A Survey on Chemical Constituents and Indications of Aromatic Waters Soft Drinks (Hydrosols) Used in Persian Nutrition Culture and Folk Medicine for Neurological Disorders and Mental Health

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Abstract
In Persian nutrition culture, drinking aromatic waters (hydrosols, distillate) has a long history as functional beverages or therapeutic remedies. The co-distilled water with essential oils, which contains partial amounts of more water-soluble volatile compounds are diluted and used as beverages. Since the solubility of volatile components is different in water, the overall composition, and thus the biological activities of aromatic waters seem to be different from the essential oils they were co-distilled with. Despite the essential oils, chemical constituents of many aromatic waters have not been evaluated scientifically. This research investigated hydrosols used for mental and neurological health maintenance in Persian nutrition culture and their chemical constituents. Constitutions of these hydrosols were extracted by liquid/liquid extraction method and identified by gas chromatography–mass spectrometry. Furthermore, cluster analysis was used to evaluate the relevance of these hydrosols chemical constituents. About 93 compounds were identified from 20 aromatic waters. the major or second major constituents were thymol (azarol howthorn, frankincense, lemon balm, valerian, shadab), phenethyl alcohol (damask rose, dog-rose, starflower), carvacrol (basil, creeping buttercup, lemon balm); eugenol (shadab, dog-rose, starflower, basil), camphor (yarrow and wormwood), carvone (oriental plane), carophyllene (cuminum), cinnamaldehyde (Chinese cinnamon), \( \text{-cymen-7-ol} \) (musk willow), limonene (lemon verbena), linalool and \( \text{a-terpineol} \) (bitter orange), menthol (date palm) and methyl 5-vinylnicotinate (olive). Although, these hydrosols prepared from plants belong to different genus and families, but cluster analysis showed obvious similarities between their chemical constituents. Results of this investigation showed in many cases that the constituents of aromatic waters are different from the pure essential oil.

Keywords
essential oil, neurological disorders, hydrosol, Aragh, aromatic waters, distillate

Mental disorders are one of the most debilitating diseases that in compression to other chronic conditions have a higher prevalence in different societies.¹ They have been clearly documented for accompanying to the many serious chronic illnesses.² A diverse range of neurological disorders symptoms, including anxiety, depression, phobia, tension, headache, insomnia, and others have a great impact on patient quality of life as well as dynamics and health status of communities.³ These neurological disorders affect a large number of populations, for example, major depression, based on the World Health Organization reports, is the fourth cause of disability disorders, which affects 121 million people worldwide.⁴ For centuries, traditional herbal formulations and different functional foods have been widely used for treatment of various mental and neurological conditions. In Persian traditional medicine many aromatic plants and their derivatives such as

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Table 1. Plants Name and Their Medicinal Parts That Are Used to Prepare Aromatic Waters for Neurological Disorders or Maintaining Mental Health.

| Aromatic Waters Beverage Name | Aromatic Water Name in Persian | Scientific Name | Family | Plant Parts |
|-------------------------------|--------------------------------|-----------------|--------|-------------|
| Azarol Hawthorn               | Aragh-e-Keyalak                | Crataegus azarolus var. chlorocarpa (Moris) K.I.Chr. | Rosaceae | Leaf and fruits |
| Basil                        | Aragh-e-Reyhan                 | Ocimum basilicum L | Lamiaceae | Aerial parts |
| Bitter orange                | Aragh-e-Bahar Naranj           | Citrus aurantium | Rutaceae | Flowers |
| Chinese cinnamon             | Aragh-e-Darchin                | Cinnamomum cassia (L.) J.Presl | Lauraceae | Stem bark |
| Creeping buttercup           | Aragh-e-Alaleh                 | Ranunculus repens L | Ranunculaceae | Flowers |
| Cuminim                      | Aragh-e-Ziereh                 | Cuminum cyminum L | Apiaceae | Seed |
| Date palm                    | Aragh-e-Tarooneh               | Phoenix daucylfera L | Arecaeaceae | Spathe |
| Damask rose                  | Golab                         | Rosa × damascene | Rosaceae | Flowers |
| Dog-rose                     | Aragh-e-Nastaran               | Rosa canina | Rosaceae | Flowers |
| Frankincense                 | Aragh-e-Kondor                 | Baswellia sp | Burseraceae | Ole-gum-resin |
| Lemon balm                   | Aragh-e-Badanbooye             | Melissa officinalis L | Lamiaceae | Leaf |
| Lemon verbena                | Aragh-e-Beh Limoo              | Aloysia citriodora Palau | Verbenaceae | Leaf |
| Musk willow                  | Aragh-e-Bidmeshk               | Salix aegyptiaca L | Salicaceae | Catkins |
| Olive                        | Aragh-e-Zeytoon                | Olea europea L | Oleaceae | Leaf |
| Oriental plane               | Aragh-e-Chenar                 | Platannus orientalis L | Platanaceae | Leaf |
| Starflower                   | Aragh-e-Gol Gavzaban           | Echium amoenum Fisch & C.A.Mey | Boragineae | Flowers |
| Valerian                     | Aragh-e-Sonbol tib             | Valeriana officinalis L | Caprifoliceae | Aerial parts |
| Wormwood                     | Aragh-e-Dermaneh               | Artemisia sieberi Besser | Astereaeae | Aerial parts |
| Yarrow                       | Aragh-e-boonmadaran            | Achillea millefouhum L | Astereaeae | Aerial parts |
| A polyherbal hydrosol        | Aragh-e-Shadab                 | A mixture of Ocimum basilicum L, Aloysia citriodora Palau, Echium amoenum Fisch & C.A.Mey, Salix aegyptiaca L, Valeriana officinalis L, Cinnamomum cassia (L.) J.Presl, Ranunculus repens L Tanacetum parthenium (L.) Sch.Bip. | Astereaeae | Aerial parts |

Aromatic waters have been used as functional beverages for mental and neurological disorders. In Persian traditional medicine system, therapeutic remedies divided by the nature of drugs origins. Based on this classification the remedies could have hot, cold, dry, wet, or moderate nature. In Persian traditional medicine systems, several hydrosol drinks obtained from different medicinal plants have been used for a range of neurological conditions. Different therapeutic effects have been cited for them such as antianxiety, sedative, anticonvulsant, antifatigue, and analgesics for headaches.

Pervious investigations on biological activity of medicinal plants on neural system showed diverse mechanisms of action, including upregulating of monoamine neurotransmitters by suppressing the reuptake, inhibiting monoamine oxidases, simulating of brain-derived neurotrophic factor expression, blocking 5-HT1A receptor and promoting the secretion of adrenocorticotropic for some of them.6,7

Although extensive evidences showed potential effects of phytochemicals on neurological disorders but a few researches focused on volatile constituents of traditional formulation such as hydrosols or aromatic waters.8 Aromatic water beverages constitute the major part of herbal market in Iran, more than 50 different types of these products present as functional drinks. The diverse origin of these products caused a very diverse volatile constituents and therapeutic activity. Although in some cases, these aromatic waters have a similar aroma to the pure essential oils they were co-distilled with, in many cases, they have different volatile constituents due to different water solubility of the volatile compounds and thus these have different properties.

This study investigated constituents of aromatic waters used in Persian nutrition culture and folk medicine for neurological conditions.

Materials and Methods

Phytochemical Analysis

Names and therapeutic properties of aromatic waters used for different neurological disorders were obtained using questioners filled by manufacturers and retail sellers of these aromatic waters in Fars province (2016-2017). The most frequently cited aromatic waters were purchased from the herbal market and their constituents were investigated. Briefly, 500 mL of each aromatic water was extracted with 500 mL of petroleum-ether. The essential oils of the samples were extracted from aqueous phase to organic phase (petroleum-ether) using a glass liquid-liquid extractor. In order to increase the concentration of volatile component in the organic phase, the aqueous phase was replaced by the fresh hydrosol after 150 minutes. Petroleum-ether extract was concentrated by rotary evaporator (IKA RV10), equipped with a Heidolph Rotavac vacuum pump.

Gas Chromatography–Mass Spectrometry

The concentrated petroleum-ether extracts of the beverages were subjected to gas chromatography–mass spectrometry (Agilent Technologies 7890 Gas Chromatograph) for analysis of the chemical compositions equipped with HP-5MS capillary column (Agilent Technologies 19091 S-433., 30 × 0.25 mm inner diameter). Mass detector was Agilent Technologies model 5975 C in El mode at 70 eV. The thermal ramp rates were increasing temperature from 60°C to 220°C.
with the rate of 5 °C/min and held at 220 °C for 10 minutes. The carrier gas (helium) was used with the flow rate of 1 mL/min. The interface temperature and mass range was set up to 280 °C and 30 to 600 m/z, respectively. Identification of the volatile compounds was done using the NIST (National Institute of Standards and Technology) or Wiley libraries, previous literature, and by comparison with retention times and mass spectra of the reference compounds.9,10

**Table 2. Aromatic Waters Indications in Mental Health Conditions as Well Mental Disorders Treatment.**

| Aromatic Waters | Nature | Indications | Dosing |
|----------------|--------|-------------|--------|
| **Monoherbal aromatic waters** | | | |
| Azarol hawthorn | Cold nature | Anticonvulsant | 100 mL TID, before meal |
| Basil | Hot nature | Sedative, anti-hystera | 100 mL TID, after meal |
| Bitter orange | Hot nature | Neurotonic, antidiizziness, antiasthma, sedative, antidepressant | 100 mL TID, after meal |
| Cardamom | Hot nature | Neurological pain treatment, hypnotics, sedative, headache treatment | 100 mL TID, after meal |
| Chinese cinnamon | Hot nature | Neurotonic, obsessive treatment, phobia treatment | 100 mL TID, after meal |
| Clove | Hot nature | Antianxiety, neurotonic, headache treatment, anticonvulsant | 100 mL TID, after meal |
| Common purslane | Cold nature | Headache treatment | 100-150 mL ID, before meal |
| Common thyme | Hot nature | Anticonvulsant, neuralgic pain treatment | 100 mL TID, before meal |
| Coriander | Cold nature | Obsessive treatment, antiasthma, brain improvement | 100 mL QID, before meal |
| Costmary | Hot nature | treat unilateral headache, neuralgic pain treatment | 100 mL TID, after meal |
| Cottonwood | Hot nature | Neurotonic, paralysis treatment, antitremor, numbness treatment | 100 mL TID, after meal |
| Creeping buttercup | Cold nature | Analgesic for neuralgic pain, sedative, antihystera | 100 mL TID, after meal |
| Cuminum | Hot nature | Neurotonic | 100 mL TID, after meal |
| Damask rose | Hot nature | Mental refreshing, sedative, brain improvement, antifatigue, neurotonic | 100 mL TID, after meal |
| Dragonhead | Cold nature | Brain improvement, sedative, heart beating treatment, anticonvulsant, memory improvement, headache treatment | 100 mL TID, after meal |
| Date palm | Hot nature | Neurotonic, sedative | 150 mL TID, before meal and bedtime |
| Dog-rose | Hot nature | Sedative, neurotonic | 100 mL TID, after meal |
| Felty germander | Cold nature | Tonic, anticonvulsant | 100-150 mL TID, before meal |
| Frankincense | Cold nature | Dementia prevention, memory improvement, mindfulness | 100 mL TID, after meal |
| Lavender | Hot nature | Hypnotics, sedative, headache prevention, anticonvulsant, antidiizziness, antitremor | 100 mL TID, after meal |
| Lemon verbena | Cold nature | Memory improvement, antidiizziness, analgesic for neuralgic pain, sedative, antihystera, treating unilateral headache pain | 100 mL TID, after meal |
| Marjoram | Hot nature | Sedative, treat headache, anticonvulsant | 100 mL TID, after meal |
| Musk willow | Cold nature | Sedative, anticonvulsant | 100 mL TID, after meal |
| Persian hogweed | Hot nature | Hysteria treatment, anticonvulsant, memory improvement | 100 mL TID, after meal |
| Olive leaves | Cold nature | Memory improvement, headache treatment, tooth pain treatment | 100-150 mL TID, before meal |
| Oriental plane | Cold nature | Neurotonic | 50-100 mL TID, after meal |
| Starflower | Cold nature | Neurotonic, sedative, obsessive treatment, antianxiety | 100 mL TID, before meal |
| Valerian | Hot nature | Neurotonic, sedative, anticonvulsant, neurotonic, analgesic | 100 mL QID, before meal and bedtime |
| Wormwood | Hot nature | Sedative, neurotonic, headache treatment, hypnotic | 50-100 mL TID, after meal |
| Yarrow | Hot nature | Anticonvulsant, neurotonic | 100 mL TID, after meal |
| Ziziphora | Hot nature | Sedative | 100 mL TID, after meal |

| Polyherbal aromatic waters | Nature | Indications | Dosing |
|---------------------------|--------|-------------|--------|
| Shadab | Hot nature | Sedative, headache prevention, anticonvulsant, antidiizziness | 100 mL TID, before meal |

Abbreviations: TID, 3 times a day; QID, 4 times a day.

Results and Discussion
The beverages that are used for neurological disorders in Persian traditional medicine are listed in Table 1. Some of these beverages and their applications have been maintained in traditional Persian manuscripts such as Qarabadin-e-kabir and Qarabadin-e-salehi and some others recently have become popular in folk medicine without any citation in traditional literatures. The hydrosols that are used in this study prepared from plants belong to 15 families (Table 1). Most of these hydrosol beverages are prepared from the leaves and flowers of plants. Diverse effects on neurological conditions have been cited for these aromatic waters, including memory...
| Component              | Azarol | Bitter orange | Chinese cinnamon | Creeping buttercup | Cuminum | Damask rose | Date palm | Dog—rose | Frankincense | Lemon Balm | Lemon verbena | Mask willow | Olive | Oriental plane | Shadab | Starflower | Valerian | Wormwood | Yarrow |
|------------------------|--------|---------------|------------------|-------------------|---------|-------------|-----------|----------|-------------|------------|---------------|-----------|-------|---------------|--------|------------|----------|----------|--------|
| 1,8-Cineole            |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| 2,3-Dimethoxytoluene   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| 3,4-Dimethoxytoluene   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| 2,6-Dimethoxytoluene   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Apol                   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Anethol (cis)          |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Anethol (trans)        |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Artemisia alkohol      |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Ethylbenzene           |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Bornol                 |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Benzenecetonitrile     |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Camphor                |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Carvacrol              | 23.54  | 87.69         |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Carveol (trans)        |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Carvone                |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Caryophyllene (trans)  |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Caryophyllene oxide    |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Cinnamaldehyde (E)     |        | 84.28         |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Cinnamaldehyde (Z)     | 0      | 0             | 3.94             |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Citronellol            | 0      | 0             | 12.69             |                   |         |             | 8.26      |          |             |            |               |           |       |               |        |            |          |          |        |
| Chrysanthenone         |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Cumin aldehyde         |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| n-Cymen-7-ol           |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| m-Cymen-8-ol           |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| m-Cumenol              |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Davanone               |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Dihydrocarvone (cis)   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Dihydrocarveol         |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Dihydrocarvone (trans) |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Dill spicde            |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Dihydroactinidiolide   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Eudesmol               |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Eugenol                | 22.65  | 0.42          | 5.1              |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Eugenol acetate        | 0.95   |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| l-Perfizil alcohol     | 1.21   | 0             |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Fenchone               |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Felledone              |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Geraniol               | 8.82   |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Geraniol (cis)         |        | 2.51          |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Guaiacol               |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Hepten-2-one, 6-methyl-5| 0.49   |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Hexadecanoic acid      | 7.45   |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| a-Humulene             |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Indole                 | 5      |               | 5.2              |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Intermedole            |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Jasnone (trans)        |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Jasmine (Z)            |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Limonene               |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Limonol                | 1.72   | 36.68         | 0.86             | 2.08              | 0       | 0           | 0         | 0.97     | 1.68        | 1.13       | 0.72         |           |       |               |        |            |          |          |        |
| Limonol oxide (cis)    |        | 1.24          |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Limonol oxide (trans)  |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Me-2-en-1-ol (cis-p)   |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |
| Menthol                |        |               |                  |                   |         |             |           |          |             |            |               |           |       |               |        |            |          |          |        |

(continued)
| Component                  | Azarol | Hawthorn | Bitter orange | Chinese cinnamon | Creeping buttercup | Cuminum | Damask rose | Date palm | Dog—rose | Frankincense | Lemon Balm | Lemon verbena | Musk willow | Olive | Oriental plane | Shadab | Starflower | Valerian | Wormwood | Yarrow |
|----------------------------|--------|----------|---------------|------------------|-------------------|---------|-------------|-----------|----------|-------------|-----------|--------------|-------------|-------|---------------|--------|------------|---------|----------|--------|
| Menthol (neo)              | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Menthone                   | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| α-Methylindolene           | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Methyl anthranilate        | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Methyl eugenol             | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Methyl hexadecanoate       | 1.43    | —        | —             | —                | —                 | —       | —           | 9.54      | —        | 1.15         | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Methyl 5-vinylpiracillin    | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Methyl jasmonate (Z)       | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Methyl octadecanoate       | —       | 1.94     | —             | —                | —                 | —       | —           | 0.74      | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Myristicin                 | 1.12    | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Myrtanol                   | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Nerol                      | 2.94    | —        | —             | —                | —                 | —       | —           | —         | 3.42     | 0.68         | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Nerolidol (trans)          | —       | 0.67     | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Phenethyl alcohol          | —       | 1.54     | —             | 0                | 76.95             | 0       | 46.9        | 0         | —        | 0.92         | 0         | 58.78         | —           | —     | —             | —      | —          | —       | —        | —      |
| Pinocarveol (trans)        | —       | —        | —             | —                | —                 | —       | —           | 8.02      | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Pinocamphone (trans)       | —       | —        | —             | —                | —                 | —       | —           | 0.38      | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Pinocarvone                | —       | —        | —             | 0                | 0                 | 0.66    | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Piperitenone               | 2.66    | —        | —             | —                | —                 | —       | —           | 2.78      | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| α-Pinene                   | —       | —        | —             | —                | —                 | —       | —           | 3.72      | —        | 6.12         | 0.33      | 1.15          | —           | —     | —             | —      | —          | —       | —        | —      |
| Pulegone                   | 2.64    | —        | —             | —                | —                 | —       | —           | 6.46      | —        | 6.12         | 1.04      | 0.33          | —           | —     | —             | —      | —          | —       | —        | —      |
| Sabinenehydrate (cis)      | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | 1.15          | 6.3         | 0.74 | —             | —      | —          | —       | —        | —      |
| Spathulenol                | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | 2.26      | 2.6           | 5.1         | 4.54 | —             | 0.77   | —          | —       | —        | —      |
| α-Terpineol                | 1.67    | 29.36    | 1.09          | —                | —                 | —       | —           | 1.15      | 6.3      | 0.74         | 0.82      | 0.35          | —           | —     | —             | —      | —          | —       | —        | —      |
| Terpin-4-ol                | —       | 0.7      | 0.47          | —                | —                 | —       | —           | 2.26      | 5.1      | 4.54         | 0.77      | 0.35          | —           | —     | —             | 8.15   | 1.09       | —       | —        | —      |
| α-Terpinyl acetate         | —       | —        | 4.81          | 0                | —                 | —       | —           | —         | —        | —            | —         | 0.35          | —           | —     | —             | —      | —          | —       | —        | —      |
| γ-Terpine                 | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Terpinolene                | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Thujone (cis)              | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | 0.29      | 0.33          | —           | —     | —             | —      | —          | —       | —        | —      |
| Thujone (trans)            | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | 0.29      | 0.33          | —           | —     | —             | —      | —          | —       | —        | —      |
| Thymol                     | 29.01   | 22.29    | 4.41          | 6.1              | —                 | —       | —           | 32.63     | 45.19    | 4.87         | 12.3      | 7.38          | 22.49       | 0.63  | 9.76          | 2.79   | 0.82       | —       | —        | —      |
| Thymol acetate             | —       | —        | —             | —                | —                 | —       | —           | 0.4       | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Verbenol (trans)           | —       | —        | —             | —                | —                 | —       | —           | 16        | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Verbenone                  | —       | —        | —             | —                | —                 | —       | —           | 5.78      | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| α-Xylene                   | 20.2    | —        | —             | —                | —                 | —       | —           | 2.03      | 11.64    | 2.26         | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| p-Xylene                   | 20.2    | —        | —             | —                | —                 | —       | —           | 2.03      | 11.64    | 2.26         | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
| Yamogi alcohol             | —       | —        | —             | —                | —                 | —       | —           | —         | —        | —            | —         | —             | —           | —     | —             | —      | —          | —       | —        | —      |
improvement, antidementia, sedative, analgesic, antiepileptic, neurological pain killer, antidepressant, antihysteria, and antianxiety. From the point of view of Iranian folk medicine, most of these beverages have hot nature (Table 2). Sedative effect was the most frequent therapeutic application of these hydrosol beverages.

The chemical constituents of investigated aromatic waters were determined by gas chromatography–mass spectrometry technique and the identified compounds are listed in Table 3. Since the plants that are used to prepare these aromatic waters belong to different genus and families, hierarchical cluster analysis and K-means analysis based on chemical constitutes were used to make clusters and subclusters and find any correlations between aromatic waters and their constituents (Figure 1, Table 4). As seen in Table 3, which shows the constituents of beverages, the major or second major constituents were thymol (azarol hawthorn, frankincense, lemon balm, valerian, shadab), phenethyl alcohol (damask rose, dog-rose, starflower), carvacrol (basil, creeping buttercup, lemon balm); eugenol (shadab, dog-rose, starflower, basil), camphor (yarrow and wormwood), carvone (oriental plane), caryophyllene (cuminum), cinnamaldehyde, (Chinese cinnamon), p-cymen-7-ol (musk willow), limonene (lemon verbena), linalool and α-terpineol (bitter orange), menthol (date palm), methyl-5-vinylcicotate (olive), and yamogi alcohol (yarrow). There is a correlation between hierarchical cluster analysis and K-means analysis mean analysis results (Figure 1, Table 4). Based on both analyses damask rose, dog-rose, and starflower aromatic waters made a distinct cluster because of the presence of 47% to 77% phenethyl alcohol. The similarity of wormwood and yarrow aromatic waters seen in hierarchical cluster analysis and K-means cluster analysis might be because of the presence of camphor (23.56%–42.49%) as the major constituent, artemisia alcohol (3.12%–8.16%) and trans-thujone (4.36%–6.74%) in these aromatic waters. Considering hierarchical cluster analysis and K-means analysis, cuminum, creeping buttercup, and Chinese cinnamon constituents had a big difference with other aromatic waters.

Table 4. K-Means Cluster Analysis of the Aromatic Waters Constituents.

| Cluster | Constituents |
|---------|--------------|
| 1       | Wormwood, yarrow |
| 2       | Azarol hawthorn, basil, frankincense, olive, shadab, valerian, lemon balm |
| 3       | Bitter orange, lemon verbena, musk willow |
| 4       | Chinese cinnamon |
| 5       | Creeping buttercup |
| 6       | Cuminum |
| 7       | Damask rose, dog-rose, starflower |
| 8       | Date palm, oriental plane |
Table 5. Profile of Essential Oils Reported in Literature for the Plants Being Used to Prepare Aromatic Waters for Mental Health and Neurological Conditions.

| Plant Name        | Profile of Essential Oils Monoherbal Aromatic Waters                                                                 | References |
|-------------------|------------------------------------------------------------------------------------------------------------------------|------------|
| Azarol howthorn   | Viridiflorol, borneol, eicosane, heneicosane, tricosane, squalene, (E)-2-hexenal, butyl butyrate, linalool, butyl hexanoate, methyl octanoate, pentyl hexanoate, and hexyl hexanoate | 13, 14     |
| Basil             | Estragole, linalool, methyl cinnamate, (Z)-cadinol, eugenol, 1,8-cineole, methyl eugenol, (Z)-bergamotene               | 15         |
| Bitter orange     | trans-(Z)-Bergamotene, (Z)-santalone, germacrene-B and (Z)-sesquiphellandrene, hexanol, (Z)-terpinene, cis-(Z)-ocimene, cis-(Z)-sabinene | 16, 17     |
| Chinese cinnamon  | 3-Methoxy-1,2-propanediol, trans-cinnamaldehyde, (E)-methoxy-cinnamaldehyde, eugenol, coumarin                          | 18         |
| Creeping buttercup| Methyl linoleate, carvacrol methyl ether, globulol, aromadendrene, phytol, (Z)-farnesene, (Z)-terpinyl acetate, (Z)-ocimene, and fatty acid derivative | 19         |
| Cuminum           | Cuminum, cuminal, γ-terpinene, p-cymene, (Z)-pinene                                                                       | 20         |
| Damask rose       | Citronellol, nerol, geraniol, nonadecane, 2-phenylethyl alcohol, geranyl acetate                                             | 21         |
| Date palm         | (E)-(Z)-ionone, (E)-2-tridecene, limonene, (E)-geranylacetone, decanal, ethyl decanoate, ethyl acetate, 2-propanol, isoamyl alcohol | 22, 23     |
| Dog-rose          | Vitispirane, (Z)-dehydro-ar-himachalene, spathulenol, (Z)-caryophyllene oxide                                              | 24         |
| Felty germander   | (Z)-Pinene, (Z)-pinene, (E)-cymene, (Z)-caryophyllene, pinocarveol, spathulenol, eudesmol, cadinol                       | 25, 26     |
| Frankincense      | (Z)-Pinene, camphene, (Z)-pinene, (Z)-pinene, myrcene, limonene                                                        | 27, 28     |
| Lemon balm        | trans-Cardveol, citronellol, δ-3-carene, citronellal, geraniol, 1-occtene-3-ol, and spathulenol                         | 29         |
| Lemon verbenae    | l,8-Cineole, geraniol, 6-methyl-5-hept-2-one, nerol, limonene, (Z)-caryophyllene, ar-curcumene, spathulenol              | 30, 31     |
| Musk willow       | 1,4-Dimethoxybenzene, phenylethyl alcohol, carvone, medheleugenol, citronellol, 4-methoxyacetophenone                   | 32         |
| Olive leaves      | (E)-2-hexenal, (E,E)-R-farnesene, linalool, (Z)-caryophyllene, valencene, 4-terpineol, (E)-ocimene, p-cymen-8-ol, carvone, R-humulene, germacrene D, trans-nerolidol | 33         |
| Starflower        | (Z)-Cadinene, viridiflorol, 3-murolene, ledene, (Z)-calacorene, (Z)-cadinene                                              | 34         |
| Valerian          | Camphene, (Z)-camphene aldehyde, bornyl acetate, (Z)-gurjunene, (Z)-cadinene, epizonaren, germacrene-B, valerenal       | 35, 36     |
| Wormwood          | (Z)-epoxycocimene, chrysanthenyl acetate, (Z)-thujone, trans-sabinyl acetate, sabincene                                | 37, 38     |
| Yarrow            | Chamazulene, 1,8-cineole, (Z)-pinene, (Z)-pinene, (Z)-pinene, thujane, p-menthane, pipertone, linalool, (Z)-caryophyllene, borneol, camphor, nerolidol, and limonene | 39         |

According to the hierarchical cluster analysis, azarol howthorn, basil, frankincense, olive, shadab, valerian, lemon balm, lemon verbena, date palm, bitter orange, and musk willow made a big cluster based on their thymol and carvacrol contents with some subcluster within it. For example, basil, shadab, and lemon balm made a subcluster because of similar thymol (22%-45%) and carvacrol (14%-32%) contents (Figure 1).

Date palm and oriental plane made a subcluster according to K-means, which might be due to the similar content of thymol (6.1%-7.3%), pulegone (6.12%-6.46%), and carvone (7.69%-24.21%) in these aromatic waters.

For many of these aromatic waters, this is the first report on their chemical composition. Since many of these aromatics are said to have multipurpose applications such as cardiovascular, hormonal, neurological, and gastrointestinal effects. In our previous works on hydrosols used for cardiovascular conditions or women's reproductive and hormonal conditions we have reported chemical composition of some of these aromatic waters such as wormwood, yarrow, oriental plane, and azarol howthorn. On the other hand, it was essential for the current research to find relation between these aromatic waters using cluster analysis. Thus, the previously reported aromatic waters were analyzed again to avoid any variation in results due to the experimental conditions.

There is a good agreement between the results of the current article with the aromatic waters that were reported in the previous works. In most of the cases, the major constituents are the same and the chemical compositions are similar with some degree of variation in constituents' percentages. For some other aromatic waters, such as shadab, lemon verbena, cuminum, Chinese cinnamon, bitter orange, and basil, this is the first report on chemical constituents of their hydrosols thus, it was not possible to compare the results of the current research with others but the major components of the reported essential oils are summarized in Table 5. Considerable differences can be observed by comparing aromatic waters and reported essential oils for these plants. For cuminum, the major components in the aromatic water are trans-caryophyllene, 3,4-dimethoxytoluene and carvophyllene oxide while main compounds in cuminum essential oil are cuminal and cuminic alcohol (Table 5). In case of lemon balm and frankincense, carvacrol, thymol, and linalool constituted the main part of aromatic water compositions (Table 3) while the major components of the essential oil of these plants (Table 5) are citronellol, δ-3-carene, and in some cases, carvacrol with citronellal and geraniol. Significant differences can also be found between compositions of damask rose, bitter orange, dog-rose, valerian, and musk willow aromatic waters and essential oils (Tables 3 and 5). These difference between aromatic water and essential oil compositions may arise from polarity and solubility of volatile compositions in water. It seems that due to different chemical composition, it is essential to consider different biological activities for aromatic waters compared with pure essential oils.
Conclusion

The present investigation introduced some aromatic waters that are used in Persian nutrition culture and folk medicine for neurological conditions and maintaining mental health. Based on this research, chemical compositions of these aromatic waters are remarkably different from the essential oils of the plants used to prepare them. These plants originated from a variety of genus and families but using cluster analysis (hierarchical cluster analysis and K-means) showed that some similarity can be identified between their chemical compositions. Thymol, phenethyl alcohol, carvacrol, eugenol, and/or camphor were the major constituents in most of the aromatic waters. This study was not designed to evaluate the efficacy of these aromatic waters (hydrosols), but centuries of production and consumption of these aromatic waters in Persian folk medicine and nutrition culture might be related to their efficacy. This research may present a valuable line for developing functional beverages for mental health or neurological conditions. Also, scientific evaluation of these aromatic waters constituents may lead to some new therapeutic agents.

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Author Contributions

AH and AP wrote the draft and contributed toward data collection and analysis. ZZ and MM contributed toward data collection and analysis.

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This study was an experimental and laboratory work and did not require ethical approval.

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