abano, 2016).

$$MCr = \frac{MCi - MCf}{Td} \qquad (2)$$

Where MCr is the moisture reduction rate (%/h), MCi is the initial moisture content of test material (%), MCf is the final moisture content of test material (%), and Td is the actual drying time (h).

Percentage Recovery Output

Percentage recovery is defined as the ratio of final weight of dried output to initial or fresh weight of sample material expressed in percent using (3) (PAES, 2000).

$$PR = \frac{Wf}{Wi} \times 100 \qquad (3)$$

Where PR is the percentage recovery (%), Wi is the initial weight of test material (g), and Wf is the final weight of test material (g)

pH and Water Activity

The pH level of stingless bee pollen was measured using a bench top professional pH meter (TRANS INSTRUMENTS) while water activity was tested using a water activity meter (NOVASINA).

Protein, Vitamin E and Beta Carotene Content

Analysis for beta carotene, protein and vitamin E content of the stingless bee pollens was done by SentroTek in Mandaluyong City. Protein content was determined using Kjeldahl method while vitamin E and beta carotene content was measured using high performance liquid chromatography.

Statistical Analysis

The stingless bee pollens dried using microwave drying and oven drying were compared and analyzed using independent t-test with 5% level of significance.

Results and Discussion

Drying Characteristic

Drying Time

Drying time is an important parameter in drying. Lessening the drying time of commodities will provide an ample time for other activities and hasten its processing. The drying time of stingless bee pollens as influenced by microwave and oven drying method were shown in Table 1. The result of the analysis found that there was a significant difference between the drying time of stingless bee pollens using microwave and oven drying treatments.

Table 1

Drying characteristics of stingless bee pollens using microwave and oven drying

	MICROWAVE DRYING	OVEN DRYING
Drying time, hr	0.07±0.00a	182.00±21.00b
Moisture Reduction Rate, %/hr	89.98±11.15a	0.03±0.00b
Percentage Recovery Output, %	93.62±0.74a	94.62±0.00a
pH	3.88±0.02a	3.87±0.03a
Water Activity	0.29±0.01a	0.33±0.01b

Note: Means with the same letters within columns are not significantly different at 5% level of significance

Using the microwave drying method, drying time was faster and only requires less than an hour of operation of 0.07 hours. The drying time of the oven drying method had significantly longer drying time of 182 hours to reach the desired level of moisture of around 7%.

Moisture Reduction Rate

The drying characteristic of the stingless bee pollen using oven and microwave drying were represented as drying curves plotted in moisture ratio against drying time as shown in Fig. 1 and 2, respectively.

Figure 1

Drying curve using oven drying method

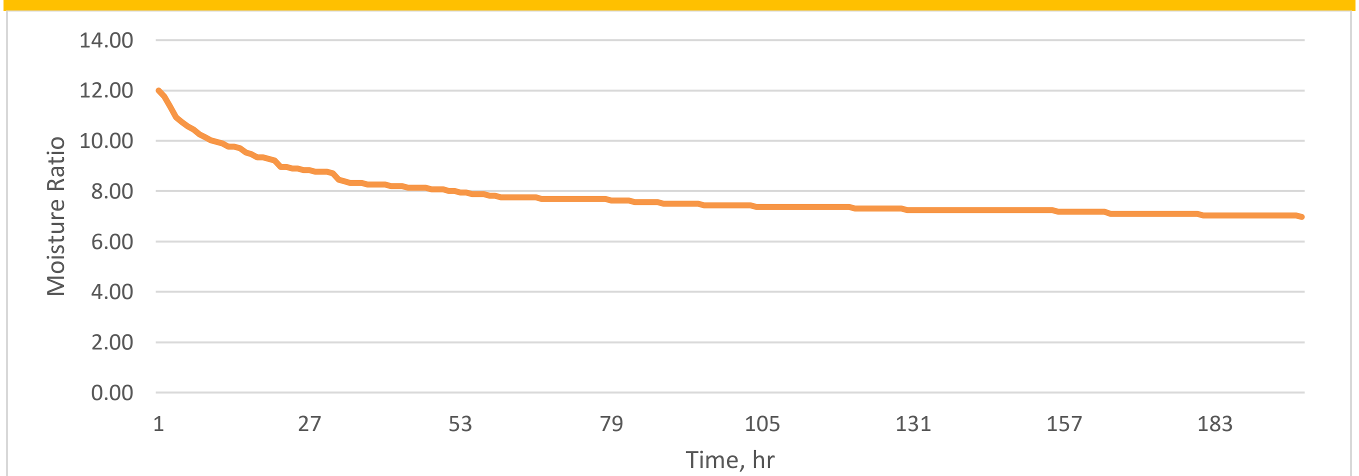
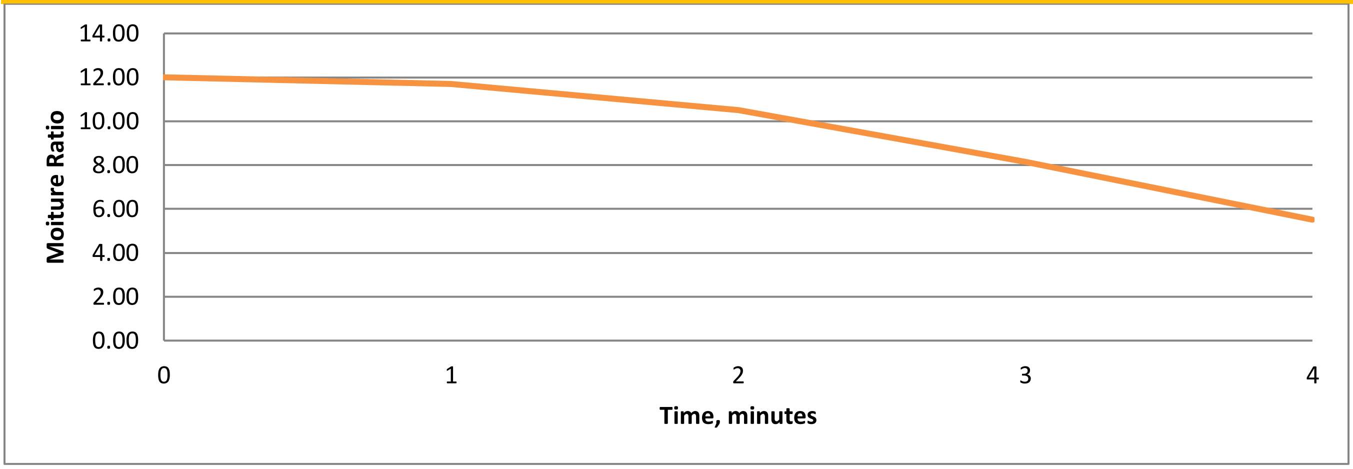


Figure 2

Drying curve using microwave drying method



When using oven drying, there was an increase in moisture loss during the first 3 hours of drying and constant weight loss thereafter. In microwave application, moisture losses at initial stage were slow and start to build up upon completion of drying.

The microwave drying treatment have significantly higher reduction rate of 89.98%/hr compared to oven drying. A 0.03%/hr drying rate was observed from the oven drying treatment.

The moisture reduction rate of stingless bee pollens as influenced by microwave and oven drying method were shown in Table 1. The result of the analysis found that there was a significant difference between the moisture reduction rate of stingless bee pollens using microwave and oven drying treatments.

The reason for the decrease of moisture of the stingless bee pollens was due to the higher water molecules content of the samples during the start of the drying that results to a higher absorption of microwave energy. This high absorption of energy leads to higher moisture loss due to moisture diffusion. Continuous moisture loss after the initial stage of drying causes less absorption of microwave energy of the product. This results to the decrease in the drying rate. This phenomenon was due to the generation of heat inside the sample creating a large vapor pressure difference with its surface as a result of volumetric heating (Zarein *et al.*, 2013).

Percentage Recovery Output

Table 1 shows the mean percentage recoveries as affected by the different drying methods. The result of the analysis found that there was no significant difference between the percent recovery of stingless bee pollens using microwave and oven drying treatments.

Quality Parameters of Dried Stingless Bee Pollens

pH

pH level is the degree of acidity or alkalinity of a substance. Acidic food has a pH value between 0 and 7 while alkaline foods has pH value between 7 and 14 having 7 as neutral in the case of distilled water.

The pH levels of dried stingless bee pollens as influenced by microwave and oven drying method were shown in Table 1. The result of the analysis found that there was no significant difference between the pH values of stingless bee pollens using microwave and oven drying

The pH value of the microwave and oven dried stingless bee pollens in aqueous solution were found to be acidic. These values were slightly lower compared to the pH range of 4 to 6 based on the Technical Regulation for bee pollen (Rebelo *et al.*, 2016). However, these values are acceptable for storage as they are lower than a pH value of 5 where most microbes stop growing (METER Group, n.d.).

Water Activity

Water activity is an important factor for the preservation of dried commodities. Depending on the level of water activity, microbial growth are prevented which can lead to the spoilage of the product. Therefore maintaining or lowering the water activity should be reduced to minimum.

The effect of using microwave and oven drying to the water activity of dried stingless bee pollens was shown in Table 1. A significant difference was found in the water activities of stingless bee pollens using microwave and oven drying treatments.

The result of the analysis shows that water activity was affected with different drying process. Specifically, microwave drying of stingless bee pollens produce lower water activity values compared to oven drying.

Data suggest a stable product with no microbial proliferation as all values falls below a water activity of 0.6 which is the growth limit for common microorganisms (METER Group, n.d.). Therefore, development of various microorganisms that deteriorate food can be prevented or stopped resulting to food with better shelf life (Rebelo *et al*., 2016).

Stingless Bee Pollen Composition

The chemical composition of bee pollens depends on various factors such as floral source, location, climate, soil, species and activity of bees. This can lead to better quality bee pollens compared to others (Campos *et al*., 2008; Barajas *et al.*, 2012; Di Pasquale *et al.,* 2013; Komosinska-Vassev *et al*., 2015).

Figure 3

Stingless bee pollens

Protein

The effect of using microwave and oven drying to the protein content of dried stingless bee pollens was shown in Table 2.

Table 2

Protein content of dried stingless bee pollens using microwave and oven drying

	MICROWAVE DRYING	OVEN DRYING
PROTEIN, %w/w	18.00±0.36a	17.73±0.12a
VITAMIN E, mg/100g	0.32±0.12a	0.19±0.04a
BETA CAROTENE, mg/100g	0.12±0.07a	0.40±0.23a
PROTEIN, %w/w	18.00±0.36a	17.73±0.12a

Note: Means with the same letters within columns are not significantly different at 5% level of significance

Results show that there was no significant difference in the protein content of stingless bee pollens dried using microwave. The protein content of the microwave dried sample is greater than the value that was stated by Miranda *et al.* (2020). They reported 16.1%w/w protein content in the microwave dried sample from the fresh sample of 16.7%w/w. This can be the result of the change in the target moisture content from 4% to 7%, from Miranda *et al.* (2020) and this paper, respectively.

Vitamin E

The vitamin E content of dried stingless bee pollens as influenced by microwave and oven drying method were shown in Table 2. The result of the analysis reveals that there was no significant difference between the vitamin E content of stingless bee pollens using microwave and oven drying treatments. Similar with the findings for the protein content, the target moisture content may be a factor affecting the nutritive value of the microwave dried samples. Miranda *et al*. (2020), reported 2.8 mg/100g vitamin E content from a 1.1 mg/100g fresh sample, their findings is greater than the value stated in this study.

Beta Carotene

Beta carotene is a provitamin that is a substance needed or can be converted into vitamins. Carotenes are sensitive to light and oxygen but stable even at high temperatures. Drying of products with carotene can concentrate its antioxidants content and preserve carotenoids (Barajas *et al.*, 2012).

The effect of using microwave and oven drying to the beta carotene content of dried stingless bee pollens was shown in Table 2. Results show that there was no significant difference in the beta carotene content of stingless bee pollens dried using microwave and oven dryer. The result shows that the microwave dried sample has lower beta carotene content compared to the reported value of Miranda *et al.* (2020), of 0.226 mg/100g.

Conclusion and Recommendation

Based on the results of the study, the drying time, and moisture reduction rate of using microwave drying to stingless bee pollens greatly outweighs the oven drying method, while parameters like percentage recovery, and pH prove to have no significant difference from each other. In terms of the nutritive value, the protein, vitamin E and beta carotene content of microwave and oven dried stingless bee pollens were found to be not significantly different to each other. Therefore using microwave drying can provide the same quality of oven dried stingless bee pollens but in a faster and more efficient way possible. Comparing results on the nutritive value of the microwave dried sample from previous work shows that the final moisture content may be a factor influencing the nutritional content of dried stingless bee pollens. Hence, it is recommended to use microwave drying as rapid method of drying stingless bee pollens with similar quality with oven dried bee pollens. Also, more in depth study about the effect of various parameter combinations is necessary to further improve the quality of the dried stingless bee pollens.

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