Healthy hydrosol production from styrrax resin harvesting waste using steam distillation

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Abstract. Styrrax resins or benzoin contain aromatic compounds that applied for medicine, perfumery, food ingredients and others. The resins harvested from Styrrax trees were distilled to produce essential oils and hydrosols. Unfortunately, the distillate water usually discarded when separating the primary oils. The objective of study was to evaluate the hydrosol production derived from steam distillation process using various qualities of styrrax resin. The materials used are the first grade and harvesting waste resin collected from community's forests in Humbang Hasundutan, North Sumatra, Indonesia. Three replicates of both resin quality were analysed for moisture content, then steam distillation applied for essential oils and hydrosols production. The research shows that at termination of distillation, the best quality resins produced approximately 3.18 kg (31.8%) and 2.74 kg (27.4%) hydrosol from the waste resin. The essential oils production from first quality is higher than the lowest, approximately 64 g (yield 0.64%), while residue resins produce 53 g (0.53%). It is estimated 7.7% of water in hydrosol derive from waste resin assuming all water contained evaporates and condenses to hydrosol. Considering harvesting residues disposed and unutilized, distillation of lowest quality resin for hydrosol production proposes an alternative strategy for optimizing the forest resources utilization.

1. Introduction

Styrrax resin or benzoin as known as kemenyan is an aromatic resin that has been utilized as a fragrance and medicine since the beginning of world civilization. This valuable resin is harvested from endemic trees species Styrrax sumatrana and S. benzoin since the sixth century from Tapanuli region, Lake Toba, North Sumatra, Indonesia [1]. Until now, the non-timber forest product management has become the main local community livelihood as well as a significant source of regional income [1, 2].

The growing attention to styrrax resin refers to various aromatic compounds content. Some volatile compounds are presented, with benzyl benzoate (76.1%), cinnamic acid (3.5%) and benzyl cinnamate (3.3%) as the major constituents [3, 4]. These pharmacological contents have been used for muscle pain, anxiety, nervous disorders, treatment of skin diseases, arthritis, wounds, etc. [4, 5].

Essential oils derived from styrrax resins are usually obtained by solvent extraction and or steam distillation [3, 6]. The first method applies an ethanol, n-hexane, and others as solvents. In steam distillation method, both essential oils and water-soluble constituents are removed from plant materials by flowing steam or water vapor. During the distillation, some of essential oil constituents are dissolved and remain in distilled water or hydrosol. At the termination of process, both phases are separated. The distilled water contains water-soluble chemical elements from distilled plant materials.
[7,8]. Despite the composition is different compared to primary essential oils, hydrosols are so aromatic with particular distinctive and also referred as aromatic water. In another essential oil extraction, such as lavender, hydrosol or distilled water have a very pleasant aroma with commercial applications [7]. This aromatic water is applied in cosmetics, fragrances, food flavoring, aromatherapy, and traditional therapy [3-5,7,8]. Hydrosols have also some biological activities with high potential for global economic products [8].

The distilled water is discarded after the primary oils separated in most essential oil producers, so that hydrosol is also wasted. The same condition occurs in incense resin distillation in Indonesia. Until now, almost all aromatic distilled water was removed and unutilized. Moreover, the production of styrax essential oil still utilizes the best quality resin raw materials. There is limited attempt to utilize the low-quality resin from the harvest residue, even though the amount is abundant.

The objective of study was to evaluate the hydrosol production derived from steam distillation process using various qualities of styrax resin. The research results are expected to encourage essential oil producers to take advantage of hydrosol, a by-product of distillation process and to utilize wasted resin in harvesting incense resins.

2. Materials and methods

2.1. Materials

The materials used are two different qualities of styrax resin: first grade and harvesting residue resin (ashes and flakes) collected in February 2020 from the community forest in Humbang Hasundutan district, one of incense production centre in North Sumatra [9], Indonesia. Three replications of both resin quality were used to determine the moisture content using a moisture analyser set at 105°C.

2.2. Steam distillation and hydrosol production

Both qualities of styrax resin were steam distilled following the procedure shown in Figure 1. Ten kilograms of resin for each quality and twenty kilograms of water were put down into the boiler for each replication. In order to define processing procedures and parameters including duration of distillation, first loading was applied and distillation is allowed to run for eight hours, whereas two consecutive replications (second and third load) were carried out as the main study. The results are presented as the average of these two replicates.

![Figure 1. Schematic diagram of a steam distillation unit and water flow during distillation](image-url)

Steam is generated by heating water in the boiler. Steam flowed upward through the perforated plate and into resin materials. The steam containing the volatile essential oils then leaves the tightly
closed vessel through a pipe at the top of the vessel. Steam containing volatile essential oil then leaves the vessel through a pipe at the top of vessel and flow to a water-cooled multi-tubular stainless-steel condenser.

Cold water cools the steam and converts the water vapor back into water (hydrolats) and oil (essential oils). These two phases are then separated on a Florentine flask, essential oils (lighter than water) float on top and aromatic water (hydrosol) on the bottom. During the distillation process, hydrosol drained out through an outlet at the bottom of the flask. Meanwhile, the essential oil flowed from the second outlet which located at the top of the flask after distillation process is complete.

Both essential oil and hydrosol produced were measured at the termination of process at 360 minutes even though the accumulation still occurred. The amount of water remaining in the boiler, distillation vessel, and resins were weighed. The evaporation losses were estimated by subtracting the total water passing through the system from that which remains after distillation.

3. Results and discussion

3.1. Hydrosol production

Thirty minutes after the distillation started, distillate from different resin grades were began to be produced. Distillates consist of both essential oils and distillate water (as hydrosols). However, the essential oils were detected significantly at sixty minutes. The accumulation of essential oils increases linear until the termination of distillation. After eight hours of distillation, the essential oils were detected still accumulate in the flask. Therefore, the duration of distillation process until all the essential oil content extracted is unknown.

Steam distillation of the styrax resin produces both essential oil and hydrosol. The production of essential oils from the best quality resins was higher than harvested waste resins (table 1). At the termination of distillation (360 minutes), the first-grade resin produced about 64 g of essential oil or approximately 0.64% yield, while the distillation of harvest residue yielded about 53 g or 0.53% of essential oil. These differences are due to the harvested waste resin contains high impurities such as wood, bark, or other insoluble minerals [10]. The amount of essential oil produced in this study is higher than some previous related research [3]

| Gross weight     | Beginning | End   |
|------------------|-----------|-------|
|                  | First grade | Lowest grade |
| Resin load (kg)  | 10.0       | 10.9  |
| Water in Boiler  | 20.0       | 9.68  |
| Essential oil (g)| 64 g       | 53 g  |
| Hydrosol (kg)    | 3.18       | 2.75  |
| Total            | 30.0       | 23.72 | 23.61 |

*average of two replications

The loss of weight due to evaporation was 6.28 kg from grade I and 6.39 kg from the lowest grade

Similar results were shown by hydrosol production derived from both resin qualities distillation. The first-grade resin produces about 3.18 kg of hydrosol. A total of 9.68 kg of water remains in the boiler from the initial water volume of 20 kg. Apart absorbed by resin, it is estimated that approximately 6.28 kg of water lost due to evaporation (table 1).

Furthermore, the amount of remaining water in the boiler (9.91 kg) of lowest grade resin distillation is relatively similar with the first-grade distillation (9.68 kg). However, the hydrosol produced was lower approximately 2.75 kg at the same duration. The water lost due to evaporation where estimated around 6.39 kg.
Although it is difficult to determine the absolute contribution of water from steam or resin to the hydrosol [7], it is estimated that a maximum of 8.5% of water in hydrosol derived from resin, assuming all water contained in resin (0.27 kg) evaporates and condenses become to hydrosols (3.18 kg). A relatively similar amount also occurred in the distillation of waste resin. It is estimated a maximum of 7.6% of water in hydrosol derived from this lowest grade resin (Table 2).

Table 2. Contribution of water in the hydrosol

| Origin of water     | High grade resin | Harvest waste resin |
|---------------------|------------------|---------------------|
|                     | Absolute (kg)    | Relative (%)        |
| Coming from resin   | 0.27<sup>a</sup> | 8.5                 |
| Coming from water   | 2.91             | 91.5                |
| Total               | 3.18             | 100.0               |
|                     | Absolute (kg)    | Relative (%)        |
| Coming from resin   | 0.21<sup>b</sup> | 7.6                 |
| Coming from water   | 2.54             | 92.4                |
| Total               | 2.75             | 100.0               |

<sup>a</sup>average moisture content 2.26%<br>
<sup>b</sup>average moisture content 2.10%

This assumption, however, is overestimated because not all of water contained in resin will be distilled-out and condensed into the hydrosol. The water content contribution of resin to hydrosol will also depend on duration of distillation and the pressure applied in the distillation process [8]. In this consideration, in order to maximize hydrosol production, the distillation can be continued until all the volatile aromatic oils have been distilled. In order to support this assumption, further studies to determine the water absorption over time by styrax resin as well as to further confirm about hydrosol production yield when all volatile compounds distillate are necessary.

3.2. Potential utilization

Both essential oils and hydrosols are produced by steam distillation process, but they have different in their utilization. Various studies indicated that incense resin contain Phyto-pharmacy content which important both as antiviral, anti-septic with a relaxing aroma [3-5]. Incense oil can also be used for skin beauty. For aromatherapy application, styrax essential oil aroma has a relaxing effect [6,11,12]. In topical utilization, styrax essential oil can relieve inflammation, insect bites, acne, itching, irritation, rashes, sprains, and muscular aches and pains [5,8]. The compound 1,8 cineole has potential as anti-viral, anti-bacterial and anti-fungal, expectorant, offer relief to a congested respiratory system, thereby boosts circulation and immune system.

Hydrosol has lower safety concerns, although there are some important points in its application safely. Generally, hydrosol can be applied for cuts and scrapes, base for making lotions, or consumed as a flavouring for drinks or therapeutic use, and perfume [5,8]. Meanwhile, essential oil is much stronger than hydrosol and can be applied with diffuse into the air, kills germs and helps relieve colds, or as cleansing solution [8]. However, internal consumption for acute health conditions should be under supervision of a qualified practitioner.

As a distilled product, styrax hydrosol can be stored up to 18 months, but certainly not as long as essential oils. Furthermore, storing hydrosol in a refrigerator extend the expired date. Both hydrosols and essential oils have different acidities. Styrrax hydrosols are more acidic with pH values ranging from 4.7 to 4.9, while essential oils have a pH between 5.0 and 5.8.

Hydrosol contains a higher concentration of volatile substances than herbal teas and has therapeutic benefits when consumed [8]. Some of styrax hydrosol benefits when consumed internally include helping to relieve rheumatic pain; relieves headaches; and calm nerves [5,8]. Furthermore, hydrosol also be used for make-up remover; face toner; replacing water in mask recipes and facial lotions; and application as a pleasant and relaxing perfume (cologne).
3.3. Production costs

Basically, hydrosol is a by-product of essential oil distillation. Therefore, the production costs of hydrosol are closely integrated with essential oil distillation, so there is no special cost allocation required. Production costs come from resin provision cost, installation of distillation equipment and energy to produce stem of water vapour. The average price of the first quality resins reaches IDR 250,000/kg, while the collecting cost of waste resin is around IDR 50,000/kg [6,8].

Based on research, the production cost in the form of energy for distillation is around IDR 11,000 (first quality distillation) and IDR 12,770 (harvest residues distillation) for each kilogram of hydrosol. If benzoin (styrax) hydrosol price in online market reaches at least IDR 500,000/kg, an increase in value-added of IDR 239,000/kg will be obtained from the first-grade resin processing and IDR 437,230 from distillation of the lowest grade resin.

The results indicate that harvesting waste resin processing can be a prospective scheme in increasing the added value of non-timber forest products. If harvest residues disposed all this time, the distillation of low-quality resin for hydrosol production can be an alternative strategy to optimize the sustainable use of forest resources. Recently, organic and green products have become fashionable, so that styrax hydrosol is expected to meet consumer needs for quality health products at affordable prices. On the other hand, this research shows that by utilizing the relatively abundant harvesting waste, high quality hydrosol can be produced cheaply and healthier.

4. Conclusions

The research results validated that waste resin from harvesting incense can be processed for hydrosol production. At termination of distillation, the first-grade resins resulted approximately 3.18 kg (31.8%) hydrosol and 2.74 kg (27.4%) aromatic water from harvested waste resin. The production of essential oils from the best quality is higher than lower grade. It was produced approximately 64 g (yield 0.64%) of essential oil from the best quality resin, while the distillation of harvested waste resin yielded 53 g (0.53%). It is estimated 7.7% of water in hydrosol comes from waste resin assuming all water contained in resin evaporates and condenses to hydrosol. Considering the harvesting waste resin disposed and unutilized, the distillation of low-quality resin for hydrosol production can be an alternative strategy for optimizing the forest resources utilization. To maximize the hydrosol production, further studies are required to determine the distillation duration until all the volatile aromatic oils have been distilled from the resin.

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