Vapor-solid mixer design for cinnamal tea production

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Abstract. The utilization of natural products that potentially act as anti-cancer has been widely investigated. Our previous study in 2019 on microencapsulation of several essential oils, including citral with aldehyde moiety and citronellal from lemongrass, and cinnamaldehyde from cinnamon, has proved remarkably successful to prevent cancer risk (chemo-prevention). The study is then extended to produce tea-based products with citral and cinnamaldehyde oil additives as cancer risk prevention drink drinks. The study will aim to optimizing the mixer parameters to overcome the volatility rate of essential oil. The research was designed with the Analysis, Defining, Development, Implementation and Evaluation (ADDIE) model. It was conducted to make sure that all the machine parameters work efficiently. The developed machine is equipped with a heater tank and mixer. The heater tank and mixer capacities are 2.2 L and 4.0 L, respectively. The maximum pressure tank is up to 4.0 bar, and the recommended pressure works are 2.0 bar. The heating temperature maximum is 170 °C, and it will also keep the essential oil stability. The vapor-solid mixed gently at 20 rpm to produce a well-mixed product. Power consumption up to 1500 watts at 220 V (50 Hz). However, the product at the mixing time of 60 seconds with the gas flow 2 bar was perfectly obtained.

1. Introduction
Cancer is one of the major human diseases and causes a lot of suffering and economic loss worldwide. Selective destruction of tumor cells without damaging normal cells is an important goal for cancer chemotherapy in the 21st century. Cytotoxic compounds are compounds or substances that can damage normal cells or cancer cells and are used to inhibit cell growth. The components of essential oil fall aldehydes are known to have the cytotoxic potential [1]. Essential oils have a low level of antimicrobial resistance, so it is interesting in bactericidal applications, although the complex composition of essential oils needs to be studied more in their active complement. Gram-positive bacteria (Staphylococcus aureus) and Gram-negative (Escherichia coli) have also been evaluated [2].

The use of herbs in alternative and complementary medicine in Indonesia is increasingly known. Empirical evidence of research results that have been obtained and reported to have increased public confidence in herbal medicine's efficacy. Generally, people use for preventive measures a variety of diseases, even severe diseases such as cancer, diabetes, stroke, rheumatism. The drugs used for cancer prevention measures are known as Cancer Chemo-prevention. Medical herbs' advantages are the lack of toxicity and side effects of the drug, in general it has a broad spectrum of activity, and a lack of risk of resistance to the drug. Many research results mention a compound group flavonoid is a group of natural material compounds from phenolic compounds that are many plant pigments. Compound group flavonoid has activity as an antioxidant, so it is good for cancer prevention.
Efforts to increase the added value of essential oils have been studied, extraction of essential oils, isolation of essential oil components, catalytic transformation of essential oil components, and application of essential oil as antioxidants, antibacterial, fragrances, insect repellents, pheromones, air fresheners, aromatherapy, anti-fungal, and rice lice controllers. [3-13]. Some essential oils produced by plants in Indonesia are known to have the main content of aldehyde compounds. The most important is citronellal in citronella oil, cinnamaldehyde in cinnamon oil, and citral in lemongrass oil. Research on isolation and structural testing of citronellal, cinnamaldehyde, and citral compounds has been conducted in Indonesia [14], but the study of utilization as cytotoxic compounds is still very limited.

Essential oil components that have activity as cytotoxic compounds are compounds that have aldehyde groups [1]. Here are two compounds of aldehyde namely cinnamaldehyde from cinnamon oil and citral from basil oil. The component of cinnamon and lemongrass oils were reported elsewhere. [15,16].

![Cinnamaldehyde and Citral](image)

**Figure 1. Structure of citral and cinnamaldehyde**

Traditionally, in Indonesia, the people prefer tea compared to coffee due to the former caffeine content. Current study aims to enrich the various tea with essential oil by using Vapor-Solid mixing machine.

2. Methods

At the Analysis stage, a review of the condition and composition needs to produce tea bags and efficient mixer equipment. In the second stage, define sets the mixer’s design and the procedure of production of tea bags and the maintenance of its production costs. The third stage of development is carried out by manufacture of mixer machines that serve to mix cinnamon powder and lemongrass oil. Furthermore, the packaging is carried out in a variety of tea bags with various types of tea, the time of evaporation of lemongrass oil, the composition of tea and cinnamon-lemon grass oil. The next stage is evaluation, performed analysis of organoleptic test results, cinnamaldehyde and citral content in tea bags. The research stages are summarized in Figure 2.
Figure 2. Summary of research procedures

The cinnamal-tea preparation was conducted by controlling evaporation temperature of 70°C and vapor pressure keep at 1.5 bar. The second tubes containing 500 g of black/green tea and 10 grams of cinnamon powder were stirred first with a fixed stirring speed of 20 rpm for 30 minutes, then vapor flowed. Variations are performed against evaporation times of 5 seconds and 10 seconds. The results were tested organoleptically with the color and taste of the resulting tea and GC and GC-MS analysis.

3. Results and Discussion

3.1. The design of the vapor-solid mixer

The mixer consists of a vaporizer tube where essential oils are placed with a capacity of 2.2 L with automatic heating and a generated pressurized vapor. It is equipped with a tap that connects the oil vapor pipe to the second tube. The second tube consists of an automatic stirrer with a controlled speed, where the powder and cinnamon with a certain ratio are poured into the tube. Overall, the design of vapor-solid mixer to make Cinnamal tea is presented in Figure 3.
Figure 3. Design of vapor-solid mixer for Cinnamal tea production

Specifications of the mixing machine as follows

| Type                  | BMT 4L Series             |
|-----------------------|---------------------------|
| Function              | Liquid Heater and Dry Powder Mixer |
| Power                 | 1500 Watts                |
| Voltage               | 220 V – 50 Hz             |
| Heating tube capacity | 2.2 Liters                |
| Mixing tube capacity  | 4 Liters                  |
| Maximum pressure      | 3 bar                     |
| Safe working pressure | 2 bar                     |
| Maximum temperature   | 170°C                     |
| Mixer rotation speed  | 20 RPM                    |

3.2. The result of mixing cinnamon-vapor-citral tea powder
The appearance of the black and green tea were not changing after mixing with cinnamaldehyde and citral vapor. However, the light-cinnamon taste and citral odor enriched the tea. Further, when hot water is poured into the tea, the cinnamon taste and citral odor increase. The results indicate that after mixing,
in dry condition, the essential oil absorbed on the tea surface, then desorbed in the presence of hot water. This results in line with previously reported work on aromatherapy tea preparation [17].

![Figure 4. Results of GC analysis mixing black tea powder and the green tea.](image)

In the presence of a peak on the chromatogram (Figure 4), it is known that lemongrass absorbed on tea with the presence of a citral peak. The lemongrass oil component is higher on black than green tea. However, the cinnamaldehyde cannot be observed on the chromatogram because its solubility in n-hexane is low.

4. Conclusion

The vapor-solid mixing machine consisting of an essential oil vaporizer tube with maximum heating temperature 200°C and pressure 3 bar and mixer tube (mixer) with an efficient, fixed stirring speed with evaporation time of 1 minute. The analysis results showed that lemongrass oil vapor can be absorbed on the tea surface at the mixing condition 1.5 bar vapor pressure, 190 °C, and 10 minutes mixing time.

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