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Effects of Bee Bread Microencapsulation with Biopolymers Using Spray Drying Technique

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Abstract

Bee bread (BB) is one of natural products from bees that is consumed for its nutritional and health benefits. BB contains abundance of proteins, flavonoids and phenolics and these bioactive compounds are sensitive and easily degraded over time. Therefore, effective encapsulation is essential to preserve these compounds. In this study, the spray drying technology is used to encapsulate bee bread with biopolymers like xanthan gum (XG), Arabic gum (AG), chitosan (Chi), and sodium alginate (SA) to retain its nutritional value. Several formulations of BB: biopolymer were prepared and solution was put into a spray dryer with an inlet temperature of 160°C to 170°C and a flow rate of 7 to 12 rpm. Microencapsulation efficiency (ME), total protein, total flavonoid content (TFC), total phenolic content (TPC) and antioxidant tests such as DPPH and FRAP assays were also assessed. Using spray dryer technique, there was only 45% efficiency when encapsulated with Chi and SA. Total protein value is 661.863 µg/g for a sample that used (Chi) and (SA), while sample 10, encapsulated BB with (XG), (AG), and SA, shows the highest TFC and TPC values which are 11.266 mg QE/g and 32.026 mg GAE/g, respectively, demonstrating significant retention of bioactive compounds. For DPPH, sample 4 which contains SA shows the highest IC_{50} which is 76.7% and for FRAP assays sample 16 shows the highest reading which is 2259.6mg AAE/g, when using (Chi) and AG. Additionally, tests using FTIR and SEM were performed to evaluate the microstructure of microencapsulated bee bread. Sample 12, which contains chitosan (Chi), XG, and SA shows the best result where in SEM, the structure of encapsulated BB is much bigger which is 200µm compared to raw BB which is 10µm. In FTIR, stronger functional group is present after encapsulation process, indicating stable encapsulation due to O-H bond present at peak 3270.89cm^{-1}. In conclusion, samples 15, 16 and 10 have better formulations to encapsulate bee bread while retaining its bioactive compound with spray drying technique.

1. Introduction

Bee bread (BB), also known as ambrosia, is a product of fermentation of pollen, nectar, and bee saliva in a comb cell. The components will be crammed in the combs, and the bee will seal them with wax and honey. The preserved

pollen will later undergo lactic acid fermentation and produce the bee bread [1]. BB is well known for its high nutritional value, containing bioactive compounds that positively affect human health. Moreover, bee bread contains higher nutritional value than bee pollen and is better digestible due to the free amino acids and assimilated sugars [2]. This will help the body heal damaged tissue, strengthen immunity, and maintain a healthy body. However, in a previous study, it was stated that in Malaysia, bee bread's nutrition is not widely studied, especially the stingless bee *Heterotrigona itama,* known as "kelulut" [3]. Although bee farming is expanding among beekeepers in Malaysia, they still underuse bee bread since they mainly profit from honey production. A kilogram of bee bread can cost up to MYR448.11 locally [3]. The Malaysian stingless beekeeping sector is growing, but there is still a lack of information about the by-products produced by these bees, and there are currently no recognized criteria for bee products in Malaysia.

Currently, the BB sold at the market is granulated bee bread that is hard, dry, and brown. It tastes terrible and has a strong flowery scent [4]. In order to get bee bread ready for eating, it must be ground, soaked for a few hours, and then combined with other staples like milk, juice, and water to improve its flavour [4]. Furthermore, while preparing the bee bread, particular attention should be given to the temperature, which should not exceed 50°C because overheating bee bread can significantly lose its nutritious content. Making bee bread is so time-consuming and laborious that frequent supplementation may be discouraged [4].

Current drying process of bee bread is oven drying and freeze drying. However, oven drying has a risk of loss of nutritional values of bee bread since the temperature used is high while freeze drying can be costly. Although oven drying is more accessible since most homes have ovens, this method might ruin the quality of BB due to overheating or even burning the oven. Thus, when consumed by humans, they might not get the total dietary value from the bee bread. Since BB is rich in vitamins, minerals, and other bioactive ingredients such as polyphenols and flavonoids that benefit health [5], by encapsulating the bee bread, it increases the shelf life where its bioactive compounds and antioxidant properties will not degrade over time consumers consume the bee bread. Thus, they still get the nutritional and functional value that is offered by bee bread [5].

Spray drying technique was chosen in this study since it is one of the most popular encapsulation techniques in the food business because of its high equipment availability and relatively low cost for microencapsulating bioactive ingredients as well as its efficiency during encapsulation process where the temperature and flow rate of spray dryer easily adjusted to desired parameters. More importantly, the material can be used with thermolabile compounds due to its low heat load [6]. Gum arabic, chitosan, xanthan gum, and sodium alginate were used as coating materials since all these materials are natural polymers that are more compatible for humans to consume. The microencapsulation efficiency and antioxidant of encapsulated BB were then assessed to determine the best microencapsulating formulation.

2 Materials and Method

2.1 Materials

Bee bread, xanthan gum, Arabic gum, sodium alginate, chitosan (EMORY), spray dryer (SOLTEQ Model:FD20), Fourier Transform Infrared Spectroscopy (FTIR) (Thermo Scientific Nicolet iS5), UV-Vis Spectrophotometer, Ferric Reducing Antioxidant Power (FRAP) Assays, 2,2-diphenyl-1-picrylhydrazyl (DPPH).

2.2 Microencapsulation Bee Bread

The raw bee bread was bought from the beekeeper. Then, it was stored in the chiller before drying the sample in the drying oven, before running through spray dryer. The dried bee bread was then mixed with biopolymers such as Arabic gum, xanthan gum, chitosan, and sodium alginate. The bee bread will be microencapsulated by spray drying technique with biopolymers. First, bee bread was immersed in distilled water, and then biopolymers were added. Bee bread was followed by chitosan then Arabic gum, xanthan gum and lastly sodium alginate was put into beaker with this arrangement. A homogenous solution was produced by dissolving the bee bread and biopolymer mixture in distilled water using a homogeniser. The speed of homogeniser used is 5000 rpm to 8000 rpm.

A biopolymer is used in small amount which is 5g while BB used is 1g, diluted in 500mL distilled water using homogenizer to homogenise the solution where the speed of homogenizer is 8000 rpm.

The mixture of bee bread was fed into the spray dryer feed. Before that, the spray dryer was set with desired parameters such as the inlet and outlet temperature, and feed flow rate. The solutions were put into a co-current

laboratory spray dryer, which was equipped with a 1.5 mm diameter nozzle screw cap and a pneumatic nozzle (two-fluid nozzle) atomizer with a 0.7 mm nozzle tip diameter. The pneumatic nozzle atomizer had a 5–300 µm droplet size range. The spray dryer was run with a feed flow rate of 0.08 to 0.13 ml/s and an inlet temperature range of 160 to 170°C [7]. The glass bottle at the cyclone's base was used to collect the samples of encapsulated bee bread. After solution mixture of bee bread and biopolymers went through the spray dryer, the encapsulated bee bread was collected in the collecting bottle. Around 40% of dry weight of encapsulated bee bread was collected. This was calculated by using formula:

$$\text{Yield (\%)} = (\text{Mass of collected BB (g)}/\text{Mass of feed (g)}) \times 100$$

For example,

$$\text{Yield (\%)} = \frac{2.271}{6} \times 100$$
$$= 37.9\%$$

2.3 Stability of encapsulated bee bread

There are two tests were done for this objective, which are FTIR and Scanning Electron Microscopy (SEM). For FTIR, this test was done to identify the bonding between biopolymers and bee bread itself while for SEM is to observe the structure of the raw bee bread after encapsulation with biopolymers. These two tests were chosen because it is known as complementary analysis [21]. For example, SEM-EDX makes it possible to identify inorganic materials (pigments and fillers) found in paint layers, while FTIR is more suited for the examination of organic materials (binding media) [21].

2.3.1 Fourier Transform Infrared Spectroscopy (FTIR) Analysis

In order to obtain the Fourier-transform infrared spectroscopy (FT-IR) spectra of the encapsulated BB and raw BB, a Nicolet iS5 spectrophotometer (Thermo Scientific) in Attenuated Total Reflectance (ATR) mode was used. The equipment has a wave number range of 4000 to 650 cm^{-1} at a resolution of 4 cm^{-1}. Each analysis of formulation involved placing the material directly onto the ATR crystal [8].

2.3.2 Scanning Electron Microscopy (SEM) Analysis

After bee bread went through spray dyer, samples were observed under scanning electron microscopy (SEM) using method from a previous study [9]. The samples were placed on the aluminium stub's smooth surface using adhesive tape. A thin layer of gold was applied to the samples using a Baltec SDC 005 Sputter Coater, and they were subsequently examined using a JSM-IT100 InTouchScope SEM. 63µm and 1000 µm magnification were used to see the images of raw bee bread and encapsulated bee bread [9].

2.4 Assessment of functional values in encapsulated bee bread

For the last objective, there are a few tests will be done such as total protein, total flavonoid content (TFC), total phenolic content (TPC), and antioxidant test. For antioxidant test, there will be two tests which are DPPH activity and Ferric Reducing Antioxidant Power (FRAP) assays. These two tests are for the reliability of the results achieved. This is because the mechanism for these two tests was different, where FRAP assays, calculate a sample's reduction power while DPPH activity has a more complicated chemistry that is more sensitive to organic acids and phenolics.

2.4.1 Total Protein Content

Each sample of dried bee bread was weighed at 0.1 g and hydrolysed in a centrifuge tube with 10 mL of distilled water. The fluid was then centrifuged for two minutes at 3000 rpm. Bradford Assays were used to determine the protein concentration of the supernatant [10]. Using a microplate reader set to 562 nm, the Bradford Assays were examined. Comassie Brilliant Blue G-250 with phosphoric acid and ethanol make up the Bradford reagent [10]. The absorbance of a series of standard protein dilutions of bovine serum albumin (BSA) was used to create the standard curve [10].

2.4.2 Total Flavonoid Content (TFC)

The total flavonoid content was analysed using the methodology that Popova et al. had previously outlined with some modifications. 0.5 mL of the bee bread extract and 0.3 mL of 2% $AlCl_3$ (made in methanol) were combined in a volumetric flask. The absorbance of the solution was measured at 510 nm after a 30-minute reaction. The amount of quercetin as a standard curve is equivalent per liter (mg QE/L) that the extract contained stated [8].

2.4.3 Total Phenolic Content (TPC)

The extractions were carried out using a technique from a previous study. 0.1g of BB was heated in an ultrasonic bath with distilled water for 10 minutes at 40°C. Additional phases in this process included centrifugation (4000 rpm at 4°C, 10 min), ultrasonication, and vortexing (2600 rpm, 3 min). For every sample, the final volume of the bee bread extract was 10 mL, and the extracts were kept in closed bottles until further testing [11],[12]. The method was used to calculate the TPC. 500 µL of extract and 2.5 mL of Folin-Ciocalteau reagent were combined in a glass tube. 2 mL of 7% sodium carbonate was added after two minutes. The solution was chilled in an ice bath to stop the reaction and thermostated at 40 °C for 20 minutes [11]. The amount of TPC in mg gallic acid equivalent per liter, or mg GAE/L [8]. The 765 nm wavelength was used to read the gallic acid standard curve, and the same was also applied for each sample's TPC measurement.

2.5 Measurement Antioxidant Activity

2.5.1 Ferric Reducing Antioxidant Power

Using the slightly modified procedure from the previous study [13], the reduction capacity of the bee bread was determined via FRAP Assay. The acetate buffer was made by mixing 100 mL of distilled water with 0.31g of sodium acetate and 1.6 mL of glacial acetic acid. The acetate buffer was stored at 4ºC with its pH adjusted to 3.6. The TPTZ was then produced by dissolving 0.031g of TPTZ in 10 mL of hydrochloric acid in a water bath at 50ºC. To make the Iron (III) Chloride, 0.054 g of $FeCl_3 \cdot 6H_2O$ was dissolved in 10mL of distilled water [13]. The functioning FRAP reagent was made by combining 25 ml of 300 mM acetate buffer at pH 3.6 with 2.5mL of 10 mM TPTZ solution and 2.5ml of 20 mM ferric chloride in a 10:1:1 ratio before being used in a water bath at 37˚C. Then, a blank reading was obtained using a spectrophotometer at an absorbance of 593 nm after 3mL of FRAP reagent was applied to a cuvette to measure the ferric-reducing activity. The cuvette was filled with 300 µL of ethanol and 150 µL of the sample extract. After combining the FRAP reagent with the sample extract, a second measurement was taken at an identical absorbance four minutes later. After four minutes after the initial blank reading, the absorbance variations were compared with the standard curve using ferrous sulphate. The FRAP values of each standard were plotted against their respective concentrations to create a standard curve. The final result was represented as the milligrams (mg) of ferric iron reduction to ferrous iron in the 150 µg sample extract. The outcome was displayed as the antioxidant concentration with ferric reduction activity [13].

2.5.2 DPPH Activity

The scavenging activity (H/e-transferring ability) was evaluated against the 2,2-diphenyl-1-picrylhydrazyl hydrate (DPPH) radical using a slightly modified version of Brand-Williams' Method [14]. The purple hue of DPPH is receding in the presence of an antioxidant; this change in absorbency can be detected using spectrophotometry. A 2mL DPPH solution in methanol was prepared for the UV/vis Spectrophotometer measurement. 100 µL of the bee bread phenolic extract solution in methanol (10 mg/mL) was combined with 2mL DPPH solution in a disposable microcuvette with a 1cm path length. The extract's ultimate concentration was 0.244 mg/mL. After 16 minutes, the absorbency of the residual DPPH was measured at 517 nm [14]. The antioxidants' ability to eliminate DPPH radicals increases with decreasing IC_{50} values. The radical scavenging affinity is quantitatively described by the IC_{50} values. The IC_{50} value is among the most useful methods for assessing DPPH radical scavenging affinities because of all these factors [15]. The following formula was used to determine the bee bread extracts' radical scavenging activity (RSA):

$$RSA\ (\%) = \left[\frac{Ac - As}{Ac}\right] \times 100\ or\ RSA\ (\%) = \left(1 - \frac{Ac}{As}\right) \times 100$$

Where;
Ac = absorbance at 517 nm of control sample,
As = absorbance at 517 nm of test sample.

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2.6 Statistical Analysis

Data was analysed using one way or two way ANOVA using PRISM 8. Data were presented as ±SD and a P value<0.0001 was statistically significant. The error bars were short since the differences in data achieved were only slightly different.

3 Results and Discussions

3.1 Microencapsulation Efficiency

After all samples went through the spray drying process, it is important to calculate the microencapsulation efficiency. This is because to determine the yield of encapsulation of BB. The BB powder collected then was weighted to get the percentage yield of microencapsulation efficiency. By doing this, it helps to identify losses during processing. Below is the table of percentage yield of BB after spray drying process.

Table 1: Percentage yield of BB after spray drying process

	Polymer	Formulation	Final weight (g)	Yield (%)
1 biopolymer	-	BB + Water	0.112	11.2
	XG	1	1.112	18.5
	AG	2	1.167	19.5
	Chi	3	0.753	12.6
	SA	4	0.767	12.8
2 biopolymers	XG + AG	5	2.271	37.9
	XG + Chi	6	0.708	11.8
	XG + AG	8	2.354	39.2
	XG + Chi	11	1.401	23.4
	AG + Chi	14	2.448	40.8
	AG + SA	15	2.203	36.7
	AG + Chi	16	1.307	21.8
	AG + SA	18	2.333	38.9
	Chi + SA	19	2.701	45.0
	Chi + SA	20	1.797	30.0
3 biopolymers	XG + AG + Chi	9	0.534	8.9
	XG + AG + SA	10	2.101	35.0
	XG + Chi + SA	12	2.301	38.4
	AG + Chi + SA	17	2.566	42.8

Each sample were weighted to see any difference after BB go through spray drying process. From table 1 above, there quite percentage different for BB and water only without any biopolymer with single biopolymer. It can be seen that, Arabic gum in sample 2 have the highest percentage yield among the samples that used single biopolymer while in samples that used double biopolymer, sample 19 has the highest percentage yield which contains chitosan and sodium alginate, lastly samples 17 shows the highest percentage yield among samples that used three biopolymers. From the observation above, in sample 2, 19 and 17 shows that Arabic gum, chitosan, and sodium alginate give a great protection to bee bread during encapsulation process. Although the highest percentage yield only used two biopolymers which is in sample 19, it still shows that having more than one biopolymer to encapsulate bee bread can helps increasing the yield. Having three biopolymers to encapsulate bee bread can be bothersome if the ratio between biopolymers used were imbalance. Sample 19 have the highest percentage yield because the combination of Chi ad SA created a tight and uniform coating around the BB which lead to reduce the diffusion and leakage of bioactive compound in BB [22].

3.2 Assessment of functional values of microencapsulated bee bread

3.2.1 Total Protein Content

Since BB is rich in macronutrient such as protein (2), it is crucial to calculate the protein content in bee bread after encapsulation process. This is because the aim for this study is to encapsulate BB while retaining its functional value. Hence, in this study, the difference protein content between the raw BB and encapsulated BB should be observed.

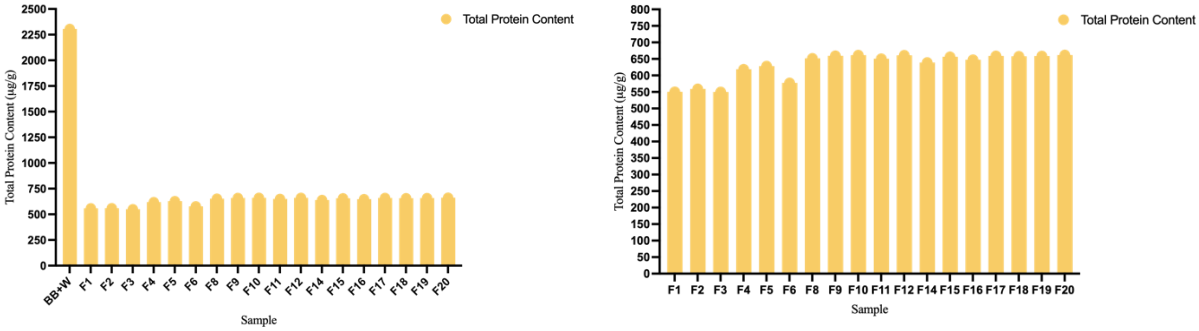

***Fig. 1*:** Effects of BB encapsulation in total protein content (a) Raw BB and encapsulated BB; (b) Encapsulated BB

From the figure above, there is huge significant difference in raw BB and encapsulated BB. This is because the raw BB is not exposed to the high temperature that can degrade the protein in bee bread while for encapsulated BB, although the biopolymers supposed to protect the bioactive compound in bee bread, since the temperature used in spray dryer were high which ranging from 150°C to 170°C. Since protein is sensitive towards high temperature, it is expected that protein content in encapsulated BB will slightly decrease due to exposure of high temperature of spray dryer. However, from Figure 1 above in (b), there is only slight difference on protein content between samples that used single biopolymer and samples that used more than one biopolymer. This indicates that the biopolymers still manage to protect some of the protein in bee bread even after went through the encapsulation process with spray drying technique.

3.2.2 Total Flavonoid Content

Flavonoid is a subclass from the phenolic. A benzopyrone ring with phenolic or polyphenolic groups at various locations makes up most flavonoids, which are secondary metabolites [16]. Flavonoid is important to test in bee bread because it is a bioactive compound which held quite significant influence towards quality and efficacy of encapsulation process. Since flavonoid is a subclass of phenolic, it is natural that the flavonoid content in BB is much lower compared to the phenolic content. There is study where it was demonstrated the TPC values was higher compared the TFC values [17]. The raw BB contains the highest flavonoid content which is 22.066 mg QE/g compared to encapsulated BB. This is because flavonoid is heat sensitive, hence, when solution of mixture BB and biopolymers enter the spray dryer, the flavonoids in BB were exposed to high temperature. This led to degradation of flavonoid content in encapsulated bee bread. For sample 1 until 15, there are significant difference in flavonoid content. This happening due to a few factors which are thermal degradation, oxidation, and incomplete encapsulation. In sample 10 shows the highest flavonoid content among samples that used three biopolymers which is 11.266 mg QE/g. In this sample contains xanthan gum, Arabic gum, and sodium alginate to encapsulate bee bread meanwhile in sample 18 shows the highest flavonoid content among samples that used two biopolymers which is 12.4 mg QE/g, and in this sample, Arabic gum and sodium alginate were biopolymers used to encapsulate BB. Although in sample 10 used three biopolymers, the ratio between biopolymers used to encapsulate BB were plays a crucial role in order to protect the bioactive compound in BB.

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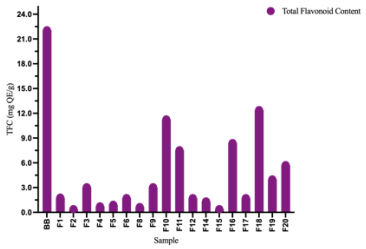


Fig. 2: Effects of BB encapsulation in total flavonoid content

3.2.3 Total Phenolic Content

Phenolic content in raw BB and the rest of encapsulated BB shows slightly difference except in sample 10 where the value is 32.026 mg GAE/g two times more than raw BB which the value is 15.032 mg GAE/g. These happens on a few factors where the encapsulating agent role enhance the release of phenolics during analysis, concentration effect since spray dryer remove moisture in BB, the concentration of phenolics is increase, lastly it may be due to encapsulation effectiveness. To support this, there are studies on microencapsulation that could protect phenolic content of propolis [18]. In this study, it was demonstrated that the phenolic compound of propolis after microencapsulated through spray drying technique shows significantly increase with encapsulation efficiency while the TPC were dispersed in microencapsulation [18]. In sample 10 there are three biopolymers used which are Arabic gum, xanthan gum and sodium alginate. This might indicate that having three biopolymers to encapsulate BB helps on retaining their functional values. Comparing in biopolymers used, sample 4 shows the highest reading among samples that used single biopolymer, while in samples that used two biopolymers, sample 11 has the highest reading which is 16.458 mg GAE/g.

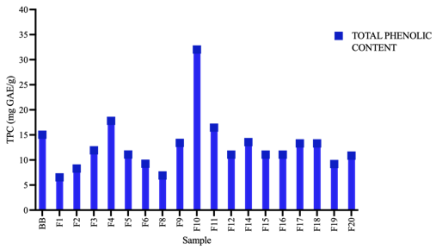


Fig. 3: Effects of BB encapsulation in total phenolic content

3.2.4 Antioxidant Analysis

3.2.4.1 Ferric Reducing Antioxidant Power (FRAP) Assays

For this research, it was found out that the FRAP encapsulated bee bread was 1513.6 to 2295.6 mg AAE/g. In sample 16 shows the highest reading which is 2295.6 mg AAE/g. This indicates that in this sample, those biopolymers protect the bioactive compound in the bee bread, which the compound able to donate the electrons to neutralize the oxidative agents. Meanwhile in sample 18 shows the lowest reading for FRAP assays which is 1513.6 mg AAE/g. In both samples used two biopolymers which in sample 16, there are Arabic gum and chitosan while in sample 18 arabic gum and sodium alginate. Both samples used same biopolymer, which is Arabic gum but having a different mix with other biopolymer plays a crucial role in assessing the antioxidant properties in encapsulated BB.

3.2.4.2 DPPH Activity

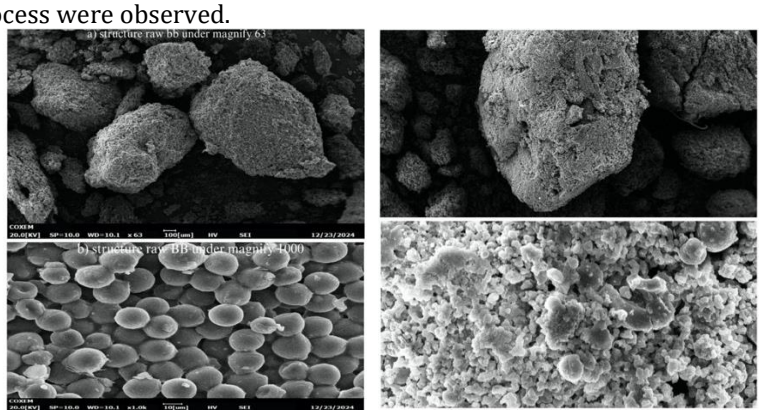
For assessing the antioxidant potential of chemicals and herbal extracts, this approach is the most popular and practical radical removal technique since it is simple, sensitive, quick, and repeatable [15]. Hence, in this study, DPPH test was done to test the antioxidant properties in encapsulated bee bread. In raw BB, the IC_{50} is 40.5% compared to encapsulated bee bread where the IC_{50} reading in sample 4 show the highest reading which is 76.7%. This happens because the raw BB was prone to oxidise since there is no biopolymers to protect the bioactive compound in BB. Although in sample 4 contain single biopolymer which is sodium alginate, the properties of biopolymers itself where it can form gels independently of temperature changes helps on retaining the antioxidant in encapsulated BB [19]. Unlike in samples that

used two and three biopolymers, the IC_{50} readings are slightly lower. However, a lower reading in IC_{50} is much preferable. This is because it indicates that the bee bread is successfully encapsulated. In this case sample 15 shows the lowest reading which is 11.4%.

3.3 Evaluation of microstructure of microencapsulated bee bread

3.3.1 SEM Analysis

SEM analysis were carried out to observe the morphology of bee bread, which in this study the size of bee bread after encapsulation process were observed.



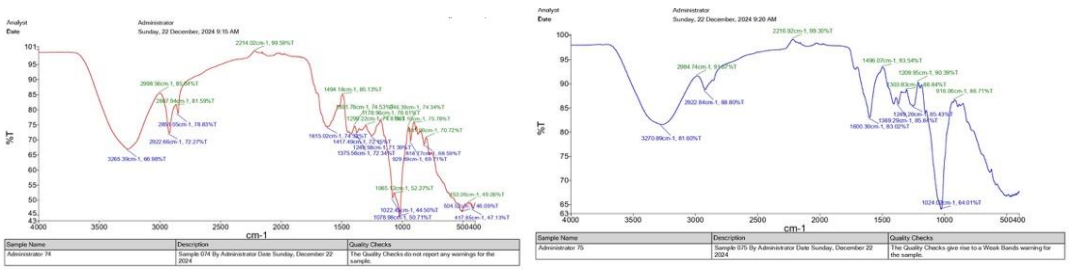
(a) **(b)**

***Fig. 4*:** Microstructure of BB under SEM (a) raw BB; (b) encapsulated BB

From the Figure 4 above, there is different in the structure of raw bee bread and encapsulated BB. In figure 4a, the shape of raw BB are even and circular which can be seen under 1000µm magnification while in figure 4b, it is an encapsulated BB, sample 12 where the shape were uneven. However, it can be observed that the size of encapsulated BB much bigger compared to the raw BB under 1000µm magnification. The size for encapsulated BB approximately 200µm while for raw BB the size, approximately is 10µm. This shows that the microencapsulation is successful because the size after encapsulation were slightly bigger due to biopolymers surrounded the bee bread.

3.3.1 FTIR Analysis

FTIR helps on identifying the functional group in encapsulated BB as well as detect the interactions between the BB bioactive compounds with encapsulating agents. This indicates that the bonding between biopolymers and BB have successful encapsulation process.



(a) (b)

***Fig. 5*:** FTIR for BB (a) raw BB; (b) encapsulated BB in sample 12 that used xanthan gum, sodium alginate, and chitosan

FTIR spectra can be seen in figure 5a for raw BB, peak that falls on range 2500cm^{-1} to 4000cm^{-1}, it is likely due to C-H stretching where it can be seen at peak 2998.56cm^{-1} while at peak 3265.39cm^{-1} may cause by O-H or N-H stretching [20]. At peak 2998.56 cm^{-1} , the intensity of the bond is strong while at peak 3265.39 cm^{-1} , the intensity of the bond is medium. Peaks around 1615.02cm^{-1} and 1494.18cm^{-1} can be associated with C=C aromatic stretching or N-H stretching. These peaks fall at range 2500-1500cm^{-1} represent fingerprint region for carbonyls (C=C) or aromatic (C=C) stretching. In figure 5b, for encapsulated BB, the peaks are 2216.92cm^{-1}, happens due to

nitrile functional groups present, where the intensity of the bond is medium. Each peak indicates the strength of the bond between the bee bread and the biopolymers. This shows the efficiency of microencapsulation bee bread with spray drying technique.

4 Conclusion

In conclusion, this report aims is to study on the effects of microencapsulation bee bread with biopolymers using spray drying technique. The first objective for this study is to encapsulate the bee bread with biopolymers using spray drying technique. From the result, the microencapsulation efficiency obtain were only 45% of dry weight of collected encapsulated bee bread which is lower than expected. For stability of encapsulation which can be found in sample 12, which contains xanthan gum, Arabic gum and sodium alginate, where the size of encapsulated BB is much smaller which is 10µm and the functional group bonding is much stronger compared to the raw bee bread. Lastly, various sample shows high reading in DPPH, FRAP assays, TPC, TFC and total protein where in DPPH, sample 15 shows the better result but in FRAP assays, sample 16 have highest reading of FRAP assays. For total protein, TPC and TFC sample 10 shows the highest reading. Thus, it can be concluded that sample 15, 16 and 10 have the better formulations to encapsulate bee bread while retaining its bioactive compound with spray drying technique.

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