An Overview on Indications and Chemical Composition of Aromatic Waters (Hydrosols) as Functional Beverages in Persian Nutrition Culture and Folk Medicine for Hyperlipidemia and Cardiovascular Conditions

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Abstract
Hydrosol beverages in Persian nutrition culture and ethnomedicine are the side products of essential oil industry that are used as delicious drinks or safe remedies. To investigate indications and chemical composition of hydrosol beverages for hyperlipidemia and cardiovascular conditions, Fars province was selected as the field of study. Ethnomedical data were gathered by questionnaires. The constituents of hydrosols were extracted with liquid/liquid extraction and analyzed by gas chromatography–mass spectrometry. Statistical analysis were used to cluster their constituents and find the relevance of their composition. A literature survey was also performed on plants used to prepare them. Thymol was the major or second major component of these beverages, except for wormwood and olive leaf hydrosols. Based on clustering methods, although some similarities could be found, composition of barberry, will fumitory, dill, and aloe hydrosols have more differences than others. These studies may help in developing some functional beverages or new therapeutics.

Keywords
essential oil, cardiovascular, hydrosol

Cardiovascular disease is a class of diseases that involve the heart or blood vessels and includes coronary artery diseases such as angina, myocardial infarction, stroke, hypertensive heart disease, cardiomyopathy, congenital heart disease, rheumatic heart disease, aortic aneurysms, peripheral artery disease, and venous thrombosis.

Coronary artery disease, stroke, and peripheral artery disease involve atherosclerosis. This also may be caused by high blood pressure, diabetes, smoking, lack of exercise, obesity, hypercholesterolemia, poor diet, and excessive alcohol consumption. According to the World Health Organization estimate, about 31% of all deaths worldwide are due to cardiovascular disease.¹,²

Functional beverages are nonalcoholic drinks that contains ingredients such as herbs, vitamins, minerals, raw fruit, or vegetable, which are consumed to provide specific health benefits beyond those of general nutrition. Most of the well-known functional beverages are used to boost energy, enhance the immune system, or increasing sense of well-being. These are marketed as sports drinks, energy drinks, enhanced fruit drinks, and enhanced water.

Aromatic waters, also known as floral water, distillate water, or hydrosols, are the side products of the essential oil and natural perfume industry.³ They are prepared by dispersion of the plant materials via industrial hydrotreatment. This water is evaporated simultaneously with the essential oil of the plants as the container is heated. These vapors are condensed and liquefied together in a collecting vessel to give 2 phases.

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A mixture of nettle, walnut, saatar
Will fumitory Aragh-e-Shatareh
Fumaria parviflora
Artemisia sieberi
Wormwood Aragh-e-Dermaneh
Brassica rapa
Teucrium polium
Parsley Aragh-e-Jafari
Petroselinum crispum
Oriental plane Aragh-e-Chenar
Platanus orientalis
Olive Aragh-e-Zeytoon
Oliva europaea
Garlic Aragh-e-Shahtareh
Allium sativum
Trigonella foenum-graecum
Berberis vulgaris
Barberry Aragh-e-Zereshk
Crataegus azarolus
Azarole hawthorn Aragh-e-Keyalak
Dill Aragh-e-Shevid
Anethum graveolens
Borago officinalis
Borage Aragh-e-Chaher
Borago officinalis
Aloe spp.
Aloe Aragh-e-Sabre zard; Aragh-e-Aloe
Berberis vulgaris
Berberidaceae
Fruits
Crateagus azarolus L.
Rosaceae
Leaf and fruits
Anethum graveolens L.
Apiaceae
Leaf
Trigonella foenum-graecum L
Fabaceae
Leaf
Allium sativum L.
Amaryllidaceae
Bulb
Olea europaea L.
Oleaceae
Leaf
Platanus orientalis L.
Platanaceae
Leaf
Petroselinum crispum Mill.
Apiaceae
Leaf
Teucrium polium L.
Lamiaceae
Aerial parts
Brassica rapa L.
Brassicaceae
Root
Artemisia sieberi Besser
Asteraceae
Aerial parts
Fumaria parviflora Lam.
Papaveraceae
Aerial parts
Urtica dioica L.
Urticaceae
Leaf
Juglans regia L.
Juglandaceae
Leaf
Zataria multiflora Boiss.
Lamiaceae
Leaf
Olea europaea L.
Oleaceae
Leaf
Apium graveolens var. dulce
Apiaceae
Aerial parts

Table 1. Plants’ Names and Their Medicinal Parts That Are Used to Prepare Aromatic Waters for Cardiovascular Diseases.

| Aromatic Water Beverage Name | Aromatic Water Name in Persian | Scientific Name | Family          | Plant Parts |
|------------------------------|-------------------------------|----------------|-----------------|-------------|
| Aloe                         | Aragh-e-Sabre zard; Aragh-e-Aloe | Aloe spp.       | Xanthorrhoeaceae | Leaf        |
| Azarole hawthorn             | Aragh-e-Keyalak               | Crataegus azarolus L. | Rosaceae | Leaf and fruits |
| Barberry                     | Aragh-e-Zerebsk              | Berberis vulgaris L. | Berberidaceae | Fruits    |
| Dill                         | Aragh-e-Shvied                | Anethum graveolens L. | Apiaceae | Leaf        |
| Fenugreek                    | Aragh-e-Shinabeile            | Trigonella foenum-graecum L | Fabaceae | Leaf        |
| Garlic                       | Aragh-e-Sir                  | Allium sativum L. | Amaryllidaceae | Bulb       |
| Olive                        | Aragh-e-Zeytoon              | Olea europaea L. | Oleaceae | Leaf        |
| Oriental plane               | Aragh-e-Chenar               | Platanus orientalis L. | Platanaceae | Leaf       |
| Parsley                      | Aragh-e-Jafari               | Petraselimum crispum Mill. | Apiaceae | Leaf        |
| Polegermander                | Aragh-e-Kalpooreh            | Teucrium polium L. | Lamiaceae | Aerial parts |
| Turnip                       | Aragh-e-Shalgham             | Brassica rapa L. | Brassicaceae | Root       |
| Wormwood                     | Aragh-e-Dermameh             | Artemisia sieberi Besser | Asteraceae | Aerial parts |
| Will fumitory                | Aragh-e-Shatereh             | Fumaria parviflora Lam. | Papaveraceae | Aerial parts |
| A mixture of nettle, walnut, saatar | Aragh-e-Taadol | Urticaceae | Leaf |
| (Shirazi thyme), olive, and celery leaves |                       | Juglans regia L. | Juglandaceae | Leaf |
|                              |                               | Zataria multiflora Boiss. | Lamiaceae | Leaf |
|                              |                               | Olea europaea L. | Oleaceae | Leaf |
|                              |                               | Apium graveolens var. dulce | Apiaceae | Aerial parts |

partly or completely soluble in water. These 2 phases are then separated; the essential oil goes to the pharmaceutical or cosmetic industry while the aromatic water depending on its unique properties is diluted 1:8 or 1:12 with water. They might go directly for marketing in big (250-1000 liters) containers without any further processing or be subjected to pasteurization in the factory. Subsequently, these preparations are kept in small (1-5 liters) plastic or glass containers for retail or wholesale marketing. In Iranian nutrition culture, they are used with sweeteners such as sugar or honey and served as natural delicious drinks. In Persian nutrition culture and folk medicine, aromatic waters are considered as very safe beverages used for medicinal purposes depending on the plants used for their production. Most aromatic waters are monoherbal but some have polyherbal constituents. Depending on the plants used for preparation of each aromatic water, an overall nature is considered including, hot, cold, wet, dry, or moderate. They are also used as remedies to treat several conditions in oral and/or topical applications. Some adverse effects have been reported in folk medicine due to their improper application or ingestion. But, in general, they are considered as a safe and effective way of consuming essential oils and vital essence of medicinal plants or vegetables. In contrast to the pure essential oils, which are usually very potent or even harsh in terms of their biological activities, aromatic waters are moderate and balanced by the water and its water soluble volatile components. Any of the aromatic waters has its own individual smell and composition, which is considerably different from the pure essential oil with which it was codistilled. The aromatic water has therefore additional properties not possessed by the essential oil alone. The moderate activity of these waters makes facilitates their use as daily soft drinks keeping their therapeutic features.

More than 50 different types of aromatic waters are produced and marketed in Iran, but as far as we know, the chemical constituents and biological activities of most of them have not been evaluated. Also, to the best of our knowledge no commercial products of them has been presented to the world markets. The aim of this study was to investigate constituents of aromatic waters and hydrosols used in Persian nutrition culture and folk medicine for hyperlipidemia and cardiovascular conditions as well as presenting them as potential functional soft drinks. Their nature and therapeutic indications have been also introduced in this study.

Materials and Methods

Information and Sample Collection

Fars Province, which is located in the south of Iran, was selected as the field of study. To gather information about different aromatic waters that are produced and used in Persian nutrition culture and folk medicine, the field study was conducted from March 2013 to March 2014 under the supervision of one local person as a native guide in all visits (84 manufactories). A suitable questionnaire was also prepared for this study, which was filled according to the information gathered in visits of the local manufactories or their shops. The frequency of each therapeutic effects for these aromatic waters from all questionnaires were calculated. The manufactories were also asked to rank these aromatic waters from 1 to 14 according to their mean of annual production over the past 3 years. The aromatic water with the lowest level of production was ranked 1. The ranking values from different manufactories are presented as mean ± standard deviation.

On the other hand, different aromatic waters that are used in Persian folk medicine as cardiovascular tonic or therapeutic beverages were purchased for further analysis. They are listed in Table 1 and coded as 1 to 14.

Phytochemical Analysis

Essential oils in each sample were extracted using a glass liquid extractor system. Five hundred milliliters of each sample was
extracted with 500 mL of petroleum-ether as solvent. Petroleum-ether was heated to evaporation during 150 minutes. The solvent vapor was then transferred to the bottom of the beverage container. The vapor was liquefied in the beverage and due to the lower density it passed through the beverage toward the upper side of the container. At the same time, the essential oil of the sample was transferred from the aqueous phase to the petroleum-ether phase. In order to increase the essential oil concentration in the organic phase, after 150 minutes the used beverage was replaced with fresh beverage and the extraction procedure was continued for another 150 minutes. The extract of each sample was concentrated to approximately 10 mL at 40°C and 60 rpm using a basic rotary evaporator (IKA RV10), equipped with a Heidolph Rotavac vacuum pump.11

Gas Chromatography–Mass Spectrometry
The concentrated extract of each aromatic water beverage was dehydrated and subjected to gas chromatography–mass spectrometry for the analysis of the respective essential oils. Agilent Technologies 7890 Gas Chromatograph with a mass detector (Model 5975C) was used in the present study. The gas chromatograph was equipped with a HP-5MS capillary column (phenyl-methylsiloxan, 30 m, 0.25 mm i.d.; Agilent Technologies; model 19091S-433 [60°C to 325/350°C]) and a mass spectrometer (Agilent Technologies; model 5975C), which was operating in EI mode at 70 eV. The interface temperature was 280°C, and the mass range was 30 to 600 m/z. The oven was heated (5°C/min) from 60°C to 220°C and then it was held for 10 minutes at 220°C. Helium was the carrier gas, and the flow rate was set to 1 mL/min. The components were identified by comparing the mass spectra and retention times with those of reference compounds, or with mass spectra in NIST or Willey libraries or in literature.12–14

Principal Component Analysis. In order to cluster the aromatic water samples based on their constituents resulting from gas chromatography–mass spectrometry analyses, principal component analysis was used as an unsupervised clustering analysis technique. Briefly, all aromatic samples together with their corresponding vectors of constituents generated a matrix in MATLAB (Mathworks Inc, Natick, MA). Principal components of the resulted matrix were thereafter extracted using singular value decomposition algorithm as implemented in MATLAB software. Principal component analysis theory is based on a ranking approach where principal components are sorted according to their eigenvalues in such a way that the first one contains the most variation inside the data set. Consequently, the next principal component is extracted to be orthogonal with respect to the previous one. The plot of the first 2 principal components is therefore representative of the whole data in a 2-dimensional space. The orthogonal feature of the first 2 principal components makes a representation of the data set in a 2-dimensional space.

Hierarchical Cluster Analysis. To perform hierarchical cluster analysis, the resultant matrix as prepared in the previous experiment was subjected once again to MATLAB software. Cluster definitions were done by means of Euclidean distance as a way to measure similarities using unweighted pair group method (UPGMA). The plot of the distances versus samples was used to represent the data based on their similarities. The final dendrogram could represent the similarities between the samples via its connectivity patterns.

K-Means Analysis. K-means separates the points of an N-by-P data matrix into K clusters. These partitions are designed in such a way to minimize the sum of the within-cluster sums of point-to-cluster-centroid distances. K-means returns an N-by-1 vector representing the cluster index for each sample. Euclidean distances were used for clustering purposes in this experiment.15

Results and Discussion
Fars province is located in the south of Iran. It has an area of 122 400 km² and a population of 4.59 million people. Fars, or known in Old Persian as Pārsā, is the original homeland of the ancient Persians. More than 84 manufactories are producing different medicinal aroma waters with traditional (65 manufactories) or full industrial techniques and equipment (about 19 manufactories). Most of these manufactories are located in Meymand and Darab cities, and their products are distributed all over the country.

Hydrosols and Their Phytochemicals
A list of aromatic waters that are used for hyperlipidemia and cardiovascular conditions was prepared according to indications on package labels or brochures written by their manufacturers or according to the information gathered via questionnaires (Tables 1 and 2).

As seen in Table 1, the plants that are used to prepare these beverages belong to 11 different plants families. Apiaceae, Lamiaceae, and Asteraceae had a greater proportion than other families. The percentage of frequency of each cardiovascular application for these aromatic waters in all gathered questionnaires is shown in Figure 1. The higher percentage of frequency can show the higher importance of an application for a beverage. For example, in all questionnaires (100%), oriental plane aromatic water was suggested as a hypotensive and mild aromatic water as a hypolipidemic agent. While only a few informants believed that aloe aromatic water has anti-anemia properties. In ethnomedical surveys, cultural importance of species can reflect more accurate and more informants’ data obtained from questionnaires.19

As seen in Figure 1, most of these beverages were believed to show antihypertension properties. The second frequently cited application was antidiabetic effects. In order to roughly evaluate the popularity of these aromatic waters in folk medicine, manufactories were also asked to rank these aromatic waters from 1 to 14 according to their mean of
annual production over the past 3 years. Since these data were confidential for these manufactories, we used a ranking system. The aromatic water with the lowest level of production was ranked 1. The obtained ranking data from different manufactories are presented as mean ± standard deviation in Figure 2. Dill, will fumitory, Taadol, and oriental plane aromatic waters had higher annual production levels during the past 3 years. This popularity might be due to their efficacy,
differences in prevalence of cardiovascular conditions in the region, or even the aromatic waters’ taste, aroma, or possible side effects during longer period of consumption.

Most of these beverages are prepared from aerial parts (leaf and fruits) of the plants except in case of turnip (roots) and garlic (bulb). Different indications for cardiovascular conditions including cardiotonic, antihypertension, anti-arrhythmic, antipalpitation, blood cleansing, blood thinning, anti-anemia, anti-atherosclerosis, lipid lowering, antidiabetic, and diuretic were mentioned for these aromatic waters. It should be also mentioned that some of these beverages were believed to have cold nature while others had warm features. Other indications apart from cardiovascular specifications were also mentioned for these beverages, as summarized in Table 2.

As discussed earlier, aromatic waters have their own individual smell and compositions that are considerably irrelevant to the pure essential oils they were codistilled with. Therefore, it was necessary to elucidate chemical constituents of these aromatic waters by gas chromatography–mass spectrometry analysis after liquid-liquid extraction. The results are summarized in Table 3. In most of these aromatic waters, thymol is major or second major component except for wormwood and olive leaf aromatic waters. Carvacrol was also detected in all of these aromatic waters except for azarole hawthorn, wormwood, and olive leaf.

According to both hierarchical cluster analysis and K-means, oriental plane, fenugreek, and azarole hawthorn aromatic waters make a distinct cluster (Figure 3). The certain similarity of azarole hawthorn and fenugreek was also seen by means of principal component analysis. The reason for the observed similarities between these samples based on clustering analysis was the presence of comparable amounts of thymol (6.2% to 28.7%) in all 3 aromatic waters. In addition, carvone (23.22%) was the main component of oriental plane aromatic water, which was not detected in azarole hawthorn. According to hierarchical cluster analysis, fenugreek and azarole hawthorn made a subcluster that could be pertained to their similar thymol content.

Turnip, parsley, taadol, garlic, and poleygermander aromatic waters were classified as one cluster based on clustering analysis. According to K-means, there are 2 subclusters: one for turnip, parsley, taadol due to thymol (44.97% to 56.61%) as their main constituents and another for garlic and
|                | Aloe | Azarole | Barberry | Dill | Fenugreek | Garlic | Olive | Oriental plane | Parsley | Poley-germander | Taadol | Turnip | Will-fumitory | Wormwood |
|----------------|------|---------|----------|------|-----------|--------|-------|----------------|---------|----------------|--------|--------|---------------|-----------|
| 2,3-Dimethoxytoluene | —    | —       | —        | —    | —         | —      | —     | 2.56           | —       | —              | —      | —      | —             | —         |
| Acetophenone    | —    | —       | —        | —    | —         | —      | —     | —              | 4.41    | —              | —      | —      | —             | —         |
| Anethole (E)    | —    | —       | —        | —    | —         | —      | —     | —              | —       | 0.98           | —      | —      | —             | —         |
| Anethole (Z)    | —    | —       | —        | —    | —         | —      | —     | 1.52           | —       | —              | —      | —      | —             | —         |
| Apiole          | —    | —       | —        | —    | —         | —      | —     | —              | 1.28    | —              | —      | —      | —             | —         |
| Artemisia alcohol| —    | —       | —        | —    | —         | —      | —     | 2.99           | —       | —              | —      | —      | —             | —         |
| Artemisia alcohol| —    | —       | —        | —    | —         | —      | —     | 2.99           | —       | —              | —      | —      | —             | —         |
| A bisabolol oxide derivative | — | — | — | — | — | — | 2.14 | 4.28 | — | — | — | — | — |
| Bisabolol oxide A (x-)| — | — | 39.98 | — | — | — | — | — | — | — | — | — | — |
| Bisabolone oxide | — | — | 16.54 | — | — | — | — | — | — | — | — | — | — |
| Borneol        | —    | —       | —        | —    | —         | —      | —     | 1.84           | —       | 23.15          | —      | —      | —             | —         |
| Carvacrol      | 6.17 | 6.69    | 12.14    | 5.31 | 24.07     | —      | —     | 2.74           | 36.90   | 13.80          | 22.22  | —      | 1.30          | —         |
| Carvone        | 3.89 | —       | —        | —    | 12.88     | 2.37   | 1.93  | 23.22          | —       | 15.84          | 5.18   | —      | —             | —         |
| 1,8-Cineole    | 3.94 | —       | —        | —    | —         | —      | 1.54  | 1.24           | 0.88    | 0.85           | 0.27   | —      | 0.27          | —         |
| m-Cumenol      | —    | —       | —        | —    | —         | —      | —     | —              | —       | 0.27           | —      | —      | —             | —         |
| p-Cymen-7-ol   | —    | —       | —        | —    | —         | —      | —     | —              | —       | —              | —      | —      | —             | —         |
| Damascenone (E-| —    | —       | —        | —    | —         | —      | —     | —              | —       | —              | —      | —      | —             | —         |
| Davanone       | —    | —       | —        | —    | —         | —      | —     | —              | —       | 0.35           | —      | —      | —             | —         |
| Dihydro carveol| —    | —       | —        | —    | —         | —      | —     | 5.96           | —       | 8.93           | —      | —      | —             | —         |
| Dihydro carveol (iso)| — | — | — | — | — | — | — | — | — | — | — | — | — |
| Dihydro carveol (neo)| 1.87 | — | — | — | — | — | — | — | — | — | — | — | — |
| Dihydro carveol (cis)| 1.80 | — | — | — | — | — | — | — | — | — | — | — | — |
| Dihydro carveol (trans)| — | — | — | — | — | — | — | — | — | — | — | — | — |
| Dihydroactinidiolide| — | — | — | — | — | — | — | 6.43 | — | — | — | — | — |
| Dill apiole     | —    | —       | —        | —    | —         | —      | —     | —              | 6.15    | 1.34           | 8.02   | —      | 0.67          | 20.29     |
| Dill ether      | —    | —       | —        | —    | —         | —      | —     | 40.91          | 4.32    | 1.56           | —      | —      | —             | —         |
| Ethylbenzene    | —    | —       | —        | —    | —         | —      | —     | 1.26           | —       | —              | —      | —      | —             | —         |
| Ethanone, 1-[2- (1,1-dimethylethyl)-1H-imidazol-4-yl)]| — | — | — | — | — | — | — | 1.08 | — | — | — | — | — |
| Eugenol        | —    | —       | 0.91     | —    | —         | —      | —     | 5.09           | —       | —              | —      | —      | —             | —         |
| Fenchone        | —    | —       | —        | —    | 0.36      | —      | —     | 0.58           | —       | —              | —      | —      | —             | —         |
| Guaiacol (p-vinyl)| — | — | — | — | — | — | — | 0.70 | — | — | — | — | — |
| Hexadecanoic acid| — | 7.71 | — | — | — | — | — | — | — | — | — | — | — |
| Intermedeol (neo)| — | — | — | — | — | — | — | — | — | — | — | — | — |
| Methyl eugenol  | —    | —       | —        | —    | —         | —      | —     | —              | —       | —              | —      | —      | —             | —         |
| Jasmine (Z)     | —    | —       | —        | —    | —         | —      | —     | —              | —       | —              | —      | —      | —             | —         |
| Linalool        | —    | —       | —        | —    | —         | —      | —     | 0.48           | —       | —              | —      | —      | 0.57          | 1.10      |
| Menth-2-en-1-ol (cis) | — | — | — | — | — | — | — | 0.82 | — | — | — | — | — |
| Menthol         | 37.48 | — | 3.80 | 2.41 | 1.13 | — | 1.01 | — | — | — | — | — | — |
| Menthone (trans)| 5.46 | — | — | — | — | — | — | 1.28 | — | — | — | — | — |
| Menthone (cis)  | 2.94 | — | 0.82 | — | — | — | — | — | — | — | — | — | — |
| Methyl hexadecanoate | — | 8.47 | — | — | — | — | — | — | 7.61 | 2.34 | 38.40 | 0.62 | — |

(continued)
| Methyl jasmonate (Z)  | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 0.35 |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| Methyl octadecanoate | —   | —   | 1.16| —   | —   | —   | —   | —   | —   | —   | —   | —   | 5.82 |
| Methyl 5-vinylnicotinate | —   | —   | —   | —   | —   | 29.75| —   | —   | —   | —   | —   | —   | —    |
| Muurolol (α)         | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 1.47 |
| m-Xylene             | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —    |
| Myristicin           | —   | —   | —   | —   | 0.33| —   | —   | 34.00| 2.03| —   | —   | —   | 0.42 |
| Myrtenol             | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 0.83 |
| Nerol                | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 0.26 |
| α-Xylene             | 0.57| —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —    |
| Phenol-4-ethyl-2-methoxy | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 7.53 |
| Phenyl ethyl alcohol | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —    |
| Piperitenone          | 2.77| —   | —   | —   | —   | —   | —   | 2.45| —   | —   | —   | 1.52| 0.76 |
| Piperitone            | 2.02| —   | —   | —   | —   | —   | —   | 0.43| —   | —   | —   | —   | —    |
| Pulegone              | 5.38| —   | —   | 0.57| —   | —   | 3.50| 5.04| 0.99| 1.67| 6.13| 6.07| —    |
| Pulegone ethanoate    | —   | —   | —   | —   | —   | 3.01| —   | —   | —   | —   | —   | —   | —    |
| p-Xylene              | 2.74| 20.12| —   | —   | —   | —   | 1.99| 12.53| —   | —   | —   | —   | —    |
| Spathulenol           | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 0.75 |
| Terpinen-4-ol         | 3.07| —   | —   | 0.56| —   | 1.07| —   | —   | —   | —   | 0.49| 0.67| 6.08 |
| Terpineol (α)         | 1.68| —   | —   | —   | —   | 0.46| —   | —   | —   | —   | —   | —   | 1.83 |
| Thujone (cis)         | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 0.74 |
| Thujone (trans)       | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | 5.63 |
| Thymol                | 11.09| 28.71| 23.82| 19.49| 20.04| 32.00| 4.34| 6.25| 56.61| 26.19| 44.98| 49.20| 6.75 |
| Thymol ethanoate      | —   | 2.34| —   | —   | —   | 0.35| 6.49| 1.24| —   | —   | —   | —   | —    |
| Yomogi alcohol        | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —   | —    |
poleygermander, which contained 26% to 32% thymol. These aromatic waters (except for parsley) also contained comparable amount of carvacrol, 1,8-cineol, piperitenone, and pulegone. Parsley contained a considerable amount of myristicin (34%), which was not detected in other aromatic waters (Table 4).

In contrast to other aromatic waters, wormwood and olive leaf had low thymol content (2%-6%). The main component of wormwood was camphor (23%), while in the case of olive leaf methyl 5-vinylindolinate composed 29.76% of the aromatic water. Since these components were not detected in others they were clustered at distinct groups.

**Figure 3.** Cluster analysis of aromatic waters constituents based on principal component analysis (A) and hierarchical cluster analysis (B). The aromatic waters are as follows: 1 = aloe, 2 = oriental plane, 3 = wormwood, 4 = parsley, 5 = poleygermander, 6 = azarole hawthorn, 7 = turnip, 8 = fenugreek, 9 = will fumitory, 10 = dill, 11 = garlic, 12 = olive, 13 = barberry, and 14 = taadol.

| Aromatic Waters’ Name                             | Class |
|--------------------------------------------------|-------|
| Barberry                                         | I     |
| Dill                                             | II    |
| Parsley, turnip, and taadol                      | III   |
| Will fumitory                                    | IV    |
| Aloe                                             | V     |
| Garlic and poleygermander                        | VI    |
| Olive and wormwood                               | VII   |
| Azarole hawthorn, fenugreek, and oriental plane  | VIII  |

**Table 4.** Analysis of the Aromatic Waters’ Constituents Based on K-Means (sqEuclidean, 10 Epochs of Training).
Based on clustering methods applied in this study, although some similarities could be found, composition of barberry, will fumitory, dill, and aloe aromatic waters revealed more differences than others. The main components of these aromatic waters were menthol (37%, aloe), methyl hexadecanoate (38.40%, will fumitory), bisabolol oxide A (39.98%, barberry), and dill ether (40.91%, dill).

**Literature Survey**

We could not find any reports on chemical composition of aromatic waters of the plants mentioned in Table 1. Thus, it was not possible to compare the results, but the major components of the reported essential oils are summarized in Table 5.

For aloe leaf, oriental plane leaf, and will fumitory, we could not find any reports and our article seems to be the first report on their volatile components. For some of these aromatic waters, such as barberry and poleygermander, garlic, and turnip, the major components in the aromatic waters and essential oils are completely different. Different allyl sulfides were reported as the major components of the garlic essential oils and isothiocyanate derivatives as the major components of the turnip essential oil but none of these components were detected in the aromatic waters in the present study. In the case of dill essential oil, the major components were reported to be phellandrene, limonene, and myristicin, followed by dill ether. In the present study, the major components of dill aromatic water was dill ether (40.9%), followed by thymol and carvacrol. On the other hand, the major components of parsley leaf (myristicin) and wormwood (camphor) were similar in the case of dill aromatic water, the major components were reported to be phellandrene, limonene, and myristicin, followed by dill ether. In the present study, the major components of dill aromatic water was dill ether (40.9%), followed by thymol and carvacrol. On the other hand, the major components of parsley leaf (myristicin) and wormwood (camphor) were similar.

### Table 5. Profile of Essential Oils Reported in the Literature for the Plants Being Used to Prepare Cardiovascular Aromatic Waters and Hydrosols.

| Plant Name          | Profile of Essential Oils Reported in the Literature                                                                 |
|---------------------|---------------------------------------------------------------------------------------------------------------------|
| Aloe                | Profile of volatile components was not found in literature                                                             |
| Azarole hawthorn    | Fruits: Limonene, 2-furaldehyde, 3-cyclohexane-2-methyl-1-propleny, γ-terpinene                                         |
| Barberry            | Fruit: Benzaldehyde, benzyl alcohol, 1-hexanol, and (E)-2-hexenal                                                    |
| Dill                | Limonene, Phellandrene, dihydrocarvone, and carveone                                                                |
| Fenugreek           | Aerial parts: α-Cadinol, α-cadinol, γ-eudesmol, and α-bisabolol                                                     |
| Garlic              | Leaves: Dialyl trisulfide, diallyl disulfide, methyl allyl trisulfide                                                 |
| Olive               | Leaf: 2-Hexenal, α-farnesene, linalool                                                                            |
| Oriental plane      | Leaf: Profile of volatile components was not found in literature                                                     |
| Parsley             | Myristicin, apiol, α-pinene, β-pinene                                                                               |
| Poleygermander      | α-Pinene, β-pinene, and p-cymene                                                                                  |
| Turnip              | 3-Butenylisoctocyanate, 4-pentenyl isothiocyanate, 2-methyl-5-hexenenitrile                                        |
| Wormwood            | Camphor, 1,8-cineole, and bornyl acetate                                                                            |
| Will fumitory       | Profile of volatile components was not found in literature                                                           |
| Taadol              | Leaf: 4-Chloro-4,4-dimethyl-3-((1-imidazolyl)-valerenophene, 1-dodecanol                                              |
| Celery              | Leaf, stalk and roots: (Z)-3-butylidenepentaladic, 3-butyl-4,5-dihydrophthalaldehyde and α-thujene                    |
| Nettle              | Leaf: α-Pinene, β-pinene, myrcene, limonene, γ-terpinene, β-elemene, β-caryophyllene                                 |
| Saatar              | Thymol, carvacrol, linalool                                                                                         |
| Walnut              | Husks: (E)-4,8-Dimethyl-1,3,7-nonatriene, pinocarvone, pinocarveol, myrtanol, myrtenol (E.E)-4,8,12-Trimethyl-1,3,7,11-tridecatarene, carophyllene epoxide, venenol, verbena | 

Leaf: Germacrene D, methyl saliclates.
Table 6. Literature Review on Plants Used in Preparing Aromatic Waters With Cardiovascular Indications.

| Plant Name                      | Medicinal Actions                                      | Preparations                      | Study Type |
|---------------------------------|--------------------------------------------------------|-----------------------------------|------------|
| **Aloe spp (Aloe vera, Aloe babadensis)** | Antidiabetic and obesity                               | Phytosterol                      | In vivo 51 |
|                                 | Antihypertensive                                       | Leaf extracts and constituents    | In vivo 52 |
|                                 | Cardioprotective                                       | Leaf gel                          | In vivo 53,54 |
|                                 | Hypoglycemic and hypolipidemic                         | Leaf gel                          | Clinical trial 55-58 |
|                                 |                                                      | Gel extracts                       | In vivo 59,60 |
| **Azarole howthorn (Crataegus azarolus L.)** | Cardioprotective                                       | Aqueous extract of aerial part    | In vivo 51 |
|                                 | Antiarrhythmic                                         | Aqueous extract of aerial part    | In vivo 62 |
|                                 | Anti-atherosclerosis                                   | Aqueous extract of aerial part    | In vitro 63 |
|                                 | Antipalpitation                                        | Aqueous extract of aerial part    | Clinical trial 64,67 |
|                                 | Hypotensive                                            | Aqueous extract of aerial part    | In vivo 68 |
|                                 | Positive inotropic and negative                        | Aqueous extract of aerial part    | In vivo 69 |
|                                 | Positive inotropic, diuretic and natriuretic           | Procyanidine of the fruit         | In vivo 70 |
| **Barberry (Berberis vulgaris L.)** | Vasoconstrictant                                       | Aqueous extract of aerial part    | In vivo 71 |
|                                 | Antihypertension                                       | Fruits in apple vinegar           | Clinical trial 72 |
|                                 | Hypoglycemic                                           | Fruits aqueous extract            | In vivo 73,74 |
|                                 | Effects on non-alcoholic fatty liver                   | Methanolic extract of root and bark | In vivo 75 |
|                                 | Hypolipidemic                                          | Berberine                         | In vivo 77 |
|                                 |                                                        | Fruits aqueous extract            | In vivo 78,79 |
|                                 |                                                        | Ethanol extracts of roots         | In vivo 80 |
| **Dill (Anethum graveolens L.)** | Antihypertension                                       | Hydroalcoholic extract of aerial part | Clinical trial 82 |
|                                 | Hypolipidemic                                          | Hydroalcoholic extract of aerial part | Clinical trial 82-85 |
| **Fenugreek (Trigonella foenum-graecum L.)** | Anti-anemia (increase hemoglobin and WBC level)         | Seed extracts                     | Clinical trial 87 |
|                                 | Antidiabetic                                           | Seed extracts                     | Clinical trial 92-95 |
|                                 | Antihypertension                                       | Essential oil                     | In vivo 96-98 |
|                                 | Hypolipidemic                                          | Seed extract                      | Clinical trial 100 |
|                                 |                                                        | Seed extract                      | In vivo 101 |
|                                 |                                                        | Leaf extract                      | In vivo 102,103 |
| **Garlic (Allium sativum L.)**   | Anti-atherosclerosis                                    | Aged garlic extract supplement    | Clinical trial 104,105 |
|                                 | Antihypertension                                       | Aqueous extract or powder         | Clinical trial 106-109 |
|                                 | Hypoglycemic effects                                   | Aqueous extracts or powder        | In vivo 110-112 |
|                                 |                                                        | Bulb extracts or powder           | Clinical trial 113,114 |
|                                 |                                                        | Garlic oil                        | In vivo 115-118 |
|                                 | Hypolipidemic                                          | Aqueous extracts or powder        | In vivo 117,119 |
|                                 |                                                        | Clinical trial and In vivo         | 114,120-126,127,128 |
| **Olive (Olea europaea L.)**     | Effects on thrombocyte aggregation                      | Aqueous extract                   | In vivo 129,134 |
|                                 | Antihypertension                                       | Leaf extracts                     | Clinical trial 135-138 |
|                                 |                                                        | Triterpenoids of the leaf         | In vivo 135 |
|                                 | Cardiovascular protection                              | Olive oil                         | Clinical trial 131,137-141 |
|                                 | Diuretic                                               | Leaf extracts                     | In vivo 142 |
|                                 | Hypoglycemic effects                                   | Leaf extracts                     | Clinical trial and In vivo 143-145 |
| **Parsley (Petroselinum crispum Mill.)** | Anti-diabetic                                           | Extracts of aerial part           | In vivo 146,147 |
|                                 | Antihypertension                                       | Extracts of aerial part           | In vivo 146,148 |
|                                 | Antiplatelet                                           | Aqueous extracts                  | In vitro 148-150 |
|                                 | Cardiovascular protection                              | Extracts of aerial part           | In vivo 151,152 |
|                                 | Diuretic                                               | Extracts of aerial part           | In vivo and in vitro 153,154 |

(continued)
components. This might be due to different water solubility of the volatile components; thus, some of these volatile components did not enter in the water phase while preparing aromatic waters. It seems that it is essential to consider different biological activities for aromatic waters due to different chemical compositions compared with pure essential oils.

Different cardiovascular effects of the plants used to prepare identified aromatic waters were investigated from the literature and are summarized in Table 6. We could not find any report on cardiovascular activity for any of the aromatic waters. But for some of these plants including fenugreek, wormwood, and celery there are some reports on extracted essential oil. Although it is not possible to compare the observed effects of the essential oils with aromatic waters due to differences in constituents as well as constituent’s concentrations, these reports strengthen the hypothesis of cardiovascular tonic effects for these aromatic waters.

For other plants, different aqueous, ethanol, methanol extracts or plants powders were investigated and it is not clear if the volatile components had a role in observed effects. On the other hand, for many of the plants listed in the Table 6, the medicinal parts that were investigated are different from those that are used to prepare the aromatic waters in Persian ethnomedicine. For oriental plane we could not find any related report. This study was not intended to investigate the efficacy of these aromatic waters, but high production level and consumption of these aromatic waters in Persian nutrition culture and folk medicine might be related to their efficacy.

Overall, this article introduced some aromatic waters that are used for hyperlipidemia and cardiovascular conditions in Persian nutrition culture and folk medicine with different popularity and sales values. As was expected, their chemical composition was different from the essential oils of the plants used for their production. But cluster analysis showed that despite the differences in the plant family and medicinal parts used to prepare them, some similarity can be found in their chemical compositions. In most cases thymol

| Table 6. (continued) |
|----------------------|
| **Poleygermander** (<i>Teucrium polium</i> L.) | Antidiabetic | Extracts of aerial part | Clinical trial<sup>155</sup> In vivo<sup>156-159</sup> |
|                     | Antihypertension | Extracts of aerial part | In vivo<sup>160-161</sup> |
|                     | Hypolipidemic | Aqueous extract of aerial parts | In vivo<sup>159,162-164</sup> |
| **Turnip** (<i>Brassica rapa</i> L.) | Antidiabetic | Root extracts | In vivo<sup>165-168</sup> |
|                     | Hypolipidemic | Seed oil | In vivo<sup>169</sup> Clinical trial<sup>169</sup> |
| **Wormwood** (<i>Artemisia sieberi</i> Besser) | Antidiabetic | Essential oil from aerial parts | In vivo<sup>170-174</sup> |
|                     | Antihypertension | Essential oil | Hypothesis<sup>175</sup> In vivo<sup>176</sup> |
|                     | Cardiovascular protection | Essential oil from aerial parts | In vivo<sup>177</sup> |
|                     | Hypolipidemic | Extracts of aerial parts | In vivo<sup>178,179</sup> |
| **Will fumitory** (<i>Fumaria parviflora</i> Lam.) | Hypoglycemic | Aerial parts | In vivo<sup>180,181</sup> |
|                     | Hypolipidemic | Extracts of aerial parts | Clinical trial<sup>182,183</sup> |
| **Taadel Celery** (<i>Apium graveolens</i>) | Antihypertension | Essential oil | In vivo<sup>184-187</sup> |
|                     | Hypoglycemic | Extracts of aerial parts | In vivo<sup>188-190</sup> |
|                     | Hypolipidemic | Essential oil | In vivo<sup>191-194</sup> |
| **Nettle** (<i>Urtica dioica</i> L.) | Antihypertension | Root extracts | Clinical trial<sup>195</sup> In vivo<sup>196</sup> |
|                     | Hypoglycemic | Root extracts | In vivo<sup>195-199</sup> |
|                     | Hypolipidemic | Extracts of aerial parts | Clinical trial<sup>200</sup> In vivo<sup>195,197,199,201-205</sup> |
| **Saatar** (<i>Zataria multiflora</i> Boiss.) | Antihypertension | Essential oil | In vivo<sup>206</sup> |
|                     | Antidiabetic | Extracts of aerial parts | In vivo<sup>207-209</sup> |
| **Walnut** (<i>Juglans regia</i> L.) | Antihypertension | Essential oil | In vivo<sup>210</sup> Clinical trial<sup>214</sup> |
|                     | Antidiabetic | Extracts of aerial parts | Clinical trial<sup>215-218</sup> In vivo<sup>219</sup> |
|                     | Hypolipidemic | Leaf extracts | In vivo<sup>219</sup> |
|                     | | Seed extract | In vivo<sup>219</sup> |
|                     | | Leaf extracts | In vivo<sup>219</sup> |
|                     | | Septum extract | In vivo<sup>219</sup> |
|                     | | Flower extract | In vivo<sup>219</sup> |
|                     | | Seed extract | Clinical trial<sup>214,219,223</sup> In vivo<sup>224</sup> |
was the major or second major component of these beverages.

Investigating aromatic waters scientifically may lead to the development of some functional beverages and soft drinks as a safe way of administration of essential oils or even new therapeutic components.

Authors’ Note
This study was part of the PharmD thesis project of Seyed Mahmoud Moheimani.

Acknowledgments
The authors also want to thank Nahal Shamaeezadeh (PharmD student at Shiraz University of Medical Sciences) for helping in extraction procedures.

Author Contributions
AH wrote the draft and contributed in guidance and data collection. AS contributed in the guidance and revisions of the final version of the article. SM, MM, and HE contributed in data collection and analyzing data.

Declaration of Conflicting Interests
The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was funded by Shiraz University of Medical Sciences (Grant # 92-01-70-7065).

Ethical Approval
This study was an experimental and laboratorial work and did not require ethical approval.

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