

Supporting Information

Rec. Agric. Food. Chem. 5:2 (2025) 125-138

From Phenolics to Function: Anti-Diabetic Potentials of Hawthorn, Pomegranate, and Jujube Vinegars

Büşra Umut Oyman¹, Çağlayan Ünsal Gürer², İsmail Yener³, Mehmet Akdeniz³, Serkan Yigitkan⁴, Mustafa Abdullah Yılmaz³, Suzan Tireki⁵, Abdulselam Ertas³ and Ash Barla Demirköz^{6,7*}

¹Haliç University, Faculty of Health Sciences, Department of Nutrition and Dietetics, 34060 İstanbul, Türkiye

²Istanbul University, Faculty of Pharmacy, Department of Pharmacognosy, 34116 İstanbul, Türkiye

³Dicle University, Faculty of Pharmacy, Department of Analytical Chemistry, 21280 Diyarbakir, Türkiye

⁴Dicle University, Faculty of Pharmacy, Department of Pharmacognosy, 21280 Diyarbakir, Türkiye

⁵Ozyegin University, Faculty of Applied Sciences, Gastronomy and Culinary Arts Department, 34794 İstanbul, Türkiye

⁶Istanbul Okan University, Faculty of Pharmacy, Department of Analytical Chemistry, 34959 Tuzla, İstanbul, Türkiye

⁷AROMSA Research and Development Center, Aromsa Flavours and Food Additives San. ve Tic. A.Ş., 41480 Kocaeli, Türkiye

Table of Contents	Page
Table S1. Phenolic compounds of the extracts	2
Table S2. Phenolic compounds of the vinegars	3
Table S3. Anti-diabetic activities of samples	4
Figure S1. Scree Plot of PCA biplot for phenolic compounds in vinegars	5

Table S1. Phenolic compounds of the extracts.

No	Analytes	Pomegranate (EtOH)	Pomegranate (EtOH: Water)	Hawthorn (EtOH)	Hawthorn (EtOH: Water)	Jujube EtOH	Jujube (EtOH: Water)
1	Quinic acid	0.960	N.A.	0.421	89.355	77.803	0.457
4	Gallic acid	0.453	0.577	N.A.	0.066	0.087	N.A.
6	Protocatechuic acid	0.164	0.171	0.092	1.710	1.823	0.035
7	Catechin	0.091	N.A.	N.A.	N.A.	N.A.	N.A.
9	Chlorogenic acid	N.A.	N.A.	N.A.	0.058	0.039	N.A.
10	Protocatechuic aldehyde	N.A.	N.A.	0.02	0.127	0.100	N.A.
17	Caffeic acid	N.A.	N.A.	N.A.	0.059	0.069	N.A.
18	Syringic acid	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
19	Vanillin	N.A.	N.A.	N.A.	0.082	0.033	N.A.
29	Salicylic acid	N.A.	N.A.	0.030	N.A.	N.A.	N.A.
30	Cyanoside	N.A.	N.A.	N.A.	0.074	0.054	N.A.
33	Rutin	0.065	N.A.	0.228	N.A.	N.A.	0.237
34	isoquercitrin	0.053	N.A.	N.A.	2.915	2.406	N.A.
35	Hesperidin	N.A.	N.A.	0.021	N.A.	N.A.	0.021
39	Ellagic acid	7.608	9.690	N.A.	N.A.	N.A.	N.A.
41	Quercitrin	N.A.	N.A.	N.A.	N.A.	0.106	N.A.
42	Astragalin	0.098	N.A.	N.A.	0.044	0.035	N.A.
43	Nicotiflorin	0.231	N.A.	N.A.	N.A.	N.A.	N.A.
47	Quercetin	N.A.	N.A.	N.A.	1.335	0.581	N.A.
48	Naringenin	0.005	N.A.	N.A.	0.014	0.006	N.A.
50	Luteolin	0.020	N.A.	N.A.	0.021	0.010	N.A.
52	Kaempferol	N.A.	N.A.	N.A.	0.030	0.013	N.A.
53	Apigenin	0.004	N.A.	N.A.	N.A.	N.A.	N.A.
		9.750	10.438	0.811	95.888	83.165	0.749

N.A.: Not applicable; *Numbers* on the far-left row indicate the standard phytochemical compounds. Undetected components are listed as follows by the applied method: 2: Fumaric acid. 3: Acotinic acid. 5: Epigallocatechin. 8: Gentisic acid. 11: Tannic acid. 12: Epigallocatechin gallate. 13: Cynarin. 14: 4-OH Benzoic acid. 15: Epicatechin. 16: Vanillic acid. 20: Syringic aldehyde. 21: Daidzin. 22: Epicatechin gallate. 23: Piceid. 24: *p*-coumaric acid. 25: Ferulic acid-D3-IS. 26: Ferulic acid. 27: Sinapic acid. 28: Coumarin. 31: Miquelianin. 32: Rutin-D3-IS. 36: *o*-Coumaric acid. 37: Genistin. 38: Rosmarinic acid. 40: Cosmosiin. 44: Fisetin. 45: Daidzein. 46: Quercetin-D3-IS. 49: Hesperetin. 51: Genistein. 54: Amentoflavone. 55: Chrysin. 56: Acacetin. Values in mg/g (w/w) of extracts. Abbreviations: Ethanolic Extract - EtOH. 70% Ethanolic Extract - 70% EtOH

Table S2. Phenolic compounds of the vinegars.

No	Analytes	Pomegranate vinegar 1	Pomegranate vinegar 2	Pomegranate vinegar 3	Hawthorn vinegar 1	Hawthorn vinegar 2	Hawthorn vinegar 3	Jujube vinegar 1	Jujube vinegar 2	Jujube vinegar 3
1	Quinic acid	19.912	40.769	20.173	35.889	8.395	35.622	101.568	76.633	6.588
3	Aconitic acid	0.229	1.268	0.342	0.217	0.028	0.236	N.A.	0.096	N.A.
4	Gallic acid	13.003	169.898	34.124	0.239	0.294	0.516	0.948	4.655	0.225
5	Epigallocatechin	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.863
6	Protocatechuic acid	6.028	17.306	4.057	4.106	6.405	4.269	7.989	4.593	0.295
7	Catechin	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.827	9.122
8	Gentisic acid	1.866	0.852	N.A.	N.A.	0.329	N.A.	0.519	0.552	0.134
9	Chlorogenic acid	0.035	0.042	1.93	0.563	0.271	1.424	1.325	1.188	N.A.
10	Protocatechuic aldehyde	0.315	0.067	0.261	0.086	0.266	0.205	0.302	0.092	0.058
11	Tannic acid	0.260	2.606	0.194	N.A.	N.A.	0.155	0.039	N.A.	N.A.
14	4-Hydroxy benzoic acid	2.458	0.924	0.235	0.143	0.287	0.148	0.312	0.196	N.A.
15	Epicatechin	68.371	12.135	2.017	N.A.	N.A.	N.A.	N.A.	4.311	40.619
16	Vanillic acid	2.302	0.692	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
17	Caffeic acid	1.178	0.371	1.283	0.206	0.212	0.368	1.117	0.432	0.004
18	Syringic acid	0.697	0.319	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
24	<i>p</i> -Coumaric acid	0.583	0.233	0.227	0.044	0.041	0.039	0.1	0.044	N.A.
26	Ferulic acid	0.851	N.A.	N.A.	N.A.	0.27	N.A.	N.A.	N.A.	N.A.
28	Coumarin	0.024	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
29	Salicylic acid	0.048	0.025	0.017	N.A.	N.A.	N.A.	N.A.	0.047	0.127
30	Cyanoside	N.A.	N.A.	0.064	0.017	N.A.	0.021	N.A.	N.A.	N.A.
31	Miquelianin	N.A.	N.A.	N.A.	N.A.	N.A.	0.016	N.A.	N.A.	N.A.
33	Rutin	N.A.	N.A.	0.079	0.069	0.755	0.075	N.A.	N.A.	N.A.
34	isoquercitrin	0.259	0.215	0.152	0.164	0.913	0.711	0.026	N.A.	N.A.
35	Hesperidin	0.03	0.004	0.015	0.063	0.092	0.053	N.A.	0.442	N.A.
39	Ellagic acid	62.643	68.76	10.429	N.A.	N.A.	N.A.	N.A.	0.445	N.A.
40	Cosmosiin	N.A.	0.007	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
41	Quercitrin	0.108	0.097	0.068	0.085	0.036	0.078	3.363	0.122	0.128
42	Astragalin	N.A.	0.021	0.071	N.A.	0.131	0.042	N.A.	N.A.	N.A.
43	Nicotiflorin	N.A.	N.A.	0.066	N.A.	0.088	N.A.	N.A.	N.A.	N.A.
47	Quercetin	0.238	0.301	0.086	0.05	0.096	N.A.	0.388	0.973	1.392
48	Naringenin	0.095	0.066	0.048	0.125	0.014	0.03	0.006	0.184	0.004
49	Hesperetin	0.246	N.A.	0.013	0.153	N.A.	0.042	0.007	0.738	N.A.
50	Luteolin	0.076	0.173	0.042	0.012	0.042	0.01	N.A.	0.009	0.006
51	Genistein	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	0.003	N.A.
52	Kaempferol	0.054	0.094	0.013	N.A.	N.A.	N.A.	N.A.	0.041	0.084
53	Apigenin	0.009	0.014	0.004	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
N.A.: Not applicable		181.918	317.257	76.01	42.231	18.965	44.059	118.009	96.623	59.649

^aNumbers on the far-left row indicate the standard phytochemical compounds. Undetected components are listed as follows by the applied method: 2: Fumaric acid. 12: Epigallocatechin gallate. 13: Cynarin. 19: Vanillin. 20: Syringic aldehyde. 21: Daidzin. 22: Epicatechin gallate. 23: Piceid. 25: Ferulic acid-D3-IS. 27: Sinapic acid. 32: Rutin-D3-IS. 36: *o*-Coumaric acid. 37: Genistin. 38: Rosmarinic acid. 44: Fisetin. 45: Daidzein. 46: Quercetin-D3-IS. 54: Amentoflavone. 55: Chrysin. 56: Acacetin.

^bValues in mg/g (w/w) of vinegars.

Table S3. Anti-diabetic activities of samples.

Samples	Enzyme inhibition% $\pm$ S.D. at 100 μ g/mL	
	α -amylase	α -glucosidase
Pomegranate EtOH	3.34 $\pm$ 0.05 ^a	82.65 $\pm$ 1.06 ^a
Pomegranate EtOH: Water	1.67 $\pm$ 0.01 ^a	50.70 $\pm$ 0.38 ^b
Hawthorn EtOH	NA	NA
Hawthorn EtOH: Water	11.55 $\pm$ 0.03 ^b	94.85 $\pm$ 1.27 ^{cd}
Jujube EtOH	10.06 $\pm$ 0.05 ^b	95.03 $\pm$ 1.37 ^{cd}
Jujube EtOH: Water	NA	92.75 $\pm$ 0.75 ^c
Pomegranate Vinegar 1	25.76 $\pm$ 0.52 ^c	106.08 $\pm$ 1.09 ^c
Pomegranate Vinegar 2	32.44 $\pm$ 0.40 ^d	110.97 $\pm$ 3.01 ^f
Pomegranate Vinegar 3	36.93 $\pm$ 0.90 ^e	98.20 $\pm$ 1.31 ^{dg}
Hawthorn Vinegar 1	66.48 $\pm$ 1.25 ^f	97.78 $\pm$ 1.27 ^{dg}
Hawthorn Vinegar 2	64.03 $\pm$ 0.99 ^{fg}	101.08 $\pm$ 1.71 ^g
Hawthorn Vinegar 3	62.89 $\pm$ 1.82 ^g	97.96 $\pm$ 1.21 ^{dg}
Jujube Vinegar 1	57.29 $\pm$ 1.25 ^h	97.96 $\pm$ 1.27 ^{dg}
Jujube Vinegar 2	58.99 $\pm$ 1.29 ^h	96.82 $\pm$ 1.37 ^{cd}
Jujube Vinegar 3	84.32 $\pm$ 1.20 ⁱ	96.70 $\pm$ 1.27 ^{cd}
Acarbose	28.19 $\pm$ 0.53 ^c	36.89 $\pm$ 0.35 ^h

Values expressed are means $\pm$ S.D. of three parallel measurements, and values were calculated according to the negative control. Acarbose: Standard compound.

NA: Not applicable.

Samples with common lower-case letters are not significantly different ($p > 0.05$).

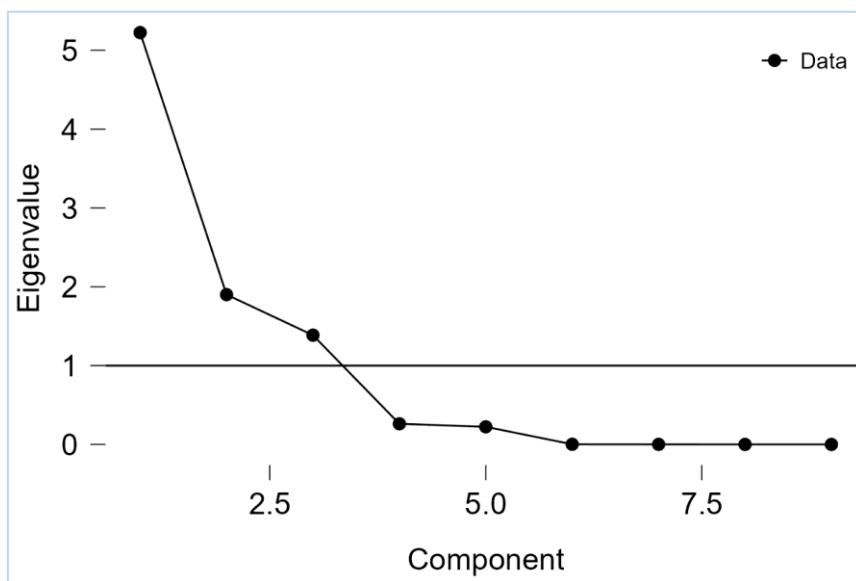


Figure S1. Scree Plot of PCA biplot for phenolic compounds in vinegars.