International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 8 (2018) pp. 6253-6256
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Comparative Study on Steam Distillation and Hydro-Distillation Methods for Agarwood Oil Extraction

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Abstract

The objective of this study was to evaluate the effiecency and quality of the produced Agarwood oil produced which were produced by steam distillation and hydordistillation methods. Aquilaria Mallacensis was choosing as the raw material study for agarwood oil process with 2 difference size of particle. The method of steam distillation process need atleast 7 days to run the process but for hydro-distillation process only need atleast 5 days. Therefore, with one month calculation for hydrodistillation process include the maintenance process will make for 4 times process otherwise the steam distillation process only need 3 times only include the maintenance process. The result study shows that the hydrodistillation process is more production oil with 150 ml and steam distillation is only with 100 ml. In conclusion, the study indicated that the hydrodistillation process exhibited more efficient and effective in the production of Agarwood essential oil.

Keywords: Agarwood Oil, Steam Distillation and Hydro-distillation

INTRODUCTION

Agarwood is a fragrant and highly valuable wood found in *Aquilaria* species of the *Thymelaeaceae* family. There are fifteen species of agarwood trees, but only three species are found in South East Asia. They are *Aquilaria Crassna*, *Aquilaria Subintegra* and *Aquilaria Malaccensis* [1]. Nowadays in Melaka, Malaysia, there are many villages that planted the agarwood trees from the *Aquilaria Malaccensis* species. A long time ago, there was a history stated that the name of Melaka was derived from that tree. Maybe for the next generation, Melaka will be the centre of agarwood industry in Asia. An "Agarwood" or "Oudh" is the dark resinous heartwood that forms in the *Aquilaria* and *Gyriops* species. The wood will be infected with a type of mould known as inoculation. When the infection occurs, the tree will produce a dark, dense, aromatic resin which is commonly known as agarwood's core [2].

Agarwood has many names depending on the places and local cultures. The word "Agar" is in Hindi, and it is originated from the Sanskrit word "*Aguru*", which is also directly used in Bengali, Telugu and Kannada [3]. For the Chinese, it is known as *Chénxiāng*, *Trầmhương* in Vietnamese [4], and *Jinkō* in Japanese meaning "sinking incense". In Japan, there are various grades of *Jinkō*, which the highest grade of Agarwood is known as *Kyara* [5]. A formation of agarwood occurs in the trunk and roots of trees that have been infected by parasites. In response, the tree produces a resin that is high in volatile-organic compounds that aids in suppressing or retarding the infection, and this process is called *tylosis*. While the unaffected wood of the tree is relatively light in colour, the resin dramatically increases the mass and density of the affected wood, changing its colour from pale beige to a dark brown or black [6]. Agarwood is traded in various forms, including the tree trunks and large branches, chips and flakes of uniform quality, powder and essential oil [7]. Medicines, perfumes and incenses are the three primary use of agarwood. It is also used as a traditional sedative, an analgesic and a digestive medicine in the Chinese and Japanese traditional medicine [8]. As for the wood grading, the agarwood industry only uses human expertise to classify the wood's grade; naked eyes are used to distinguish the shades, shapes and appearances of the woods whilst nose is used to smell the agarwood's smoke [9].

In this paper, the differences between the hydro-distillation and steam distillation methods will be discussed. Some attributes will be analysed based on the oil production and time required to complete the process.

DISTILLATION THEORY

Distillation is defined as "the separation of the components of a mixture of two or more liquids by virtue of the difference in their vapour pressure" [10]. The most important thing is to produce an essential oil using the distillation process. There are two general types of distillation process to be considered. First, the distillations are not miscible and carried out in two phases that practically applies to the rectification and fractionation of essential oils with the steam to the isolation of volatile oils from an aromatic plant. Hydro-distillation is the general term that implies the distillation process may be carried out either by boiling the plant materials or essential oil with water by creating the steam or introducing into the retort live steam generated with a separated steam boiler. Second, the distillation of liquids which are completely miscible in each other and only form one phase that practically applies to the rectification and separation of an essential oil into several fractions without the use of steam.

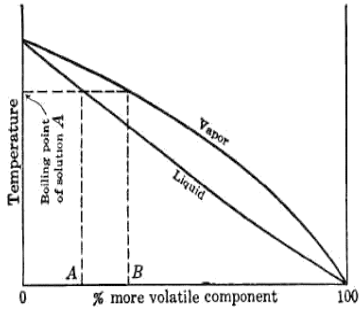

Figure 1: Typical boiling point and vapour-liquid equilibrium diagram for a single-phase binary mixture at a constant pressure [11].

The composition of the oil distillates from a mixture of two insoluble liquids, the weight quantities of the two substances depends primarily upon the boiling points, or the vapour pressure at the distillation temperature. The quantitative composition of the oil distillates can be calculated in advance when the hydro-distillation is chemically uniform with the substances insoluble in water. The basic hydro-distillation rules of the essential oils or volatile substances in general can be expressed as follows:

$$\frac{W_{H_2O}}{W_{oil}} = \frac{P_{H_2O}}{P_{oil}} \times \frac{M_{H_2O}}{M_{oil}} \qquad (1)$$

In which, W_{H_2O} is the weight of water in the condensate; W_{H_2O} is the weight of oil in the condensate; P_{H_2O} is the vapor pressure of water at a distillation temperature; P_{oil} is the vapor pressure of oil at a distillation temperature; M_{H_2O} is the molecular weight of water (=18) and $M_{oil}$is the molecular weight of oil (assuming that this constant may be determined as an average figure).

Figure 1 shows the typical boiling point and vapour-liquid equilibrium diagram for a single-phase binary mixture at a constant pressure [11].The lower of the two curves represents the relationship between the boiling point of any mixture of these two components and its composition. The upper curve represents the composition of the vapour which is formed from any liquid mixture at its boiling point.

RESULTS AND ANALYSIS

There are two types of agarwood oil production process, the water distillation (hydro-distillation) and steam distillation in accordance with Figure 2. For the hydro-distillation process, it is classified into three types; the water distillation, water and steam distillation, and direct steam distillation. Each of the process uses different methods. In general, the water distillation method occurs when the material to be distilled comes into direct contact with the boiling water. It may float on the water or be completely immersed, depending on its density and the quantity of materials. Then, for the water and steam distillation process, it requires a two-phase liquid mixture at the boiling and evaporation point. This steam distillation method directly uses the steam process [11].

The agarwood need to be soaked several times in an enclosed area before the process begins whereby the soaking time is depending on the mass and size of the wood that had been cut. The percentage of the oil content is also affected by the soaking process. If the size of the wood is in the smallest form, the highest percentage of oil content will be produced according to figure 5. Therefore, the process of hydro-distillation cans be divided into two phases; the soaking phase and distillation phase.

In the hydro-distillation process, there are three ways to heat the water until it reaches the boiling point; by burning the firewood, using a gas stove and an electric heater. Nowadays, it is not easy to find anyone who produces agarwood that use the firewood burning method because it requires a lot of work and difficult to control the temperature. Mostly, the people use the gas stove to produce the agarwood oil. Many of them have successfully produced the agarwood oil, which one of the mini hydro-distillation plants produced the agarwood oil using the water distillation process. It demonstrates a simple process of hydro-distillation [12]. The hydro-distillation process with a gas stove can produce a better physical, darker colour, heavier mass, stronger oil fragrance and higher concentrations at an elevated temperature of 120°C within 64 hours using the *Aquilaria Crassna* species[1].The best option is to use an electric heater due to controllable temperatures either in degree Celsius (°C) or degree Fahrenheit (°F).One of the important factors in producing the agarwood oil is a successfully controlled temperature during the cooking process since it will prevent the oil from being overcooked. If

the overcooking occurs, the fragrance quality of the agarwood oil will be unbearable.

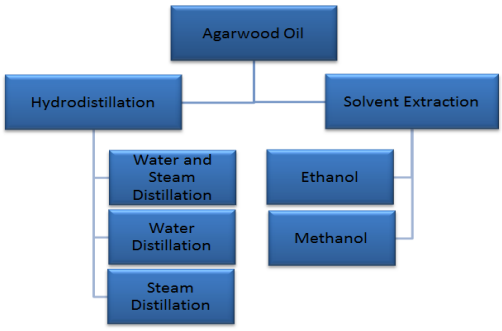

Figure 2: The types of processes in Agarwood oil production.

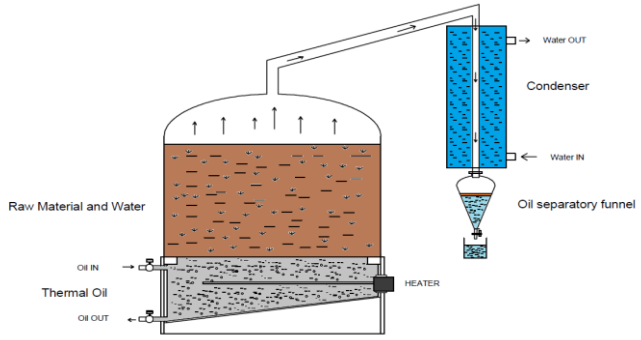

Figure 3: An example of a hydro-distillation process for the agarwood oil.

For the steam distillation process, or also known as a direct steam distillation, it resembles the preceding process except that there is no water kept at the bottom of the pot. In Vietnam, the steam distillation process is used in one of the companies called SECOIN. The equipment used is SECOIN Equipment-SHY285. This machine is able to prove that the steam distillation process can also produce agarwood oil like the other methods [1].

The soaking process in producing the agarwood oil is necessary to intermix the oil in the wood with water to create the distillation process. In general, a solvent extraction is needed to accelerate the soaking process, and among the chemical solvents that can be used such as ethanol and methanol but some of other available solvents cannot be used. This is due to after the process is completed, the chemical liquid will affect the oil's quality and able to cause itchiness to people's skin. Hence, not all chemical solvents can be used in this process. Acetone is one of the chemical solvents that cannot be used because the combination of water and acetone will produce 0% oil yield. No presence of a dark brown oil will be detected [12]. The best solvent for the agarwood oil is a mountain water due to it contains the highest chemical minerals required by the agarwood for the soaking process in obtaining the best quality of oil.

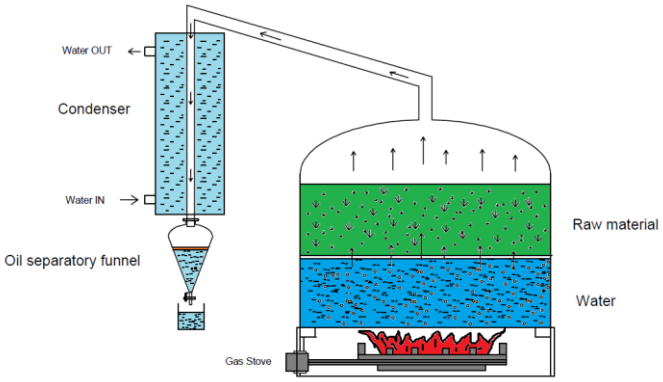

Figure 4: An example of a steam distillation system.

Figure 5: The samples of soaked pieces of Agarwood in different sizes.

DISCUSSION

The steam distillation and hydro-distillation process have many differences according Table 1. Table 1 shows a simple process used by many people nowadays to produce the agarwood oil. The quantity of oil produced is mostly the same, but the difference is in the time required for the process to be fully completed.

A controlled temperature while the process is running will produce more oil than the manual controlling system. When the temperature can be controlled, the duration of the process also can be cut down to a shorter period of time because the temperature is always maintained at a suitable temperature according to the heat of the mixture. Sometimes, when the temperature cannot be set and maintained, then, the mixture will be overcooked.

In addition, the steam distillation process is more expensive compared to the hydro-distillation process because it needs to accommodate three gas cylinders whilst the hydro-distillations only need to cater for the electricity used. Other than that, the temperature at the condenser must be at a suitable condition.

The temperature should be controlled in order to produce the oil otherwise only water will be produced.

Table 1: The comparison between the steam distillation and hydro–distillation process.

Description	Steam Distillation	Hydro Distillation
Raw material	30 kg	30 kg
Oil Production(with different grade but same process)	100 ml	150 ml
Operation Duration	7 days	5 days
Operation in one month (including cleaning process)	3 times	4 times
Heat equipment	Gas (3 cylinders)	Electricity
Heat control	Manual	Automated

CONCLUSION

The contribution of this paper is to provide an overview of the agarwood oil distillation process. It looks like a very simple process but it is not easy to produce the output (agarwood oil). Nowadays, there are many processes and apparatus of the agarwood oil that did not succeed. That is because they did not focus on the small things such as the temperature of the heater, the solvent used for the wood and the temperature of the condenser to cool the water vapour. In addition, the materials used to make the pot should also be taken into account. The material of the pot must be withstanding the pressure, no heat around the outer surface and no chemical reaction in the pot after the heat in the pot reaches a certain temperature. This chemical reaction will affect the quality of the agarwood oil. Therefore, many technologies can be created in the agarwood oil process to improve the oil's quality. The oil with the highest quality will be easily exported to other countries at a high price.

ACKNOWLEDGEMENTS

The authors would like to thank Universiti Teknikal Malaysia Melaka (UTeM; Grant Ref. No.PJP/2015/FTK (4C)/S01404 and PJP/2017/FTK-AMC/S01575, Ministry of Science, Technology and Innovation (MOSTI), Ministry of Higher Education (MoHE), and the Government of Malaysia for the support and assistance rendered to this research.

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