Solubility Enhancement of Poorly Water-Soluble Compounds

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***Abstract*—This study was undertaken to evaluate the potential of maltodextrin to enhance solubility in drug delivery in the encapsulation of Mentha x Piperita essential oil by spray drying method. Menta x Piperita essential oils was encapsulated with only combination of maltodextrin and gum Arabic (GA) in order to achieve maximum encapsulation performance. Sodium dodecyl sulfate was added to investigate the interactions with encapsulated Menta x Piperita. The performance of the Menta x Piperita essential oils encapsulation was evaluated by fourier transform infrared (FT-IR) spectroscopy and thermal transition properties (DSC). The combination of both materials (maltodexrin and gum Arabic) was considered a successful encapsulation for Menta x Piperita essential oil.**

Keywords*— *Menta x Piperita; Essential oil, Encapsulation; Maltodextrin; Gum arabic.

I. INTRODUCTION

(Bhupesh C. Roy, Motonobu Goto, Akio Kodamab & Tsutomu Hirose, 1996) has stated that peppermint extracts can provide important role in the industry. This statement can be convinced by massive usage of Peppermint in many industries such as cosmetic, food and tobacco (Yazdani et Al., 2002). In addition, peppermint production for usage in the industries has been increased in many years (Lawrence, 2006). Besides, Peppermint can produce refreshing taste and aroma. This can be one of the many reasons for the popular usage of Peppermint. The oil extracted from peppermint is the most used evaluated for study (Elise Herro, 2010). 30 and more components can be found in Peppermint (Peppermint essential oil information, 2010). For example, menthol and menthone (McKay DL, 2006). There are also additional components such as menthyl acetate, eucalyptol, limonene, and pulegone.

Peppermint is considered as herbal plant. Menta Piperita as the other name of peppermint is a medicinally plant. Peppermint plant has a wide range of pharmacological properties including respiratory, hepatic disorders, skin and mucus membranes and anti-inflammatory (Punit P Shah and P M D'Mello, 2004). Menthol from peppermint causes a reflex to prevent respiratory muscle activity (Orani GP, Anderson JW, Sant's Ambrogio G and Sant's Ambrogio FB, 1991). Menthol that have been vaporized refreshes cold receptors in the respiratory tract (Schafer K, Braun HA and Isenberg C, 1986). The impact of menthol can reduce common cold infections (Eccles R, Jawad MS and Morris S, 1990). Application of peppermint oil increase the rate for emptying gastric (Dalvi SS, Nadkarni PM, Pardesi R and Gupta KC, 1991). In addition, cooling sensation from peppermint oil has analgesic effect by stimulating the cold receptors on skin and expand blood vessel (Morimoto Y, Sugibayashi K, Kobayashi D, Shoji H, Yamazaki J and Kimuran M, 1993). Inflammation can be reduced due to the anti-inflammatory effect (Atta AH and Alkofahi A, 1998).

There are many benefits and usage of Peppermints. One of the popular usages is taken as alternative medical remedy (McKay L. D. and Blumberg B. J., 2006). For example, biliary disorders. Peppermint oil that has been extracted is effective short-term treatment for active irritable bowel syndrome and most importantly safe to use (Khanna et.Al., 2014). Since Peppermint is widely used in many industries such as for flavouring in food, fragrance, cosmetic and medical, the potential deserves recognition.

The encapsulation of essential oils is one of the alternatives to give protection towards the essential oils compound. This is due to the compound in a very volatile condition from oxidation and thermal degradation. Maltodextrin and gum Arabica are perfect examples that can provide protective sheath of wall materials to active core material such as essential oils. Encapsulation can be done in many ways. For example, spray drying, freeze drying, centrifugal extrusion and coacervation. However, spray drying can be one of the most used techniques since this process is economical and flexible (A.Z.M.Badee et. Al., 2012).

One of the important steps in encapsulation process is choosing the suitable wall material. Starch is listed as water soluble. food grade and nontoxic which is also widely available at low cost. Therefore, maltodextrin is a good choice. However, after reacting to a high temperature, starch will break down causing increase in viscosity and solid concentrations. Hence, other surface-active biopolymer such as gum Arabic is added to a combination. Gum Arabic is a good emulsifying agent due to its protective colloid ability with unique properties where high concentration does not

affect the viscosity and stability (R.F. Hermanto et. Al., 2016).

Surfactant micelles are commonly used in pharmaceutical industry as drug delivery systems due to the ability to increase solubility of hydrophobic drugs (Mirela Enache and Ana Maira Toader, 2018). Besides, micelles have similar structure with lipids (hydrophobic interior and hydrophilic surface. Hence, micelles able to replicate the natural bilayer lipid membranes. Thus, can be used to study the interactions between drugs as a model system.

Overall, this research aim is to study potential of Maltodextrin to enhance solubility in drug delivery in the encapsulation of Peppermint oil by Spray Drying Method.

II. METHODOLOGY

A. Materials

Menta x Piperita essential oil, gum Arabic and maltodextrin were purchased from local suppliers. All chemicals were used as received without any further purification or improvement.

Emulsion Preparation

Maltodextrin (dry solids) and Gum Arabic with ratio of 2:1 were poured into a 1000mL beaker. Distilled water was added into the beaker until the level was reached at 1 liter. The mixture was pre heated on a hot plate (TPS-280-0) at 180°C for 60 minutes. The heated mixture was simultaneously stirred using small size magnetic stirrer. Then, the mixture was cooled down at room temperature for 5 hours before leaving the mixture overnight in a refrigerator. Then, 10mL of Mentha x Piperita essential oils was added to the mixture before proceeding to ultrasonic homogenizer (Model 300 V/T). In order to obtain the homogenous suspension of the dispersion, the process was carried out at power indication of 50 (micro tip limit) for 60 minutes with 10 minutes interval at ambient temperature. In addition, the emulsion was maintained under slow agitation during spray drying.

Spray Drying for Encapsulation

The emulsion was spray dried by using LabPlant SD-Basic Spray Dryer with pump speed at 3. The inlet temperature used was at 150°C. Powder produced at the bottom of the dryer cyclone was collected and placed in a sealed plastic bag. The powder was kept in a refrigerator until being further analyzed.

Surfactant Preparation

Sodium Dodecyl Sulfate was weighed in a beaker for 1.2 grams. Then, 180ml of distilled water was added continuously until the volume reached 300ml. Beaker was heated at 100°C simultaneously on a hot plate with stirring was turned on. Same step was repeated for 0.6 grams of SDS. 10ml of 95% concentration ethanol was diluted with 190ml of 4% SDS solution to produce 4% ethanol concentration and placed into a volumetric flask. 50ml of the 4% concentration ethanol was added with 50ml of 4% SDS solution to produce 2% concentration of ethanol SDS solution. The steps were repeated with 2% SDS water.

Analysis for Encapsulated Menta x Piperita particles

Fourier transform infrared (FTIR) (Perkin Elmer Spectrum One FT-IR Spectrometer: Perkin Elmer SDN Bhd) analysis was conducted to the Menta x Piperita powder (maltodextrin, gum Arabic and combination with SDS solution with ethanol). The FTIR spectrometer collects high spectral resolution data over wide spectral range. FTIR spectra in mid IR range of 4000-400cm-1. The tip of the spectrometer where the sample was placed had to be wiped with acetone before started. The samples of the encapsulated essential oils were analyzed by using FTIR fingerprint profiles. Thermal transition analysis was performed using a differential scanning calorimeter (DSC) (Seiko DSC 6100, Chiba, Japan). This analysis was taken in order to reveal the DSC thermograms for spray dried powders of Mentha x Piperita particles diluted with SDS solution and ethanol. Sample solutions were placedin aluminum DSC pan. Scanning was performed at 40°C to 40°C at a constant rate (20°C/min) under nitrogen gas (at 30ml/min flow rate).

III. RESULTS AND DISCUSSION

A. Fourier Transform Infrared (FTIR) Characterization

Figure 1 showed the structural characterization of Menta x Piperita when encapsulated with maltodextrin and gum Arabic at ratio of 2:1. The purpose of this analysis was to compare all the functional groups in the compounds. Based on the figure, the encapsulated essential oils spectrum showed a wide range from 4000 cm^{-1}. The range in between 4000 cm^{-1} to 2000 cm^{-1} were usually from functional group such as -OH, C=OH, N-H, CH_3. However, a band at 3748.25 was formed. This was occurred due to the wall materials produced by gum Arabic after the spray drying process. The band at 3310.34 was referred to the vibration of O-H groups. On the other hand, the fingerprint region covered from 2000 cm^{-1} to 500 cm^{-1}. The strong spectra band at 1019.03 appeared due to C-O stretching vibration from presence of carbohydrates such as starch. The band at 671.89 was predicted as C-O-C deformation vibration.

Structural characterization by FT-IR spectroscopy shown in Figures 2 to 4 are the encapsulated Mentha x Piperita when diluted with 2% SDS solutions and ethanol (range from 0% ethanol, 0.2% ethanol and 0.4% ethanol). A strong band at 3268.02 in Figure 2 is due to O-H stretching vibration from alcohol. At 2149.59, the bond can be related to methylene groups (CH_2). The fingerprint region at medium spectra of 1638.32 indicates the amides group. The peak at 1365.59 was due to C-O-H stretching indicating the presence of SDS surfactant as well.

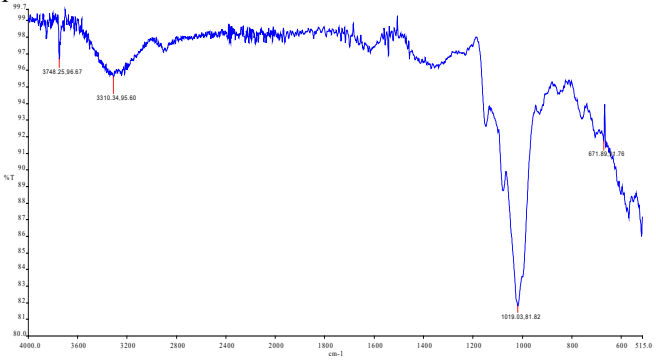

Figure 1: FT-IR spectra of Mentha x Piperita, maltodextrin and gum Arabic encapsulated with spray drying process

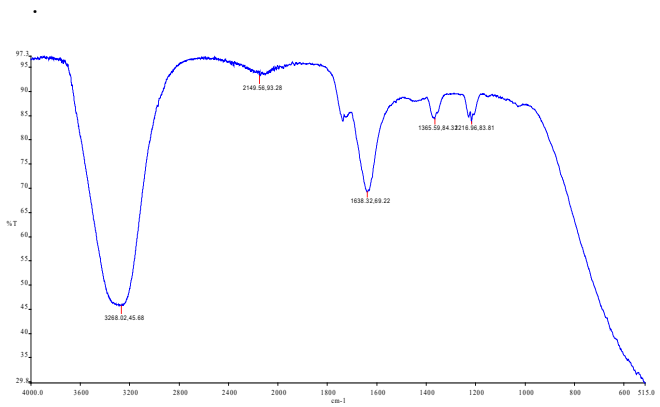

Figure 2: FT-IR spectra of encapsulated Menta x Piperita diluted in 2% SDS solution

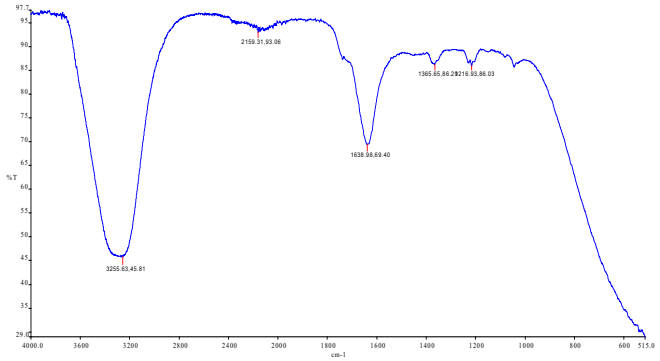

Figure 3: FT-IR spectra of encapsulated Menta x Piperita diluted in 2% SDS solution with 0.2% ethanol

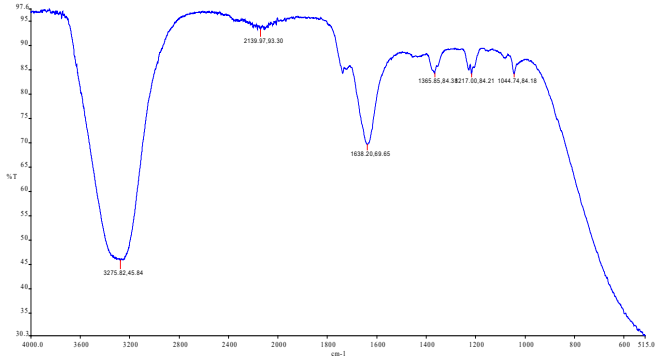

Figure 4: FT-IR spectra of encapsulated Menta x Piperita diluted in 2% SDS solution with 0.4% ethanol

Figure 2 to Figure 4 have similar peaks on major functional groups. However, there was an extra peak as the concentration of ethanol increases. The peak at 1044 on Figure 4 can be predicted due to presence of ethanol.

Structural characterization by FT-IR spectroscopy shown in Figures 2 to 4 are the encapsulated Mentha x Piperita when diluted with 4% SDS solutions and ethanol (range from 0% ethanol, 0.2% ethanol and 0.4% ethanol). The major peaks were almost identical to 2% SDS solutions. A strong band at range of 3278.27 to 3291.79 due to O-H stretching vibration from alcohol. The fingerprint region at medium spectra of 1637.98 to 1638.34 indicate the amides group. However, there was also an extra peak with SDS solution containing 0.4% of ethanol at 1044.19 similar to spectra of 2% SDS solution containing 0.4% ethanol.

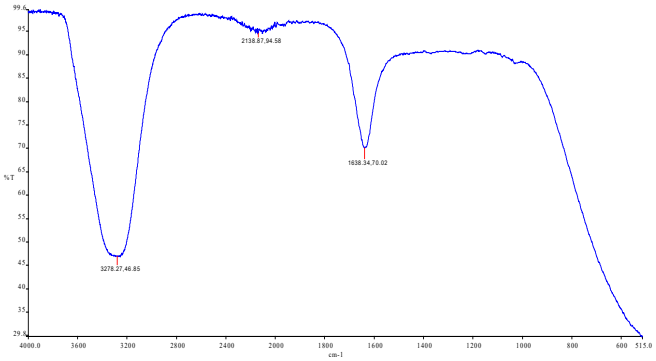

Figure 5: FT-IR spectra of encapsulated Menta x Piperita diluted in 4% SDS solution

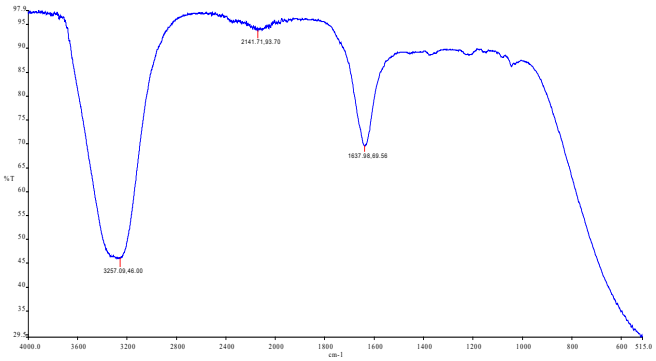

Figure 6: FT-IR spectra of encapsulated Menta x Piperita diluted in 4% SDS solution with 0.2% ethanol

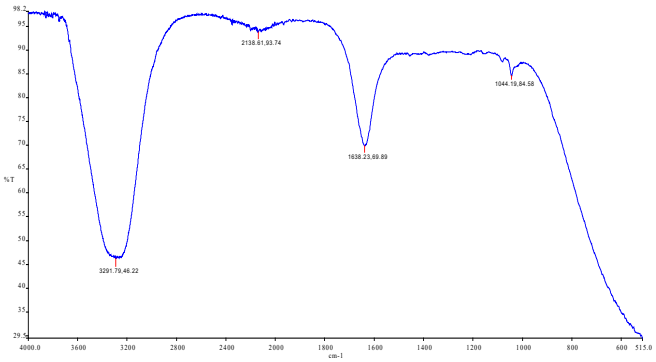

Figure 7: FT-IR spectra of encapsulated Menta x Piperita diluted in 4% SDS solution with 0.4% ethanol

B. Differential Scanning Calorimeter (DSC)

Based on DSC analysis, thermal behavior of the particles can be identified. Figures 8 to 10 represented the DSC thermograms of encapsulated Mentha x Piperita in DSC solutions (2% SDS, 4% SDS and 4% SDS diluted with 0.4% ethanol). Figure 8 to Figure 10 showed an endothermic peak between 120.45°C to 122.12°C. the melting point of Mentha x Piperita is approximately 43°C (The British Pharmaceutical Codex, 1911). Since, SDS has 206°C melting point (American Elements), adding and combining Mentha x Piperita essential oils encapsulation with SDS solutions had increased the melting point temperature. Therefore, the melting point expected to be increased by SDS solutions. Thus, improving the thermal stability of the capsules.

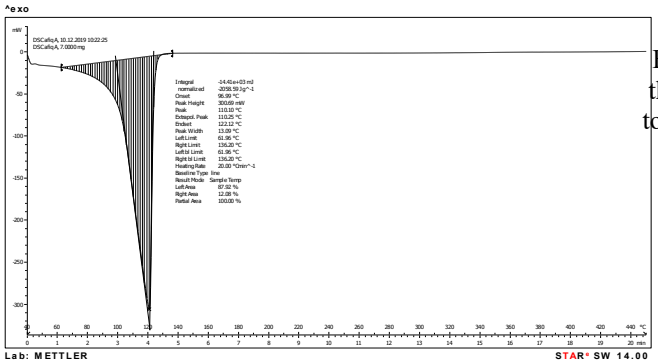

Figure 8: DSC of encapsulated Mentha x Piperita with 2% SDS solution

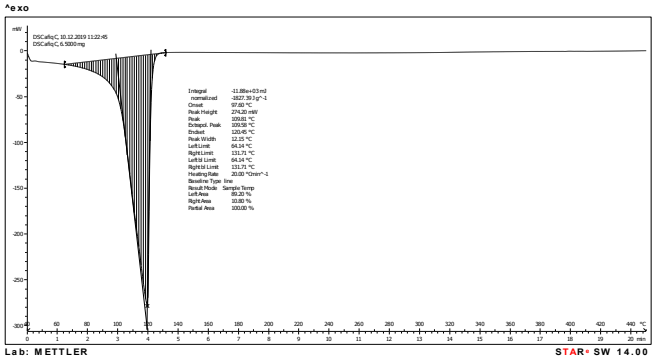

Figure 9: DSC of encapsulated Mentha x Piperita with 4% SDS solution

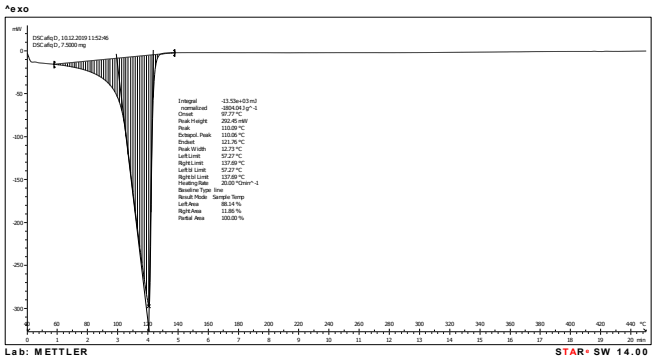

Figure 10: DSC of encapsulated Mentha x Piperita with 4% SDS solution and 0.4% ethanol

IV. Conclusion

This research was done to study the performance of the Mentha x Piperita essential oils when encapsulated with maltodextrin and gum Arabic by using spray drying method. The result from FT-IR specified the band appeared and can be observed the broadened bands of spectrum with presence of wall materials from gum Arabic and maltodextrin. The combination of both maltodextrin and gum Arabic successfully produced particle with good emulsion agent, high solubility and low viscosity. The spectrums were observed to change and presence of new band when increased of ethanol concentration in SDS solutions. The combinations of Mentha x Piperita in this study increased the endothermic of particles higher. Higher melting point strong solvent-solute interaction between wall materials and essential oils. This study concludes that the combination of Mentha x Piperita with maltodextrin and gum Arabic by spray drying was a success.

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V. References

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