µltraxtor- Low Resources High Yield Benchtop Agarwood Essential Oil Extractor

Mohd Haslizam Abdullah, Mohd Hafizu Zakaria, Muhamad Sollehudin Ibrahim, Ahmad Damanhuri Mohamad Yussof.

Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Pahang, MALAYSIA

anwarcg@ump.edu.my, ahaslizam@gmail.com, fizozakaria@yahoo.com, sollehudin92@gmail.com, damanyussof@gmail.com

Highlights: Endangered wild species of agarwood have been substituted with cultivated agarwood and are suitable to grow in Malaysian climate. More than 100 local agarwood farmers face challenge to extract the high value agarwood essential oil. The extraction facilities are normally using foreign technologies such Thais and Vietnamese which are not optimized to process local agarwood species. The extraction process with conventional hydrodistillation process requires continuous personnel monitoring and highly dependent on operator's experience. The objective of this innovation is to introduce new benchtop automatic temperature controlled agarwood oil extraction plant for use by local farmers. This benchtop agarwood essential oil extractor named *µltraxtor* manipulates the temperature distribution in the system by optimizing the boiler heat source and condenser efficiency in a compact benchtop platform to control the rate of extracted agarwood oil in order to achieve high extraction yield and high essential oil quality. The high ratio of extracted oil to the dry wood enables local farmers to produce their own oil at their farms or premises economically.

Keywords: *benchtop hydrodistillation; agarwood; essential oil; temperature control; yield and quality*

Introduction

Agarwood is considered to be the finest natural incense and has been used in many communities to fulfil cultural, religious and medicinal purposes for centuries. Agarwood is a resinous, fragrant and highly valuable heartwood. The scientific name is Aquilaria. It is also known as aloeswood, eaglewood, krissana in Thailand, gaharu in Malaysia and Indonesia, Oudh in the MiddleEast, chen-xiang in Chinese and jin-koh in Japan. Healthy agarwood is relatively light and pale coloured. Occasionally the heartwood gets contaminated by a parasitic ascomycetous mold, haeoacremonium parasitical. As a reaction, the tree produces a resin high in volatile organic compounds that aids in suppressing or retarding the fungal growth(Chang, Ng, & Kadir, 1997). This resin and its oil are valuable for their utilization in medicine, perfumery and other aromatic products. There are numerous grades of agarwood, and the most astounding quality wood is extremely expensive(Ahmad Fadzli, 2006). Plant essences and extracts that have developed into our modern essential oils were in regular use in Rome, Greece, and Egypt and used throughout the Middle and Far East, for some centuries (Knowlton & Pearce, 1993).

Currently, there are a few conventional and modern methods of extracting essential oils such as by hydro-distillation, supercritical fluid extraction and microwave extraction. Hydro-distillation is the oldest and most common method of extracting essential oil since it is economically viable and safe. During hydro-distillation the essential oil components form an azeotropic mixture with water. The extraction period influences not only the yield but also the extract composition. Hydro-distillation can be achieved by one of the two methods:

- **Clevenger distillation** - the material to be extracted is immersed in water, which is then boiled.
- **Steam distillation** - steam passes through a bed of the material to be extracted.

In both methods the vapors of the volatile components are carried by the steam to a condenser. On condensation oil-rich and water-rich layers are formed. Clevenger distillation generates steam continuously and on a large scale. Controlling the boiling process is extremely difficult - it is a highly nonlinear process, its dynamics vary with load and it is strongly multivariable. It is also inherently unstable due to the integrator effect of the drum. In addition, distillations are commonly used in situations where the load can change suddenly and without prior warning.

Essential oils are used in pharmaceutical, cosmetic and food industries and as natural remedies (Buchbauer & Wallner, 2016). Essential oils are volatile oils, generously odorous, which occur in certain plants or specified parts of plants, and are recovered by accepted procedures, such that the nature and composition of the product is, as nearly as practicable, unchanged by such procedures (Bakkali, Averbeck, Averbeck, & Idaomar, 2008; Joy, Thomas, Mathew, Jose, & Joseph). It specifies clearly that the nature and composition of the oil must be unchanged by the process of extraction, which is one reason why hydro-distillation is an appropriate method of extraction ISO/TS 211:2014 (2014). The yield, taste, flavor and chemical composition (amount and ratio of components) of essential oil depends on a number of parameters, such as plant variety, season, soil, environmental conditions, drying procedure, storage conditions, method of distillation, and the analytics used for identification of the compounds (Stanković, Nikolić, Stanojević, & Cakić, 2004; Stanojević et al., 2011). Despite of the generally successful practical hydro-distillation technology used to extract essential oils, there is still a need to consider a procedure or method in detail that would enable the production of essential oils at an optimum output (Milojević, Stojanović, Palić, Lazić, & Veljković, 2008). Up to now many investigators have studied the thermolability and thermostability of the fragrant components when the plant material is under distillation process (Cheah, 2009; Fisher, Scarlett, & Stott, 1997). They conclude that optimum temperature should be determined to avoid losses of volatile and thermolabile substances during extraction of the essential oils.

Boiler for distillation process is different to boiler for energy generation, where the boiler in energy generation is commonly operated at maximum capacity (Molloy, 1997), whereas the boiler for essential oil distillation process must consider the critical temperature that may potentially degrade the thermolabile bioactive components (Cheah, 2009). However, both boiler systems have process parameters that are strongly dependent on load. The process parameters drift over time for a number of reasons such as the build-up of soot on heating surfaces, actuator wear and variations in raw materials quality. It may be necessary to continuously update the controller parameters (Unbehauen, 1969; Unbehauen & Kocaarslan, 1990).

The aim of the present work is to discuss an innovative benchtop hydro-distillation system of essential agarwood oil for economical use by local farmers. The advantageous of this benchtop hydro-distillation is mainly attributed to its high ratio between the amount and quality of extracted agarwood oil to the amount of raw dry chip which is highly beneficial to the local famers with limited resources. In this report the main components of the system, the approach in deployment of the system and the results of extraction trials with inoculated local cultivated agarwood oil are presented.

Development and deployment of µltraxtor

µltraxtor consists of five main components, mainly (1) boiler, (2) evaporator, (3) condenser, (4) separator and (5) controller which are built on a portable benchtop platform. In addition the system is also equipped with chilling system for improving the cooling efficiency of the condenser.

µltraxtor was designed to overcome two main problems of local farmers, which are (1) to process low volume of agarwood economically and (2) to extract agarwood oil on-site due to restriction in logistics. *µltraxtor* is able to process as minimum as 900 g dry woods which makes it highly sought after by small farmers.

Conclusion

This project presents an innovative benchtop hydro-distillation system of essential agarwood oil called *µltraxtor* for economical use by local farmers. Deployment of *µltraxtor* at local farms was encouraging with appreciated oil of 3 ml.

Acknowledgement

This work was supported under the KTP Grant number RDU151007 by the Universiti Malaysia Pahang, Malaysia.

The authors would like to thank Faculty of Engineering and Bio Aromatic Centre of Universiti Malaysia Pahang. Also to the industrial partner which are Igawa Resourses, Wafiqah Industries Sdn. Bhd. and R&Z Agarwood for strong support and priceless contribution during this research.

References

Ahmad Fadzli, Z. (2006). *Extraction of gaharu essential oil using spinning band distillation.* Universiti Malaysia Pahang.

Bakkali, F., Averbeck, S., Averbeck, D., & Idaomar, M. (2008). Biological effects of essential oils – A review. *Food and Chemical Toxicology, 46*(2), 446-475.

Buchbauer, G., & Wallner, I. M. (2016). Essential Oils: Properties, Composition and Health Effects. In B. Caballero, P. M. Finglas, & F. Toldrá (Eds.), *Encyclopedia of Food and Health* (pp. 558-562). Oxford: Academic Press.

Chang, I., Ng, L., & Kadir, A. (1997). A review on agar (gaharu) producing Aquilaria species. *Journal Tropical Forest Product*, 272-285.

Cheah, L. C. E. (2009). *Study of extraction processes and their impact on bioactivity of botanicals.* (Doctor of Philosophy Ph.D Thesis), National University Singapore, Singapore.

Fisher, J. A., Scarlett, M. J., & Stott, A. D. (1997). Accelerated solvent extraction: an evaluation for screening of soils for selected US EPA semivolatile organic priority pollutants. *Environmental science & technology, 31*(4), 1120-1127.

ISO/TS 211:2014. (2014). Essential oils -- General rules for labelling and marking of containers.

Joy, P., Thomas, J., Mathew, S., Jose, G., & Joseph, J. Aromatic Plants. Retrieved from jonnsaromatherapy.com

Knowlton, J., & Pearce, S. (1993). Oils, Fats and Waxes. In J. Knowlton & S. Pearce (Eds.), *Handbook of Cosmetic Science & Technology* (pp. 21-32): Elsevier.

Milojević, S. Ž., Stojanović, T. D., Palić, R., Lazić, M. L., & Veljković, V. B. (2008). Kinetics of distillation of essential oil from comminuted ripe juniper (Juniperus communis L.) berries. *Biochemical engineering journal, 39*(3), 547-553.

Molloy, B. (1997). *Modelling and predictive control of a drum-type boiler*. (Doctor of Philosophy Ph.D. Thesis), Dublin City University, Dublin, Ireleand.

Stanković, M. Z., Nikolić, N. Č., Stanojević, L., & Cakić, M. D. (2004). The effect of hydrodistillation technique on the yield and composition of essential oil from the seed of Petroselinum crispum (Mill.) Nym. ex. AW Hill. *Hemijska Industrija, 58*(9), 409-412.

Stanojević, L., Stanković, M., Cakić, M., Nikolić, V., Nikolić, L., Ilić, D., & Radulović, N. (2011). The effect of hydrodistillation techniques on yield, kinetics, composition and antimicrobial activity of essential oils from flowers of Lavandula officinalis L. *Hemijska Industrija, 65*(4), 455-463.

Unbehauen, H. (1969). The load dependent multivariable steam temperature control system in a boiler. *Automatica, 5*(4), 421-432.

Unbehauen, H., & Kocaarslan, I. (1990). *Experimental modelling and adaptive power control of a 750 MW once-through boiler*. Paper presented at the Proceedings of 11th IFAC world congress, Tallin, SU.