

A novel vaporizer to release volatile substances from aromatic plants

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ABSTRACT

Background: Oils of Aromatic plants have potent pharmacological activity. The vapor phase of the volatile oils clearly has a more effective antibacterial and antifungal effect in the laboratory environment compared to the liquid phase. One of the non-edible drug delivery methods in Iranian medicine is inhalation of vapor coming from aromatic plants (leaves, seeds or roots) in warm or boiled water. This drug delivery method is known as Enkebab. Existing vaporizers convert water or distilled liquids into vapors and there is no possibility to use plant and inhale the aromatic vapors of the plant directly. People commonly boil different parts of plants in kitchen utensils to use the vapor of aromatic plants. The objective of this study is to design and manufacture vaporizer using the technology of realizing volatile substances of aromatic plants in water. **Methods:** The most important components of the device consist of thermal element, wind pump, fan, reservoir, control and regulating components. The device was composed of three main parts: a controllable thermal system, an agitator system and a system for rapid evacuation of vapor from reservoir. **Results:** This vaporizer was designed and engineered with a new technology to release volatile substances of aromatic plants. The agitator and vapor exhaust fan in this device has led to the volatile components of the plant be released at a lower temperature than heat alone. the agitator and vapor exhaust fan in this device has led to the volatile matter of plants and their seeds to be released at a lower temperature than heat alone. Level of heat, stirring intensity and vapor outlet speed are customizable for the user in digital form. **Conclusion:** The vaporizer with technology to release volatile substances of aromatic plants can create a new method in use of volatile substances in laboratory and clinical places.

Keywords: Essential oils, volatile oils, traditional persian medicine, drug delivery, vaporizer, enkebab.

Introduction

Plants are oldest friends of humans and have been the subject of scholarly researches since ancient times due to their anti-microbial activity and therapeutic properties ^[1]. About three quarters of the world's population rely on traditional herbal medicine to care for their health based on statistics provided by World Health Organization (WHO) ^[2, 3] and have been

traditionally used for treatment of various respiratory infections ^[4].

The study of effective Ingredient of herbs has become extremely important with the increasing acceptance of herbal medicine ^[5] as alternative medicine for health care ^[6].

Volatile oils are organic compounds of aromatic plants ^[7]. These are stored in vacuoles and storage glands, skin, leaves, stems, seeds, fruits, blossoms, even roots and rhizomes of plants, flowers, trees, vegetables, and mosses ^[8, 9].

Volatile oils are responsible for absorbing pollinator insects in addition to protecting plants against microorganisms, insect bites and herbivorous animals ^[8, 10].

Volatile oils (essential oils) are secondary metabolites and active biological compounds of plants which have potential pharmacological activities ^[11, 12]. The volatile oils have multiple components which are associated with biological processes ^[11] and modulate the effects of each other ^[13]. Although the

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quantity and quality of essential oils are genetically controlled, the interaction between the plant and the environmental conditions (Eco physiological) are also important factors [6, 14, 15]. In a way that ingredient of volatile oils depends on the type of plant, the chemo type, and the regional weather. Hence, their antibacterial activity, anti-fungal activity and other pharmacological properties are influenced by these factors [9, 14, 16].

The combination of volatile oils varies in different parts of plants. In such a way that it even makes the extraction method different. For example, orange essential oil is extracted from orange peel by squeezing while the orange blossom essence, which is much more expensive, is derived from plant blossom and by distillation method [17].

The volatile oils and their components are widely used in the medical, food, cosmetic and perfumery industries [18, 19].

The predominant chemical composition of these organic materials are terpenes and non-terpenes components (variety of low molecular-weight aliphatic hydrocarbons, acids, alcohol, aldehydes, phenolic compounds, acyclic esters, or lactones [6, 20, 21].

Terpenes are made of five-carbon units known as isoprene [20]. The number of isoprene and method of their connection create different terpenes [21]. These compounds have antioxidant and anti-cancer properties in addition to the antibacterial, anti-fungal and anti-viral effects [22, 23].

The volatile oils are used in the treatment of diseases of the neuromuscular system, such as improving cognitive functions [24, 25], especially in Alzheimer [26], depression [27], insomnia, headache [28], analgesic and anti-inflammatory effects [29] and cardiovascular system [18], such as atherosclerosis [30], thrombogenesis [31], improve the cardiovascular function [32], Regulating lipid profile [33], blood pressure [34] and digestive system like gastric ulcers, ulcerative colitis [35] parasitic infections [36, 37], diarrhea and constipation [38], and respiratory system, such as respiratory infections [39, 40], asthma [41], bronchitis [42], metabolic diseases such as diabetes [34], skin diseases such as controlling sebum secretion, dry skin, dermatitis, eczema [43], alopecia Aerate [44], psoriasis [45] and autoimmune system such as rheumatoid arthritis [46, 47], genitourinary system, such as primary dysmenorrhea [48], menopause disorders [49], and as diuretics [7, 50]. In general, volatile oils have strong antibacterial properties with a mechanism of increasing the permeability of the bacterial cell wall due to phenolic compounds [51].

Volatile oils are more potent antimicrobials compared to synthetic antibiotics particularly against infectious pathogens [52] and are the potential source of new and safe drugs. For example, Clove essential oil kills 1 to 6,000 tuberculosis bacilli or Sandal essential oil is a potent disinfectant of the urinary system [11]. The combination of several volatile oils together, is sometimes more active than an oil alone [53]. Microbial resistance is not created against volatile oils unlike synthetic drugs (possibly due to strengthening host defense mechanisms) [54]. The vapor phase of the volatile oils clearly has a more

effective antibacterial and antifungal effect in the laboratory environment compared to the liquid phase [4, 55].

Application of essential oils is the most commonly used method of aromatic plants [22]. There are different methods for the extraction of essential oils such as distillation, compression, solvent extraction and carbon dioxide extraction [13, 22] but distillation (release of volatile oils by steaming or boiling water and plants) is still the most common method of extracting volatile oils for therapeutic applications [13]. Volatile substances are stored in the secretory cells, cavities, canals, epidermis cells of aromatic plants [56]. Hence, their release is possible with the physical process. In the process of distillation, the walls of the vacuoles rupture and secretion glands containing volatile substances are disconnected (torn) in water at a temperature of about 100 °C (hydro distillation) and essential oil is extracted. The therapeutic use of essential oils is called aromatherapy [25].

Although the extracted volatile oils have several advantages but their preparation and storage are costly and extremely expensive. Volatile oils should be kept away from light and in containers that cannot evaporate and with no possibility for being combined with the body of the container. Synthetic and fake volatile oils which have no therapeutic results are also found in the market [13, 57].

One of the other methods of using volatile substances of aromatic plants is direct use of vapor from aromatic plants [58, 59]. This non-edible drug delivery method has been considered to be Enkebab in literature of Iranian medicine [60]. Even though extraction of essential oils has been attributed to medieval Persia (the Avicenna, who was Iranian physician and Sage) [19, 61]. Enkebab is one of the most important non-edible drug delivery methods in this Iranian medicine. It seems that the Iranian medical Sage have considered the results of the treatment with direct use of vapor from various parts of the aromatic plants to be different compared to therapeutic results of the inhalation of extracted and purified essential oils. Therefore, it is the need to design a vaporizer with the ability to release the volatile oils from the plants directly. Some of the most important features of the initial device which was recommended in the past in Iranian medicine sources for this drug delivery method are: 1) the ability to deliver gradual and controlled vapor to target organs. 2) Ability to control the amount and duration of temperature (heat) with the aim of avoiding prolonged boiling time of the plant. 3) Avoiding patient's burn 4) Avoid spreading aromatic vapor in the environment which may on the one hand lead to waste of medicine and on the other hand harm others 5) do not damaging the reservoir after use [62].

Cold or warm vaporizers and diffusers in the market are not designed to release essential oil from aromatic plants and are rather designed to turn water or distilled liquids to breathable droplets. Hence, direct use of plants in existing vaporizer and diffusers will cause damage to these devices. Inevitably, a number of patients traditionally use kitchen utensils to use steam-boiled water mixtures and aromatic herbs or seeds to treat respiratory system diseases [63] (Fig.1). This method has limited use in other places such as treatment centers in addition to the complications of skin and mucous membrane burns [63].

These complications and limitations have led the clinical researchers to improve this therapeutic approach.



Figure 1. kitchen utensil

The purpose of this study is to design and manufacture a vaporizer with the ability for releasing volatile substances of aromatic plants directly.

Materials and Methods

This device consists of different sections as below:

1. An electric heater section: this part includes heating elements, controller and regulating components of electric current, such as thermostats, relays and protective devices. The thermostat equipped with a temperature selector and display.
2. An agitator section: this part includes wind pump and a voltage regulator in order to rate and severity control of the mixing process and some necessary Connectors. The wind pump was designed to activate the air bubble (blender) in a way that wind flow through the embedded pipes and transfer into the reservoir causes mixture of water and various parts of the aromatic plants.
3. Exhaust part of the produced steam: this part consists of Bladeless Fan and variable selectors to regulate flow speed and exhaust steam which is easily customizable by the user.
4. Vapor Outlet Sockets Section, Reservoir and other parts include sections contributed to the regulation and safety of the device.

Designing and manufacturing the device were followed as below:

1. Design of the heating system: to avoid direct contact of water and herbs with the heating elements (400W), the heat source is embedded outside the reservoir to indirectly transfer heat to water and plants.
2. Agitator system design: this has been designed to help release volatile substances and to prevent deposits and sticking of plants to the floor or wall of the reservoir
3. Quick vapor Exhaust System Design: Exhaust of generated vapor is accelerated by bladeless fan embedded

in door of reservoir. The rapid vapor exhaustion changes dynamical equilibrium (the equilibrium of the transformation of the liquid state to vapor and vice versa) in favor of converting the liquid state into a gas (vapor) state by reducing surface pressure (or relative vacuum), therefore evaporation occurs at lower temperatures^[64].

4. Vapor Outlet Sockets Section: It has been located on reservoir's door has ability to connect to the parts used to push the vapor into the target organ.
5. Reservoir: It has been selected to be made of Pyrex in order to avoid potential chemical reaction between the contents and the wall.
6. Design of safety systems: device is equipped with a fuse (3 Ampere) and an earth (ground connection system).

Results

The proposed device (Fig. 2) was made up of four portions of heat source (Fig. 3), agitator and reservoir (Fig.4) and vapor exhaust fan (bladeless fan) (Fig.5) which is washable, replaceable and can be sterilized efficiently.



Figure 2. Vaporizer Device

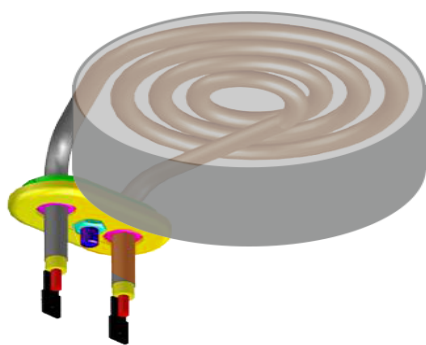
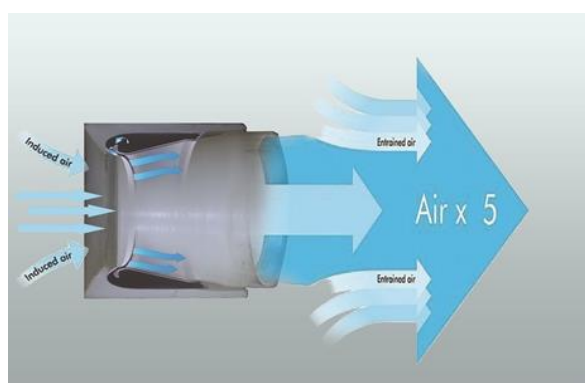


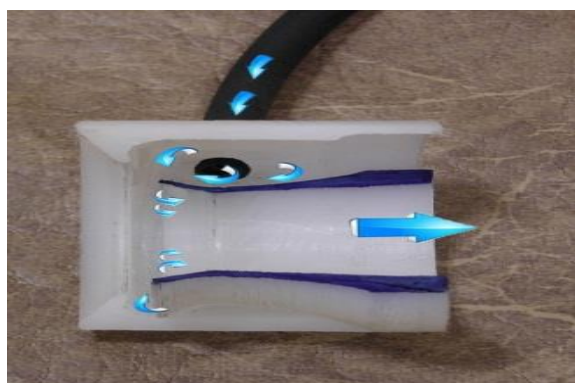
Figure 3. Heating element (400W)



Figure 4. Reservoir & Agitator section of device



(a)



(b)

Figure 5. Sagittal cutting of Bladeless Fan section of device (a, b)

The presence of physical mediators including the agitator and vapor exhaust fan in this device has led to the volatile matter of plants and their seeds to be released at a lower temperature than heat alone.

Level of heat, stirring intensity and vapor outlet speed are customizable for the user in digital form.

Accelerating vapor exhaust with the mechanism of reducing the surface pressure of the liquid produces vapor at a lower temperature and reduces the return of the vapor to the liquid phase [64].

Discussion

Although the pharmacological effects of essential oils are known more and more day by day, at the same time, identification of different methods of using volatile substances of aromatic plants and their seeds will lead to more exploitation of these substances. Also, the provision of multiple methods for the use of these materials will increase the choice of options for therapeutic users. The vapor phase of the volatile oils clearly has a more effective antibacterial and antifungal effect in the laboratory environment compared to the liquid phase in a way that essential oils can be used effectively to prevent or treat patients with respiratory infections or to disinfect the hospital air [4, 55]. The much greater and better effect of essential oils' vapor compared to their Liquid state enhances this thinking that various methods of using volatile substances are effective in the amount of consumption, strength, and range of effect of essential oils [8, 55]. The study of Iranian medical resources shows that use of vapor from aromatic plants in warm or boiled water (Enkebab) is one of the most important non-edible drug delivery methods in Iranian medicine [62, 65, 66]. Although Iranian medical practitioners are aware of the method of supplying essential oils (distillation) [19, 61], but its prescription with Enkebab style has been associated with specific therapeutic purposes [60]. Vaporizer with technology to release volatile substances of aromatic plants and seeds might differentiate the possible diversity in the therapeutic effects of aromatic substances with water vapor compared to direct use of synthetic and purified essential oils. This difference seems to be related to water vapor and volatile substances which do not exist in extracted essential oils alone.

Currently, there is no vaporizer with technology to release volatile substances of herbs in the treatment centers. With respect to antibacterial and antifungal effects of essential oils, this device can be a starting point in the prevention of hospital infections, as well as helping of treat patients with various infections, especially respiratory infections with herbs [4, 55]. Existing vaporizers have not been designed to release volatile substances of plants and have rather been designed to convert distilled liquids into particulate matter. Using the conventional methods used at home (boiling medicinal herbs in kitchen utensils) causes skin and mucous burns [63]. It is not possible to use conventional methods used at home in treatment centers.

Two factors of stirring and rapid exhaust of the generated steam with following mechanisms accelerate the release of volatile

substances and evaporation of water in the proposed device. Stirring leads to wall rupture of vacuoles and glands holding volatile substances. Stirring also increase inter-molecular energy and reduces the temperature required for water evaporation. In normal condition the pressure from the accumulation of evaporated molecules in the space above the liquid surface based on the dynamic equilibrium law (the conversion of liquid to steam and vice versa) reduces the conversion of liquid to steam. But in this device reduction of the surface pressure and increase of vapor pressure accelerates the evaporation of water. In addition to the fact that Stirring leads to rupture wall of vacuoles and glands holding volatile substances and secretion of volatile substances at lower temperatures, it also prevents deposition and clinging of plants or their seeds to the reservoir. Functioning of bladeless fan to exhaust vapors above the surface of the liquid, helps to decrease the surface pressure and increase the evaporation rate.

In addition to the unique effect of above-mentioned factors which are temperature, stirring the mixture and reducing surface pressure, the cumulative effect of these factors also facilitates and accelerates the release of volatile oils of herbs. Therefore, water evaporates at temperatures below the required temperature than the distillation method or the conventional method used at homes. As a result, the possibility of skin and mucosal burns and the likelihood of changes and degradation of heat-sensitive volatile materials are also decrease.

The washable and replaceable properties of reservoir which cause this part to be sterilized easily help the patient not to be infected by different organisms.

Conclusion

Access to water vapor with volatile oils from aromatic plants and seeds at temperatures below water boiling point with the help of this device provided the possibility of necessary clinical studies to evaluate the therapeutic effects of vapor of the volatile oils.

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Conflict of Interest

There is no conflict of interest to be declared.

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