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Investigating Chemical Composition and Indications of Hydrosol Soft Drinks (Aromatic Waters) Used in Persian Folk Medicine for Women's Hormonal and Reproductive Health Conditions

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Abstract

Hydrosol soft drinks in Persian nutrition culture are produced as side products of the essential oil industry to be used as safe remedies for treatment of some ailments. This study investigated hydrosols for women's hormonal health conditions. Detailed information was gathered by questionnaires. Chemical constituents of these mono- or poly-herbal hydrosols were identified after liquid/liquid extraction and gas chromatography–mass spectrometry. Hierarchical cluster and K-means analysis (SPSS software) were used to find their relevance. A literature survey was also performed. In most cases, thymol, carvacrol, and carvone were the major constituents except for dill, white horehound, willow, Moderr, and yarrow hydrosols, whose their major components were dill ether, menthol, phenethyl alcohol, linalool, or camphor. Based on clustering methods, some similarities could be found in their constituents with some exceptions. None of them have been studied scientifically before. These investigations may lead to the development of some functional drinks or even new lead components.

Keywords

essential oil, women's reproductive disorder, distillate, aromatic waters, *Aragh*

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Different ethnomedicinal herbal formulations have long been used by women to treat hormonal and reproductive health conditions such as premenstrual syndrome, menopausal symptoms, hormonal imbalance, infertility, or as contraceptives.[1,2] In many communities, because of economic or cultural issues, herbal remedies are the most—or even the only—available therapeutics. Despite the necessity of evaluating their purity, safety, efficacy, and authenticity, herbal formulations are not currently subjected to the same regulations as conventional drugs, which is due to a lack of knowledge about their constituents.[3] Another problem arises from misadministration and lack of knowledge about the side effects. For example, many herbal formulations—which may be used for other therapeutic properties or even ingested as daily food or drinks—may cause unwanted side effects for a pregnant woman or her fetus.[4] Scientific investigation of safety and efficacy of herbal remedies, food, and beverages with potential effects on hormonal condition may prevent a notable number of unwanted infertility cases, abortions, or fetal abnormalities. It also can lead researchers to reach new active components as well as functional food or beverages for use as contraceptives or fertility therapeutics or supplements.[5,6]

In Iranian nutrition culture as well as Persian ethnomedicine aromatic waters, or *Araghijat* or *Araghiat* (plural of *Aragh* in Persian), are consumed as delicious daily drinks or as functional beverages. They are usually sweeten with natural sugars

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such as sucrose or honey. Some prepared syrup of aromatic waters can also be found in food markets containing some additives such as colors, flavoring agent, and sweeteners to improve the organoleptic properties.

Aromatic waters, which are also called floral water, distillate water, or hydrosols, are the side products of the volatile oil industry.[7] During industrial hydrodistillation water is evaporated simultaneously with the essential oil of the plants. After condensation of the vapors in contact with cold vessels or tubes, the liquefied components are separated into 2 phases inside a collecting vessel, an oily phase and the aromatic water saturated with different amounts of the volatile components of the plant, which are partly or completely soluble in water.[8,9] These 2 phases are then collected; the oily phase (essential oil) is usually sold to the pharmaceutical or cosmetic industry while the aromatic water, depending on its taste, potency, and biological properties, is diluted 1:8 or 1:12 with water. For marketing purposes, the aromatic waters might be distributed in big containers (250-1000 liters) for retail shops or in small sealed polyethylene terephthalate or glass containers (1-5 liters). Some are pasteurized before marketing. In traditional and folk Persian medicine, aromatic water drinks are used also for medicinal purposes to treat different conditions. Despite some adverse effects in improper applications, they are considered as safe beverages. They are mostly mono-herbal but some poly-herbal hydrosol (*Aragh*) can be found in the food market.[10,11] Depending on the plants used to prepare each of the aromatic waters, an overall nature is considered including, hot, cold, wet, dry, or moderate. Pure essential oils are very potent or even harsh in presenting their medicinal activities and are not usually safe in oral administration. But these hydrosols have their unique aroma and composition, which is considerably different from the pure essential oil they co-distilled with. They are usually moderated and balanced by the water and their water-soluble volatile components.[12,13] On the other hand, aromatic waters have additional properties not possessed by the essential oils alone.

Over 50 different types of hydrosol beverages are manufactured and marketed in Persian nutrition culture, but as far as we know, chemical composition and biological activities of many of them have not been investigated scientifically. This study was designed to investigate the chemical composition of aromatic waters and hydrosol beverages used in Persian folk medicine for women's hormonal and reproductive health conditions. A wide range of plants are used in Persian folk medicine for these conditions, but only those plants were investigated that are used to prepare hydrosol beverages.

Materials and Methods

An Overview of Geographical Profile and Climate Variation of Field Study

Fars Province with the highest production rate for aromatic waters was selected as the field of study. Fars, or known in Old Persian as Pârsâ, is the original homeland of the ancient Persians.

The province, with area of 122 400 km^2 and a population of 4.59 million people, is located in the south of Iran. There are 3 different climates in the Fars province: the highland area with moderate cold winters and mild summers; the central regions, with relatively rainy mild winter and hot dry summers; and the south to southeast region, which has cold winters with hot summers. The average temperature of Shiraz as the province administrative center is 16.8°C (ranging from 4.7°C to29.2°C).[14]

The geographical and climatic variation enriches the province with varieties of plants that has a huge influence on agricultural and herbal industries. Over 84 manufactories in Fars province produce different aroma water beverages with full industrial techniques (19 manufactories) or traditional (65 manufactories) equipment. These manufactories are mostly located in Meymand and Darab cities, and their products are distributed in retail markets all over the country.

Information and Sample Collection

To gather information about different aromatic beverages used in Persian folk medicine for women's hormonal and reproductive health conditions, a field study was conducted from June 2013 to June 2014 under the supervision of a local researcher as a native guide in all visits. A suitable questionnaire was filled according to the information gathered in all visits to local manufactories or their shops. However, most popular aromatic waters with indications for women's hormonal and reproductive system health conditions were purchased for further analysis (Table 1).

Phytochemical Analysis

Volatile components of each beverage sample (500 mL) were extracted with 500 mL of petroleum ether using a glass liquid/liquid extractor system during 150 minutes. Chloroform was used for liquid/liquid extraction of ginger hydrosol. In this technique, the solvent vapor was transferred to the bottom of beverage container. The liquefied vapor in the beverage traveled to the top of the beverage container due to its lower density. Meanwhile, volatile components of the sample were transferred from the aqueous phase to the petroleum ether phase. In order to increase the concentration of volatile components in the organic phase, after 150 minutes the used beverage was replaced with fresh beverage and then extracted for another 150 minutes. The volume of each extracts was decreased to approximately 10 mL at 40°C and 60 rpm using a basic rotary evaporator.[15]

Gas Chromatography–Mass Spectrometry

The concentrated and dehydrated extract of each ample beverage was injected to a gas chromatography–mass spectrometer for the analysis of respective volatile components. Agilent Technologies 7890 gas chromatograph with a mass detector (Agilent Technologies model 5975 C) was used in this study. The gas chromatograph was equipped with a HP-5MS capillary column (phenyl-methylsiloxan, 30 m, 0.25 mm id; Agilent Technologies 19091S-433 [60°C to 325/350°C]) and a mass spectrometer (Agilent Technologies 5975 C), 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 at a rate of 5°C/min from 60°C to 220°C and then it was held for 10 minutes at 220°C. Helium was used as the carrier gas with a flow rate of 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.[16,17]

Table 1. Plant Names and Their Medicinal Parts That Are Used to Prepare Aromatic Waters for Women's Hormonal and Reproductive Health Conditions.

No.	Aromatic Water Beverage Name	Aromatic Water Name in Persian	Scientific Name	Family	Plant Parts
Monoherbal aromatic waters					
1	Chamomile	*Aragh-e-Babooneh*	*Matricaria chamomilla* L.	Asteraceae	Flowers
2	Dill	*Aragh-e-Shevid*	*Anethum graveolens* L.	Apiaceae	Leaf
3	Fennel	*Aragh-e-Raziyaneh*	*Foeniculum vulgare* Mill.	Apiaceae	Seeds
4	Ginger	*Aragh-e-Zanjebil*	*Zingiber officinale* Roscoe	Zingiberaceae	Rhizome
5	Lemon balm	*Aragh-e-Badranjbooye*	*Melissa officinalis* L.	Lamiaceae	Leaf
6	Parsley	*Aragh-e-Jafari*	*Petroselinum crispum* Mill.	Apiaceae	Leaf
7	Persian cumin	*Aragh-e-Zireh*	*Carum carvi* L.	Apiaceae	Seeds
8	Persian leek	*Aragh-e-Tareh*	*Allium ampeloprasum* ssp. *persicum*	Amaryllidaceae	Leaf
9	Polygermander	*Aragh-e-Kalpooreh*	*Teucrium polium* L.	Lamiaceae	Aerial parts
10	Persian hogweed	*Aragh-e-Golpar*	*Heracleum persicum* Desf. ex Fisch.	Apiaceae	Fruits
11	Stinging nettle	*Aragh-e-Gazaneh*	*Urtica dioica*	Urticaceae	Aerial parts
12	Valerian	*Aragh-e-Sonbolottib*	*Valeriana officinalis* L.	Caprifoliaceae	Aerial parts
13	Willow	*Aragh-e-Beedemeshk*	*Salix* spp L.	Salicaceae	Catkins
14	White horehound	*Aragh-e-Farasiyon*	*Marrubium vulgare* L.	Lamiaceae	Aerial parts
15	Yarrow	*Aragh-e-Boomadaran*	*Achillea millefolium* L.	Asteraceae	Aerial parts
Polyherbal aromatic waters					
16	Chehelgeyah (polyherbal)	*Aragh-e-Chehelgeyah*	A mixture of:		
			Carum carvi L.	Apiaceae	Seeds
			Carum copticum L.	Apiaceae	Seeds
			Citrus aurantium L.	Rutaceae	Fruits peel
			Glycyrrhiza glabra L.	Leguminosae	Root
			Lavandula angustifolia Mill.	Lamiaceae	Aerial parts
			Matricaria chamomilla L.	Asteraceae	Flowers
			Mentha longifoilia (L.) L.	Lamiaceae	Leaf
			Satureja hortensis L.	Lamiaceae	Aerial parts
			Valeriana officinalis L.	Caprifoliaceae	Aerial parts
			Zataria multiflora Boiss.	Lamiaceae	Aerial parts
17	Moderr (polyherbal)	*Aragh-e-Moderr*	A mixture of:		
			Alhagi maurorum Medik.	Leguminosae	Aerial parts
			Cerasus avium (L.) Moench	Rosaceae	Stalks
			Cichorium intybus L.	Asteraceae	Aerial parts
			Fumaria parviflora Lam.	Papaveraceae	Aerial parts
			Marrubium vulgare	Lamiaceae	Aerial parts
			Salix spp L.	Salicaceae	Leaf
			Tribulus terrestris L.	Zygophyllaceae	Fruits
			Zea mays L.	Poaceae	Silk
18	Taadol (poly herbal)	*Aragh-e-Taadol*	*Apium graveolens* var. *dulce*	Apiaceae	Aerial parts
			Juglans regia L.	Juglandaceae	Leaf
			Olea europaea L.	Oleaceae	Leaf
			Urtica dioica L.	Urticaceae	Aerial parts
			Zataria multiflora Boiss.	Lamiaceae	Aerial parts

Results and Discussion

Hydrosols and Their Phytochemicals

The aromatic waters soft drinks that are used for women's hormonal and reproductive health conditions are listed in Table 1. The data were prepared according to the information gathered via questionnaires (Tables 1 and 2).

This study was designed to investigate the aromatic waters that are used in Persian folk medicine, but some of these aromatic waters and their applications listed in this article have been mentioned also in some traditional Persian manuscript such as *Qarabadin-e-salehi*[18] and *Qarabadin-e-kabir*.[11] Although most current ethnopharmacological knowledge in Iran has been derived from historical Persian manuscripts,[19] it seems that some also have been arisen and accepted in recent years. This might be due to impact of new research on medicinal plants extracts on the knowledge of traditional healers as well as the companies that produce such products, although as far as we know there are not much research studies to provide evidence based data on the effects of aromatic waters or to elucidate their constituents.

In ethnomedical surveys, frequency of citation can reflect a kind of cultural importance of species, which may result in

Table 2. Aromatic Waters' Indications for Women's Hormonal and Reproductive Health Conditions as Well as Their Other Indications.

Aromatic Water Beverage Name	Nature	Indications for Women's Hormonal and Reproductive Health Condition	Other Indications	Dosing
Monoherbal aromatic waters				
Chamomile	Hot nature	Regulating menstrual cycle Treatment of dysmenorrhea (chronic ingestion is contraindicated for pregnant women)	Energizer Treatment of painful infections Treatment of phlegmatic fever Vermicide	100 mL TID, before meal
Caraway (Persian cumin)	Hot nature	Treatment of dysmenorrhea Galactogogue	Energizer Nerve tonic Cholesterol lowering Digestant Gastrointestinal tonic For body slimming	100 mL TID, after meal
Dill	Hot nature	Galactogogue Menstrual inducer	Antihypertension Cholesterol lowering Gastrointestinal tonic Relieve hiccups Antiasthma To treat urinary tract pain	150 mL TID, after meal
Fennel	Hot nature	Galactogogue Menstrual inducer (there is a belief that ingestion during pregnancy may help newborn to have more beautiful eyes)	Carminative Treatment of colic To remove phlegm Diuretic Treatment of gall stone Treatment of kidney inflammation	100 mL TID, after meal
Ginger	Hot nature	Treatment of morning sickness	Energizer Nerve tonic Cholesterol lowering effect Digestant Gastrointestinal tonic For body slimming Expectorant	100 mL TID, after meal
Lemon balm	Hot nature	Treatment of morning sickness in pregnant women Treatment of dysmenorrhea	Nerve tonic, antiseizure Antidepressant Cardiotonic, for heart failure Hypertensive Treatment of insects Bits (topical applications)	100 mL TID, after meal
Parsley	Cold nature	Galactogogue Menstrual inducer Aphrodisiac	Anti-arthritis Antihypertension Anti-anemia Diuretic Blood cleansing Gastrointestinal tonic Antipyretic	100 mL TID before meal
Persian hogweed	Hot nature	Menstrual inducer	Appetizer Digestant Carminative Diuretic Strengthening memory Relieve hiccups Antimicrobial Treatment of numbness	100 mL TID, after meal
Persian leek	Hot nature	Uterus and reproductive system cleansing Thinning vaginal discharge Prevention of abortion	Aphrodisiac Expectorant, antitussive For laryngitis and pharyngitis Digestant Antihemorrhoid Skin lightening	100 mL TID, after meal

(continued)

Table 2. (continued)

Aromatic Water Beverage Name	Nature	Indications for Women's Hormonal and Reproductive Health Condition	Other Indications	Dosing
Poleygermander	Hot nature	Facilitate delivery (start treatment 1 month before delivery due date) Treatment of infertility (start treatment 3 month before pregnancy intention)	Energetic Appetizer Liver tonic Anti-emetic Anti-asthma Antihypertension Antidiabetic Blood cleansing	100 mL TID, after meal
Stinging nettle	Hot nature	Menstrual inducer Galactogogue Antihypertension Anti-atherosclerosis	Antidiabetic Expectorant, anti-asthma Energizer, anti-anemia Treatment of tonsillitis and for strengthening the gums (by gargling) Treatment of prostatic hypertrophy Diuretic Hair tonic	100 mL TID, before meal
Valerian	Hot nature	Treatment of dysmenorrhea	Nerve tonic, antianxiety Treatment of headache	100 mL QID, before meal and bedtime
White horehound	Hot nature	Treatment of ovarian and uterine cysts Treatment of breast cysts Uterus and reproductive system cleansing Thinning vaginal discharge Regulating menstrual cycle Treatment of dysmenorrhea Facilitate delivery Treatment of infertility Treatment of fibroma Prevention and treatment of lipoma mass	Liver tonic Treatment of fatty liver Astringent Anti-catarrh in brain	150 mL TID, after meal (contraindicated during pregnancy and menstruation)
Willow	Cold nature	Treatment of dysmenorrhea	Gastrointestinal tonic Anti-epilepsy Treatment of headache Cardio-tonic Anti-pyretic Anti-dandruff (topical)	150 mL TID, before meal
Yarrow	Hot nature	Regulating menstrual cycle Treatment of dysmenorrhea	Blood cleansing Nerve tonic, anti-epileptic Cardio tonic Anti-hemorrhoid Antipyretic To treat muscle cramps To treat gastrointestinal inflammations	100 mL TID, after meal
Polyherbal aromatic waters				
Chehelgeyah		Treatment of dysmenorrhea	Digestant Gastrointestinal tonic Antidiarrhea Treatment of colic	100 mL TID, after meal
Moderr		To facilitate delivery Treatment of uterus cyst		100 mL TID, after meal
Taadol	Hot nature	Treatment of dysmenorrhea	Antihypertension Anti-atherosclerosis Antidiabetic Blood thinning Lipid lowering	100 mL TID, after meal

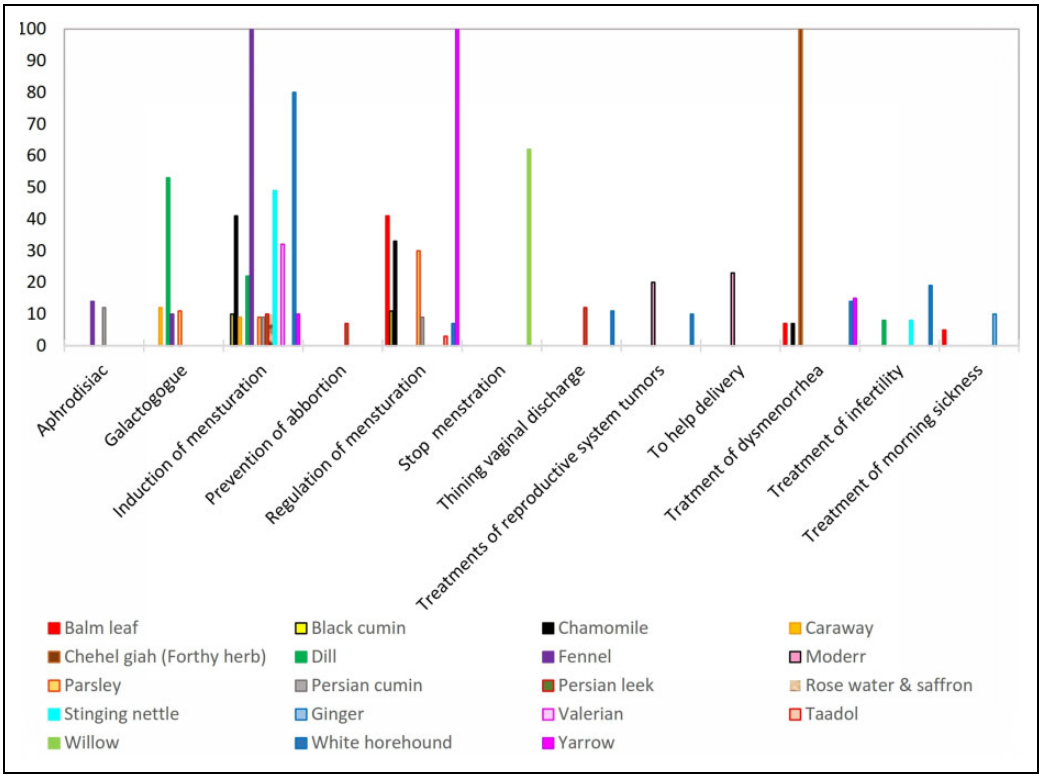

Figure 1. Frequency of citations in questionnaires for women's hormonal and reproductive health conditions.

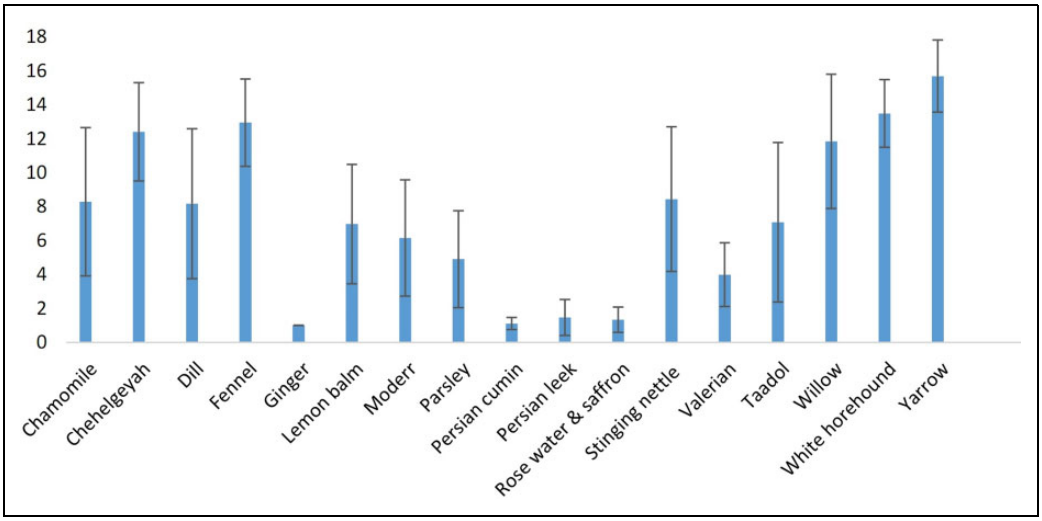

Figure 2. Ranking (1-18) of annual production level of aromatic waters in different manufactories over the past 3 years. Data are represented as mean $\pm$ SD.

more accurate and more informants' data obtained from questionnaires.[20] The frequency of citations of each hormonal and reproductive application for these beverages in all gathered questionnaires is shown in Figure 1. The higher frequency of citation can show the higher importance of an application for any of these aromatic waters. As seen in Figure 1, in all of the questionnaires (100%), fennel aromatic water was suggested to start menstruation, yarrow aromatic water to regulate menstruation, and Chehelgeyah aromatic water to treat dysmenorrhea. On the other hand, only a few informants believed that valerian aromatic water can regulate menstruation. As seen in Figure 1, most of introduced aromatic waters were believed to have indication to start menstruation. The second frequent cited application was regulation of menstruation.

Table 3. Aromatic Water Constituents Resulting From Gas Chromatography–Mass Spectrometry Analysis.

	Monoherbal												Polyherbal		
	Chamomile	Dill	Fennel	Ginger	Lemon balm	Parsley	Persian leek	Stinging nettle	Valerian	Willow	White horehound	Yarrow	Chehelgeyah	Moderr	Taadol
cis-Anethole	5.93	0.53	12.47	—	0.94	—	—	—	—	—	—	—	1.08	—	—
trans-Anethole	—	—	—	0.752	—	—	—	—	1.13	—	—	—	—	—	—
Anisyl methyl ketone	—	—	0.49	—	—	—	—	—	—	—	—	—	—	—	—
Apiole	—	—	—	—	1.43	1.28	—	—	—	—	—	—	—	—	—
Aristolane	—	—	—	—	—	—	—	—	3.03	—	—	—	—	—	—
Artemisia alcohol	—	—	—	—	—	—	—	—	—	—	—	7.32	—	—	—
Benzene, 1,4-dimethoxy	—	—	—	—	—	—	—	—	—	8.16	—	—	—	—	—
α-Bisabolol oxide A	18.63	—	—	—	—	—	—	—	—	—	—	—	—	—	—
α-Bisabolone oxide A	9.08	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Borneol	—	—	—	3.21	—	—	0.481	—	—	—	—	4.84	—	—	—
δ-Cadinene	—	—	—	—	—	—	—	—	—	0.92	—	—	—	—	—
Bornyl acetate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Camphor	—	—	—	—	—	—	2.183	5.91	—	—	—	41.88	—	3.84	—
Carvacrol	6.71	12.14	4.65	26.20	30.49	2.74	26.27	12.34	4.12	—	5.39	—	29.36	2.76	—
Carvone	8.12	9.9	14.53	3.38	3.92	—	2.257	—	—	—	—	—	0.95	6.54	15.84
Caryophyllene oxide	—	—	—	—	—	—	—	—	—	0.74	—	—	—	—	—
1,8-Cineole	0.43	—	0.92	4.37	—	—	0.62	4.14	—	—	1.24	8.27	—	0.98	0.85
trans-Citral	—	—	—	0.76	—	—	—	—	—	—	—	—	—	—	—
Citronellol	—	—	—	—	—	—	—	—	—	4.78	—	—	—	—	—
Coumarin, 7-methoxy	0.57	—	—	—	—	—	—	—	—	—	—	—	—	—	—
p-Cymen-8-ol	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Diethyl disulfide	—	—	—	—	—	—	—	1.67	—	—	—	—	—	—	—
Dihydroactinolide	—	—	—	—	—	—	—	2.47	—	—	—	—	—	0.59	—
Dihydro carveol	—	—	—	—	0.72	—	—	—	—	—	—	—	—	—	8.93
neo-Dihydro carveol	1.33	—	2.17	—	—	—	—	—	—	—	—	—	—	—	—
cis-Dihydro carvone	—	1.32	—	—	—	—	0.54	—	—	—	—	—	—	—	5.76
trans-Dihydro carvone	2.18	0.66	1.72	0.761	1.23	—	—	—	—	—	—	0.64	—	1.44	—
Dill apiole	0.35	5.96	—	—	—	—	3.375	—	—	—	—	—	—	22.48	—
Dill ether	—	40.91	—	—	—	1.56	4.783	—	—	—	—	—	—	—	—
Durenol	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
β-Eudesmol	—	—	—	—	—	—	—	—	—	0.67	—	0.52	—	—	—
Eugenol	—	0.91	—	—	—	—	—	—	—	20.43	—	0.62	—	1.06	—
Farnesyl acetate c	—	—	—	—	—	—	—	—	—	0.48	—	—	—	—	—
Fenchone	—	—	13.22	1.05	—	—	0.978	—	—	—	—	—	—	—	—
Geraniol	—	—	—	2.57	—	—	—	—	—	—	—	—	—	—	—
p-Vinyl guaiacol	—	—	—	—	—	—	—	—	—	—	—	—	—	1.34	—
Hexadecanoic acid	—	—	—	—	—	2.16	—	18.09	—	—	—	—	—	—	—
β-Humulene	—	—	—	—	—	—	—	—	—	—	1.143	—	—	—	—
trans-Isolimonene	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
trans-Jasmone	—	—	—	—	—	—	—	—	—	—	—	0.64	—	—	—
Linalool	0.38	—	—	1.64	0.92	—	—	2.31	—	—	—	—	1.22	26.69	—

(continued)

Table 3. (continued)

	Monoherbal												Polyherbal		
	Chamomile	Dill	Fennel	Ginger	Lemon balm	Parsley	Persian leek	Stinging nettle	Valerian	Willow	White horehound	Yarrow	Chehelgeyah	Moderr	Taadol
cis-Linalool oxide (furanoid)	—	—	—	—	—	—	—	4.61	—	—	—	—	—	—	—
trans-Linalool oxide (furanoid)	—	—	—	—	—	—	—	4.17	—	—	—	—	—	—	—
Menthol	—	3.8	—	0.839	—	—	—	—	—	—	36.27	—	1.79	—	—
Menthone	—	2.41	—	—	—	—	0.67	—	—	—	16.16	—	—	—	—
Iso-Menthone	—	0.82	—	—	—	—	—	—	—	—	6.06	—	—	—	—
Methyl eugenol	—	—	—	—	—	—	—	—	—	1.2	—	1.13	—	—	—
Methyl hexadecanoate	—	—	—	—	4.58	—	—	—	4.33	—	—	—	—	—	—
Methyl jasmonate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Methyl octadecanoate	—	—	—	—	0.57	—	—	3.23	—	—	—	—	—	—	—
Myristicin	—	—	—	—	—	34	—	—	—	3.54	—	—	—	—	—
Nerol	—	—	—	2.955	—	—	—	—	—	—	—	—	—	—	—
Phenethyl alcohol	—	—	—	—	—	—	—	—	—	55.78	—	—	—	—	—
Pinocarvone	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Piperitenone	5.74	—	0.81	—	—	—	—	—	—	—	—	—	—	—	0.76
Piperitenone oxide	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Piperitone	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pulegone	3.1	0.57	4.77	2.209	2.56	0.99	—	1.93	—	1.07	0.48	—	—	—	6.13
Sabina ketone	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
γ-Terpinene	—	—	—	—	—	—	—	—	—	1.16	—	—	—	—	—
Terpinen-4-ol	—	0.56	0.45	0.58	0.89	—	—	—	—	—	0.838	2.02	0.85	—	0.49
α-Terpineol	0.36	—	—	1.675	1.11	—	—	—	—	—	—	—	—	—	—
Terpinolene	—	—	1.15	—	—	—	—	—	—	—	—	0.47	—	—	—
β-Thujone	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
trans-Thujone	—	—	—	—	—	—	—	—	—	—	—	3.16	—	—	—
Thymol	34.35	19.49	42.2	41.455	46.97	56.6	56.944	27.28	8.45	0.63	14.55	0.52	64.74	8.25	44.98
Thymol ethanoate	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13.8
Toluene, 2,3-dimethoxy	—	—	—	—	—	—	—	—	—	—	1.043	—	—	—	—
Verbenone	—	—	—	—	—	—	—	—	—	—	—	1.97	—	—	—
m-Xylene	0.44	—	—	—	—	—	—	—	—	—	—	—	—	—	—
o-Xylene	—	—	—	—	—	—	—	—	—	—	1.16	—	—	0.93	—
p-Xylene	—	—	—	—	—	—	—	—	—	—	5.53	0.482	—	5.95	—
Yomogi alcohol	—	—	—	—	—	—	—	—	—	—	—	19.36	—	—	—

In order to roughly investigate the popularity of these beverages, manufactories also were asked to rank them from 1 to 18 according to their mean of annual production over the past 3 years. Since these data were confidential for these manufactories, a ranking system was applied. The aromatic water with the lowest level of production was ranked 1. The manufactories ranking data represented as mean ± SD are shown in Figure 2. Among the aromatic waters that have indication for women's hormonal and reproductive health conditions, yarrow, white horehound, Chehelgeyah, and fennel aromatic waters had higher annual production level during the past 3 years. This popularity might be because of their efficacy, the aromatic waters' organoleptic properties such as taste and aroma, or even possible side effects during longer periods of consumptions. This might be also, due to their other applications rather than their effects on the reproductive system.

The plants that are used to prepare these aromatic waters belong to 17 families. Apiaceae, Lamiaceae, and Asteraceae had a greater portion than others (Table 1).

Most of these aromatic waters are prepared from aerial parts of the plants. Different effects on women's reproductive conditions including aphrodisiac, galactogogue, induction or regulation of menstruation, thinning vaginal discharge, cleansing reproductive system tracts, prevention of abortion, delivery induction, antitumor, treating infertility, and treating morning sickness were mentioned for these aromatic waters. Most of these beverages were believed to have hot nature.

Other indications rather than women's hormonal and reproductive health were also mentioned for these beverages, which are summarized in Table 2. As mentioned in the introduction, aromatic waters' aroma and compositions are considerably irrelevant to the pure volatile oil they were co-distilled with. As far as we know, the chemical constituents of most of these aromatic waters have not been investigated scientifically. This study determined constituents of these aromatic waters by gas chromatography–mass spectrometry after liquid-liquid extraction. As seen in Table 3, which shows the results of gas chromatography–mass spectrometry analysis, thymol is major or second major component except for dill, white horehound, willow, Moderr, and yarrow aromatic waters, whose major constituents are dill ether, menthol, phenethyl alcohol, linalool, or camphor. Carvacrol was also detected in all of these aromatic waters except for Taadol.

According to both hierarchical cluster analysis and K-means, all the aromatic waters that contain thymol as the major constituent make a cluster that includes some subcultures (Figure 3, Table 4). Lemon balm, Persian leek, Chehelgeyah, and ginger aromatic waters make a distinct subcluster. The reason behind the observed similarities between these aromatic waters based on clustering analysis was the presence of comparable amounts of thymol (41.45% to 64.74%) and carvacrol (26.20% to 30.49%) in these aromatic waters. The certain similarity of fennel, Taadol, and chamomile was also seen by hierarchical cluster analysis, which might be due to the presence of comparable amounts of thymol as the major constituent (42.20%, 44.98%, and 34.35%), carvone (14.53%, 15.84%, and 8.12%), and carvacrol (6.71%, 4.12%, and 4.65%) in these 3 aromatic waters.

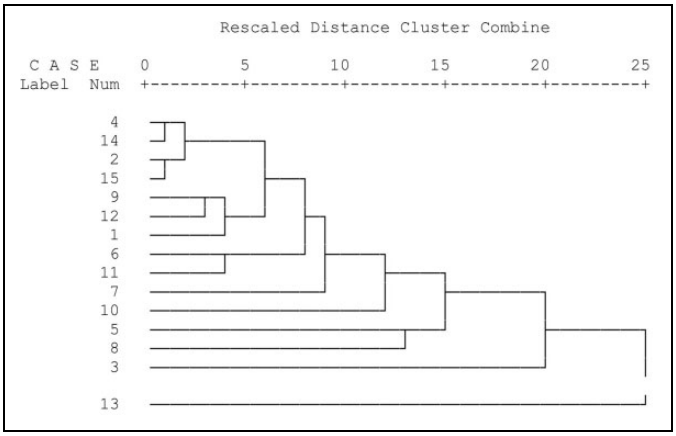

Figure 3. Cluster analysis of aromatic waters' constituents based on hierarchical cluster analysis. The aromatic waters are the following: 1, chamomile; 2, lemon balm; 3, yarrow; 4, Chehelgeyah; 5, white horehound; 6, stinging nettle; 7, parsley; 8, Moderr; 9, fennel; 10, dill; 11, valerian; 12, Taadol; 13, willow; 14, Persian leek; and 15, ginger.

Table 4. Analysis of the Aromatic Waters' Constituents Based on K-Means by SPSS Software (10 Epochs of Training).

Aromatic Waters' Name	Class
Dill	I
Chamomile, stinging nettle, fennel, valerian, Taadol	II
Yarrow	III
Lemon balm, Chehelgeyah, Persian leek, ginger	IV
White horehound	V
Willow	VI
Parsley	VII
Moderr	VIII

In contrast to other aromatic waters, thymol was fond in zero or trace amount in willow and yarrow aromatic waters. Their major constituents are also completely different from others, and they were clustered at distinct groups.

Based on clustering methods applied in this study, although some similarities could be found, composition of white horehound, Moderr, willow, and yarrow aromatic waters revealed more differences than others. The main components of these aromatic waters were menthol (36.27%, white horehound), linalool (26.69%, Moderr), camphor (41.88, yarrow), and phenethyl alcohol (55.73%, willow).

Literature Survey

We could not find any reports on chemical constituents of aromatic waters of the mentioned plants 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 most of these aromatic waters including lemon balm, stinging nettle, valerian, fennel, Persian leek, ginger, and white horehound, the major components in the aromatic waters and

Table 5. Profile of Essential Oils Reported in Literature for the Plants Used to Prepare Aromatic Waters With Indications for Women's Hormonal and Reproductive Health Conditions.

Plant Name	Profile of Essential Oils Reported in Literature for Plants Used to Prepare Monoherbal Aromatic Waters	References
Chamomile	Bisabolol oxide A and B, bisabolon oxide A, (E)-β-farnesene, α-bisabolol, chamazulene	23
	α-Bisabolol, chamazulene, farnesene and a-pinene, bisabolol oxides A and B	24
Dill	Carvone, *trans*-dihydrocarvone, dill ether, α-phellandrene, limonene	22
Fennel	Limonene, β-pinene, myrcene, fenchone	25
Ginger	Geranial, a-zingiberene, (E,E)-α-farnesene, neral, ar-curcumene	26-28
Lemon balm	Citronellal, citral, geranial, beta-caryophyllene, beta-caryophyllene oxid, citronellal, geraniol, β-pinen	29
Parsley	Myrcene, myristicin, α-pinene, β-pinene, α-phellandrene, p-mentdatriene, dillapiol, bisabolole, camphor	30
Persian cumin	Thymol, *o*-cymene, γ-terpinen, trimethylene dichloride, β-pinene, 2-(1-cyclohexenyl) cyclohexanone, β-hellandrene	31
	Carvacrol, carvone, α-pinene, limonene, γ-terpinene, linalool, carvenone, *p*-cymene	32
Persian leek	Dipropyl disulfide, dipropyl trisulfide, methyl propyl disulfide, dimethyl disulfide, allyl methyl disulfide	21
Persian hogweed	Stem oil before flowering: (E)-anethole, terpinolene, γ-terpinene, limonene	33
	Stem oil at the full flowering stage: (E)-anethole, terpinolene, γ-terpinene	
	Seed oil: hexyl butyrate, octyl acetate, hexyl isobutyrate	
Stinging nettle	Neophytadiene, butyl tetradecyl ester, bis(2-ethyl hexyl) maleat, 1,2-benzen dicarboxylic acid	34
Valerian	Patchoulol, α-pinene, β-humulene	35
	Bornyl acetate, valerenic acid, (*Z*)-valernyl acetate, acetoxyvaleranone	36
White horehound	4,8,12,16-Tetramethyl heptadecan-4-olid, Germacrene D-4-ol and α-pinene, eudesmol, citronellol, citronellyl formate, germacrene D	37
Willow	*Salix aegyptiaca* leaf: 1,4-Dimethoxybenzene, phenylethyl alcohol, carvone	38
Yarrow	Sabinene, 1,8-cineole, borneol, bornyl acetate, α-pinene, β-pinene, terpinine-4-oland chamazulene	39

Plant Name	Profile of Essential Oils Reported in Literature for Plants Used to Prepare Polyherbal Aromatic Waters		
Chehelgeyah	Persian cumin	Mentioned above	
	Ajowan caraway	Thymol, ρ-cymene, γ-terpinene	40, 41
	Bigarade orange	Limonene, Myrcene, Octane	42
	Licorice	2-Ethoxy-1-propanol, 4-terpineol, hexanal	43
		Thymol, carvacrol, (2*E*,4*E*)-decadienal, ß-caryophyllene oxide, 1a,10a-epoxyamorpha-4-ene	44
	Lavender	Linalool, linalyl acetate, 1,8-cineole, ocimene, terpinen-4-ol, camphor	45
	Chamomile	Mentioned above	
	Mint	Piperitone oxide, menthone, isomenthone	46
		Piperitone oxide, 1,8-cineole, caryophyllene oxide, piperitenone oxide	47
	Summer savory	γ-Terpinene, carvacrol, thymol, cymene	48, 49
	Valerian	Mentioned above	
	Saatar	Thymol, carvacrol, linalool	50
Moderr	Caltrop	Whole plant: a-Amyrin, n-hexadecanoic acid, 9,12,15-octadecanoic acid	51
	Camelthorn	Leaf oil: drimenol, 9-octylheptadecane, 4-hexyl-2,5-dihydro-2,5-dioxo-3-furanacetic acid	52
		Stem oil: neophytadiene, *trans*-ionone, 6,10,14-trimethyl-2-pentadecanone, actinidiolide	52
	Cherry stalk	Profile of volatile components was not found in literatures	
	Chicory	Octane, *n*-nonadecane, *n*-hexadecane, pentadecanone	53
	Corn silk	*cis*-Terpineol, acor-4-ene (6,11-oxido), citronellol	54
		2-Heptanol and geosmin	55
	White horehound	Eudesmol, citronellol, citronellyl formate, germacrene D	56
	Willow	Mentioned above	
Taadol	Celery	Leaf: 4-Chloro-4,4-dimethyl-3-(1-imidazolyl)-valerophenone, 1-dodecanol, 9-octadecen-12-ynoic acid	57
	Olive	Leaf: 2-hexenal, α-farnesene, linalool	58
	Stinging nettle	Profile of volatile components was not found in literatures	
	Saatar	Mentioned above	
	Walnut	Husks: (*E*)-4,8-dimethyl-1,3,7-nonatriene, pinocarvone, pinocarveol, myrtenal, myrtenol, (*E*,*E*)-4,8,12-trimethyl-1,3,7,11-tridecatetraene, caryophyllene epoxide, verbenol	59
		Leaf: germacrene D, methyl salicylate	60

essential oils are completely different. Different allyl sulfides were reported as the major components of the Persian leek essential oils[21] 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, myristicin, followed by dill ether.[22] In the present study, the major compound in dill aromatic water was dill ether (40.9%), followed by thymol and carvacrol. On the other hand,

Table 6. Literature Survey on Biological Activities of Plants Used in Preparing Aromatic Waters With Indications for Women's Hormonal and Reproductive Health Conditions.

Plant name	Observed effects	Plant preparation	Study type	Reference
Chamomile	Relieving the intensity of mastalgia associated with premenstrual syndrome	Capsule 100 mg	Clinical trial	61
	Treatment of menopausal symptoms	Chewable tablets	Clinical trial	62
	Improving the symptoms of vaginitis	Chamomile douche	Clinical trial	24, 63
	Treatment of polycystic ovary syndrome (PCOS)	Alcoholic extract	In vivo	64, 65
	Pain relief effect with and without physiological doses of sex hormones	Hydroalcoholic extract	In vivo	66
	Decrease in the serum level of estrogen	Hydroalcoholic extract	In vivo	67
	Decline in the mean number of primary and graafian follicles	Hydroalcoholic extract	In vivo	
	Uterotonic action	Aqueous extract	In vitro	68
Dill	Treatment of premenstrual syndrome and dysmenorrheal	Aqueous extract or tea	Clinical trial	61, 69-71
	Reducing the pain severity in primary dysmenorrhea	Dill powder	Clinical trial	72
	Facilitating delivery, prevention of post term pregnancy	Seed infusion	Clinical trial	73-75
	Regulating menstrual cycle, increasing the duration of the estrous cycle	Aqueous extract	In vivo	76
	Contractive effects on myometer, enhanced releasing of oxytocin	Seed extracts	In vivo	77, 78
	Infertility induction	Seed fractions	In vivo	79-81
	Estrogenic activities	Ethanolic extracts	In vitro	82
Fennel	Treatment of primary dysmenorrhea	Seed extracts	Clinical trial	69, 83-87
	Reducing the severity of dysmenorrhea	Essential oil (oral drop)	Clinical trial	88, 89
	Inhibitory effect on the response of uterine to oxytocin and PGE2	Essential oil	In vivo	90
	Inducing folliculogenesis	Alcoholic extract	In vivo	91
	Effects on blood sex hormones and reproductive tissues	Alcoholic extract	In vivo	89, 92, 93
	Effects on uterine contraction	Essential oil	In vivo	90
	Effects on fertility	Alcoholic extract	In vivo	94
Ginger	Treatment of morning sickness during pregnancy	Extract or plant powder	Clinical trial	27, 95-102
	Treatment of postoperative nausea and vomiting after gynecological surgery	Extract or plant powder	Clinical trial	103, 104
	Treatment of primary dysmenorrhea	Extract or plant powder	Clinical trial	105-110
	Effects on uterus muscles	Hydroalcoholic extract	In vivo	111, 112
	Effects on sexual behavior and fertility	Hydroalcoholic extract	In vivo	113-115
	Effects on the fetal development	Hydroalcoholic extract	In vivo	116, 117
Lemon balm	Emmenagogue (stimulate menstruation)	Aqueous extract	In vivo	118, 119
Persian hogweed	Inhibitory effects on folliculogenesis and cause infertility in females	Hydroalcoholic extract	In vivo	120
	Testosterone level	Hydroalcoholic extract	In vivo	121
Persian leek	Antimicrobial and antifungal effects (possibly useful for vaginosis)	Hydroalcoholic extract	In vitro	122, 123
Stinging nettle	Anti-androgenic activity	Aqueous extract	Clinical trial	124
	Treatment of heavy menstrual bleeding	Aqueous extract	Clinical trial	125
	Hyperoestrogenism, gynaecomastia	Aqueous extract	Case report	126
	Anti-proliferative activities against breast cancer cell lines (MCF-7)	Aqueous extract	In vitro	127
	Positive effect on luteinizing hormone or testosterone level	Hydroalcoholic extract	In vivo	128-130
	Positive effects on spermatozoa sperm parameters	Hydroalcoholic extract	In vivo	131
	Follicular development and induction of estrus	Hydroalcoholic extract	In vivo	132
Valerian	Improves the quality of sleep in women with menopause	Hydroalcoholic	Clinical trial	133
	Treatment for dysmenorrhea	Hydroalcoholic	Clinical trial	134
	Destructive effect on the ovarian tissue	Hydroalcoholic extract	In vivo	135
	Significant decrease in zinc level in fetal brain		In vivo	136
White horehound	Improving hormonal parameters in PCOS	Alcoholic extract	In vivo	137
	Estrogen like activity	Phytoestrogen constituents	Hypothesis	138
Yarrow	Reducing fetal weight and increasing placental weight (unsafe during pregnancy)	Hydroalcoholic extract	In vivo	139
	Estrogenic/antiestrogenic activity	Aqueous extract	In vivo	140
	Estrogenic activity	Aqueous extract from leaves	In vitro	141, 142

the major components of parsley leaf (myristicin) and willow (phenylethyl alcohol) were similar in aromatic waters and reported essentials but their amount as well as nonmajor constituents were different (Tables 3 and 5). As was expected, comparing the results of this study on chemical composition of the aromatic waters (Table 3) with the previous reports on the

plants' essential oils (Table 5) shows that there is a significant difference between aromatic waters and essential oil components. This difference may arise from different water solubility of the volatile components. It is possible that some of these volatile components were not entered in water during the preparation procedure of aromatic waters. Also, it can be concluded that it is essential to consider different pharmacological and biological properties of the aromatic waters due to different chemical compositions compared with the pure co-distilled essential oils.

Different biological activities of the plants used to prepare the identified aromatic waters on the reproductive system or sexual hormone conditions were investigated in the literature and summarized in Table 6. We could not find any report on hormonal activity or effects on reproductive system conditions for any of the aromatic waters. But, for some of these plants including fennel, dill, chamomile, and ginger, some clinical trial have been reported on their essential oils or different extracts. Of course, we cannot compare the observed effects of the essential oils or other extracts of these plants with their aromatic waters due to differences in constituents as well as their concentrations but these reports might strengthen the hypothesis of the beneficial effects for these aromatic waters on women's reproductive and hormonal health conditions.

For some of these plants mentioned in Table 6, different aqueous, ethanol, and methanol extracts or plant powders were investigated and it is not clear that if the volatile components had a role in the observed effects. On the other hand, for some others listed in Table 6, the medicinal parts that were used in these studies 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. The present investigation was not intended to evaluate the efficacy of these aromatic waters, but high consumption of these aromatic waters in Persian folk medicine and nutrition culture might be related to their efficacy.

Conclusion

This article introduced some aromatic waters that are used for women's reproductive and hormonal health conditions in Persian folk medicine with different popularity and market values. Almost in all investigated aromatic waters the chemical composition was remarkably different from the essential oils of the plants that were used for their preparations. Clustering these aromatic waters using SPSS software revealed that despite the differences in the plants genus, family, and the medicinal parts of the plants that are used to prepare them, some similarity can be identified in their chemical compositions. In most cases thymol, carvacrol, and carvone were the major constituents and may have a role in their biological activities.

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

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Author Contributions

AH wrote the draft and contributed in guidance, data collection, and revisions of the final version of the article. HE and MA contributed to data collection, analyzing data, and revising the final version of the article.

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Ethical Approval

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