

# Supplementary Materials

## Beneficial effects of *Pistacia terebinthus* resin on wine making

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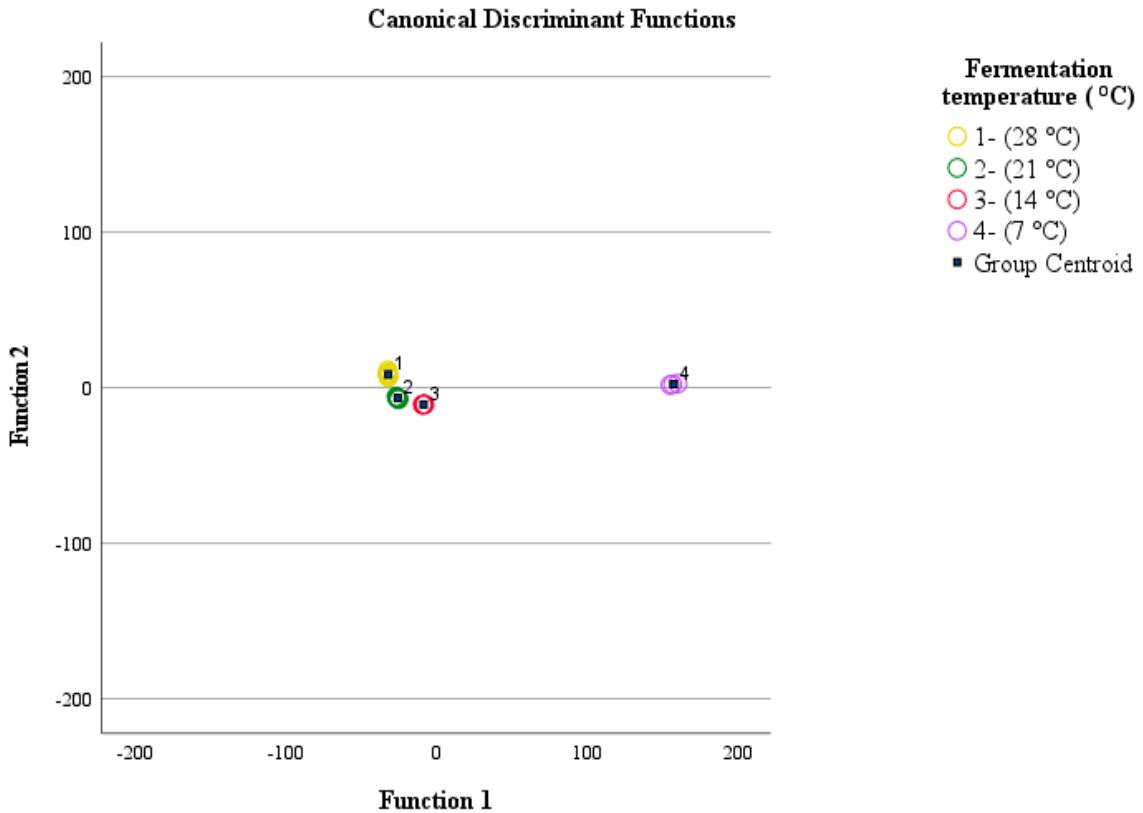
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For the fermentation batches 1-22 (Table 1), ANOVA showed that statistically significant differences existed for the fermentation time ( $F=26784.289$ ,  $p<0.001$ ), ethanol ( $F=16.284$ ,  $p<0.001$ ), ethanol productivity ( $F=577.14$ ,  $p<0.001$ ), residual sugar ( $F=13.115$ ,  $p<0.001$ ), and sugar conversion ( $F=13.099$ ,  $p<0.001$ ) with respect to fermentation temperature.

The application of LDA analysis allowed the construction of classification models. The results of LDA showed that initially three discriminant functions were formed: Wilks' Lambda=0.000 ( $X^2=218.718$ ,  $df=12$ ,  $p<0.001$ ) for the first; Wilks' Lambda=0.013 ( $X^2= 74.336$ ,  $df=6$ ,  $p<0.001$ ) for the second; and Wilks' Lambda=0.991 ( $X^2=0.155$ ,  $df=2$ ,  $p=0.925$ ) for the third. As it can be observed the third discriminant function was not significant and did not contribute to the classification analysis.

The first discriminant function accounted for 98.4% of total variance and had the highest eigenvalue (4879.688) and canonical correlation (1.000). The second discriminant function had a lower eigenvalue (77.539) and canonical correlation (0.994), while accounted for 1.6% of total variance. The statistically significant discriminant functions accounted for 100% of total variance. In Figure S1 it is shown the clear separation. The classification rate was 100% using the original and 100% using the cross-validation method. The group centroid values, representing the coordinates (x,y) in the two-dimensional space of LDA, were: (-31.824, 8.491), (-25.503, -6.652), (-8.361, -10.798), and (157.626, 2.227) for the fermentation temperature of 28, 21, 14, and 7 °C, respectively.

The parameters that contributed most to the discrimination of the fermentation temperature were those with the highest absolute correlation value within the discriminant functions. These were fermentation time with a correlation value of 0.956 in the first discriminant function; and ethanol productivity with a correlation value of 0.856 in the second discriminant function.



**Figure S1.** Classification of fermentation temperature (batches 1-22) based on fermentation time (h), ethanol (% v/v), ethanol productivity (g/L/d), residual sugar (g/L), sugar conversion (%), and LDA.

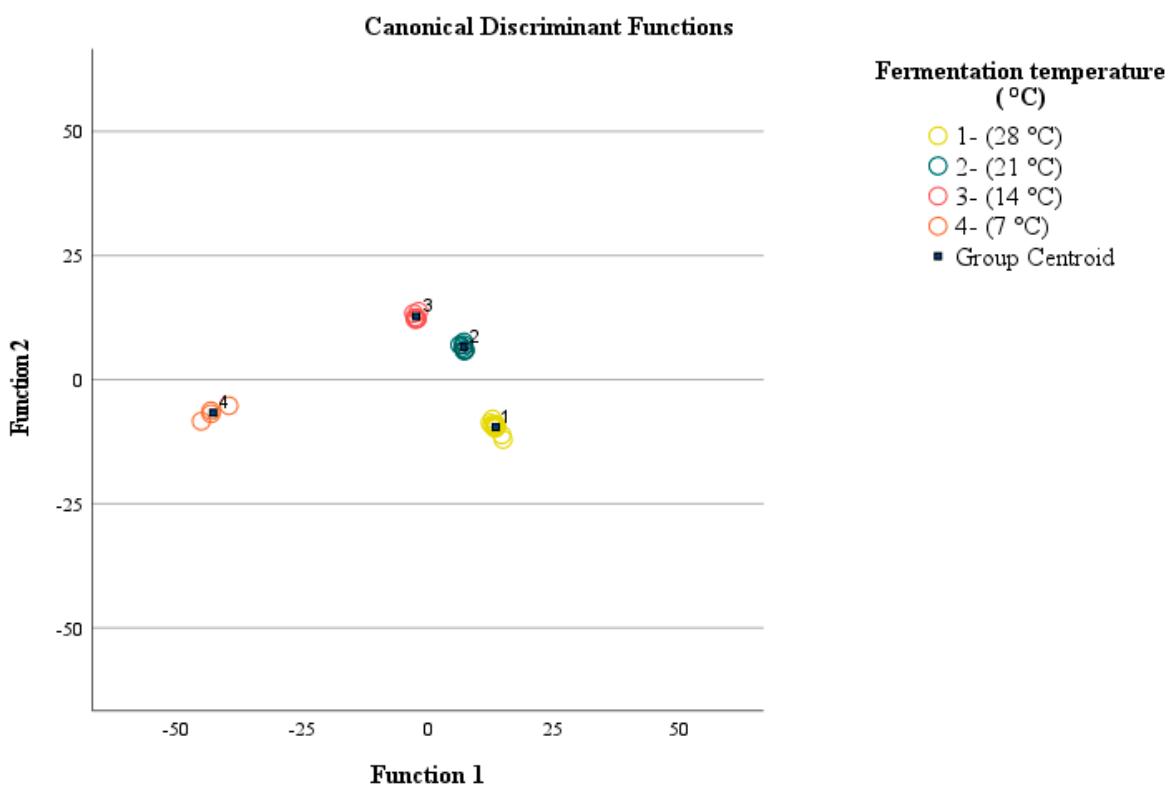
Similarly, for the fermentation batches 1-27 (Table 2), ANOVA showed that statistically significant differences existed only for the fermentation time ( $F=1913.91, p<0.001$ ), ethanol productivity ( $F=1032.329, p<0.001$ ), residual sugar ( $F=36.132, p<0.001$ ), and sugar conversion ( $F=36.223, p<0.001$ ) with respect to fermentation temperature. Ethanol content showed no significant differences ( $F=1.975, p=0.146$ ).

The results of LDA showed that two significant discriminant functions were formed: Wilks' Lambda=0.000 ( $X^2=239.071, df=12, p<0.001$ ) for the first; and Wilks' Lambda=0.008 ( $X^2=106.568, df=6, p<0.001$ ) for the second.

The first discriminant function accounted for 80% of total variance and had the highest eigenvalue (411.763) and canonical correlation (0.999). The second discriminant function had a lower eigenvalue (102.857) and canonical correlation (0.995), while accounted for 20% of total variance. Both discriminant functions accounted for 100% of total variance.

In Figure S2, it is also shown a clear separation. The classification rate was 100% using the original and 100% using the cross-validation method. The group centroid values were: (13.472, -9.562), (7.097, 6.569), (-2.309, 12.723), and (-42.635, -6.674) for the fermentation temperature of 28, 21, 14, and 7 °C, respectively.

As in the case of fermentation batches 1-22, the parameters that contributed most to the discrimination of the fermentation temperature in batches 1-27, were fermentation time with an absolute correlation value of 0.771 in the first discriminant function; and ethanol productivity with an absolute correlation value of 0.690 in the second discriminant function.



**Figure S2.** Classification of fermentation temperature (batches 1-27) based on fermentation time (h), ethanol productivity (g/L/d), residual sugar (g/L), sugar conversion (%), and LDA.

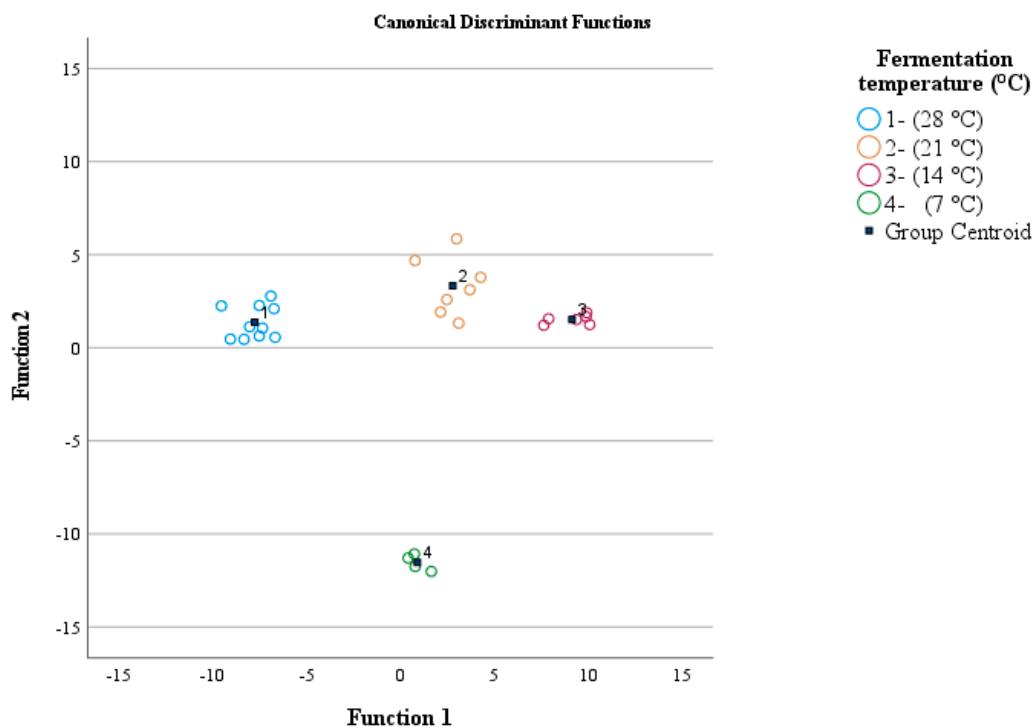
## Volatile compounds

For the fermentation batches 1-27 (Table 3), ANOVA showed that statistically significant differences existed on the content (mg/L) for all the volatile compounds: methanol ( $F=4.249$ ,  $p=0.016$ ), acetaldehyde ( $F=4.505$   $p=0.013$ ), ethyl acetate ( $F=174.280$ ,  $p=0.000<0.001$ ), 1-propanol ( $F=35.841$ ,  $p<0.001$ ) (isobutyl alcohol ( $F=123.711$ ,  $p<0.001$ ), and amyl alcohol ( $F=65.764$ ,  $p<0.001$ ) with respect to fermentation temperature.

The results of LDA showed that three significant discriminant functions were formed: Wilks' Lambda=0.000 ( $X^2=176.229$ ,  $df=18$ ,  $p<0.001$ ) for the first; Wilks' Lambda=0.012 ( $X^2= 93.454$ ,  $df=10$ ,  $p<0.001$ ) for the second; and Wilks' Lambda=0.338 ( $X^2= 22.796$ ,  $df=4$ ,  $p<0.001$ ) for the third. The first discriminant function accounted for 62.8% of total variance and had the highest eigenvalue (50.503) and canonical correlation (0.990). The second discriminant function had a lower eigenvalue (27.924) and canonical correlation (0.983), while accounted for 34.7% of total variance. Finally, the third discriminant function had the lowest eigenvalue (1.961) and canonical correlation (0.814), while accounted for 2.4% of total variance. All discriminant functions accounted for 100% of total variance.

In Figure S3 it is shown a clear separation. The classification rate was 100% using the original and 100% using the cross-validation method. The group centroid values were: (-7.775, 1.373), (2.774, 3.328), (9.129, 1.518), and (0.889, -11.533) for the fermentation temperature of 28, 21, 14, and 7 °C, respectively.

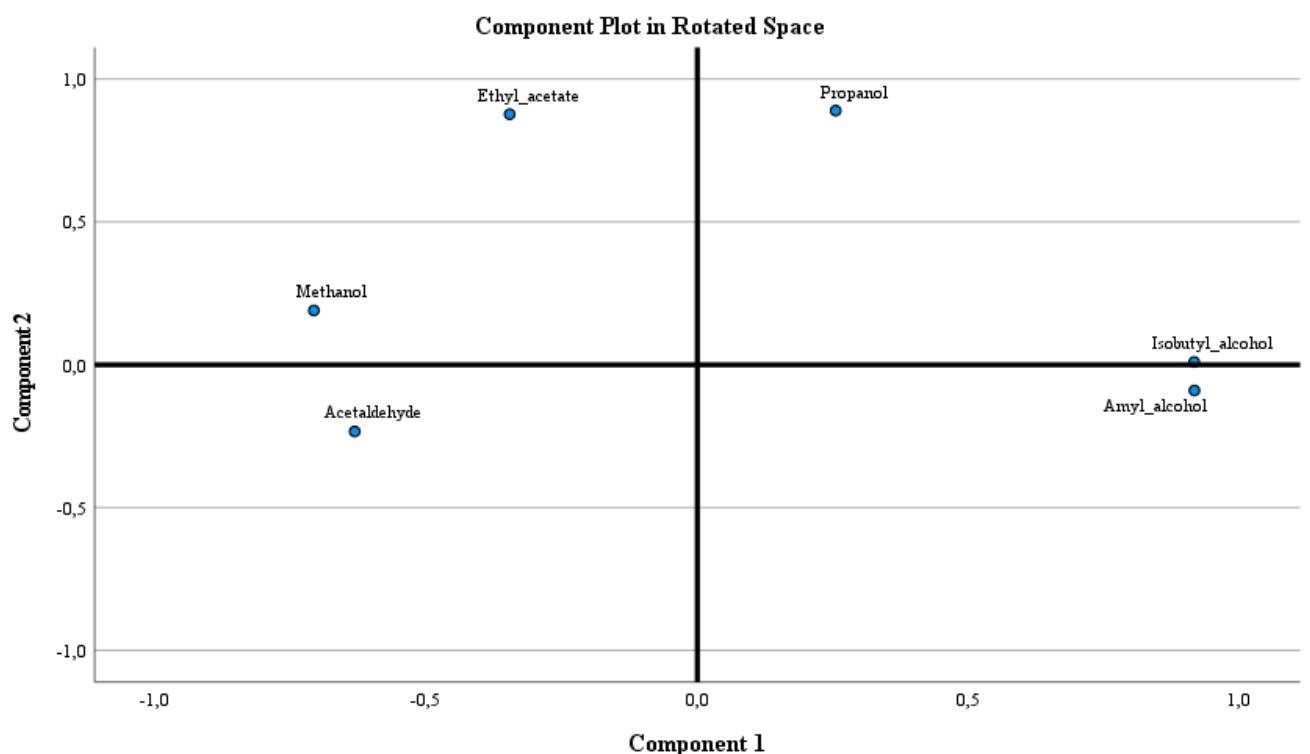
The volatile compounds that contributed most to the discrimination of the fermentation temperature in batches 1-27, were ethyl acetate with an absolute correlation value of 0.657 in the first discriminant function; isobutyl alcohol with an absolute correlation value of 0.654 in the second discriminant function; 1-propanol with amyl alcohol with an absolute correlation value of 0.654 and 0.428, respectively, in the third discriminant function.



**Figure S3.** Classification of fermentation temperature (batches 1-27) based on volatile compounds and LDA.

### Factor analysis

Factor analysis showed that volatile compounds adequately describe the variability in the poly-parametric space. The Keiser-Meyer-Olkin (KMO) index was 0.609 while Bartlett's Test of Sphericity index (*p*-value should be  $<0.05$ ) had the values  $X^2 = 73.623$ ,  $df = 15$ ,  $p < 0.001$ , indicating that there are correlations between the variables that allow the application of factor analysis. The main volatile compounds that showed the highest absolute correlation (factors) were the amyl and isobutyl alcohols (having both absolute correlation value of 0.916 and contribution 46.036% to the total variance) and 1-propanol (absolute correlation value of 0.890 and contribution 27.662% to the total variance). These principal components explained 73.698% of the total variance, considered as a satisfactory rate (Figure S4).



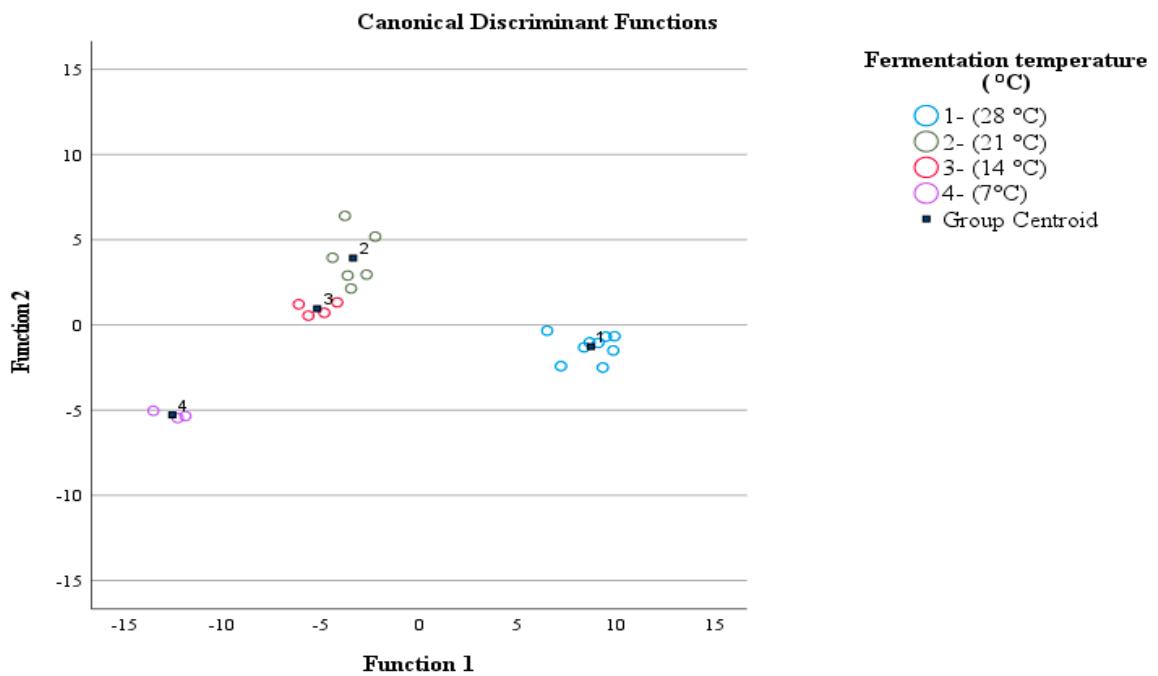
**Figure S4.** Volatile compounds correlated with the fermentation temperature in batches 1-27 as principal components during factor analysis.

For the fermentation batches 1-22 (Table 4.), ANOVA showed that statistically significant differences existed on the content (mg/L) of methanol ( $F=5.734, p=0.006$ ), ethyl acetate ( $F=133.498, p<0.001$ ), propanol ( $F=37.050, p<0.001$ ), isobutyl alcohol ( $F=93.083, p<0.001$ ), and amyl alcohol ( $F=82.136, p<0.001$ ) with respect to fermentation temperature. Acetaldehyde content showed no significant differences ( $F=1.578, p=0.229$ ).

The results of LDA showed that three significant discriminant functions were formed: Wilks' Lambda=0.000 ( $X^2=122.732, df=18, p<0.001$ ) for the first; Wilks' Lambda=0.035 ( $X^2= 53.647, df=10, p<0.001$ ) for the second; and Wilks' Lambda=0.413 ( $X^2= 14.168, df=4, p=0.007$ ) for the third. The first discriminant function accounted for 85.8% of total variance and had the highest eigenvalue (74.026) and canonical correlation (0.993). The second discriminant function had a lower eigenvalue (10.792) and canonical correlation (0.957), while accounted for 12.5% of total variance. Finally, the third discriminant function had the lowest eigenvalue (1.424) and canonical correlation (0.766), while accounted for 1.7% of total variance. All discriminant functions accounted for 100% of total variance.

In Figure S5, it is shown a satisfactory separation. The classification rate was 100% using the original and 90.9% using the cross-validation method. The group centroid values were: (8.724, -1.276), (-3.358, 3.922), (-5.180, 0.950), and (-12.550, -5.283) for the fermentation temperature of 28, 21, 14, and 7 °C, respectively.

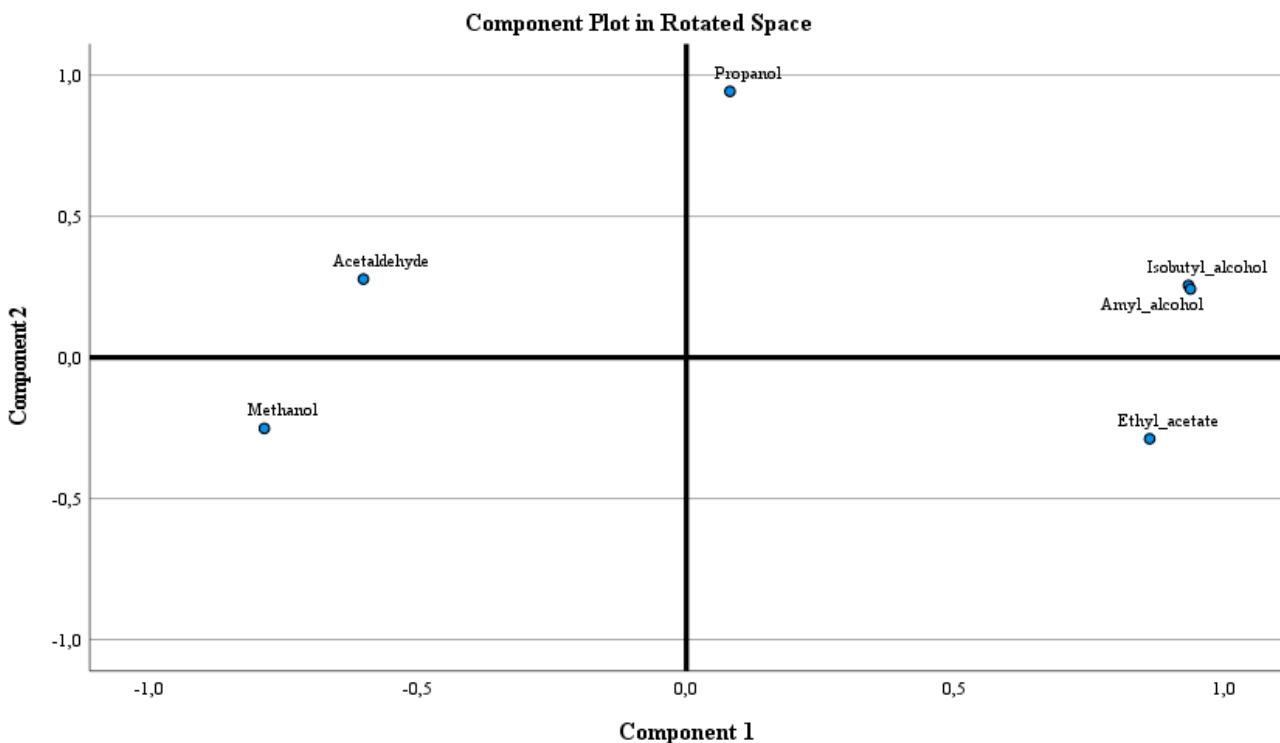
The volatile compounds that contributed most to the discrimination of the fermentation temperature in batches 1-22, were ethyl acetate with an absolute correlation value of 0.537 in the first discriminant function; propanol with an absolute correlation value of 0.729 in the second discriminant function; and isobutyl alcohol with an absolute correlation value of 0.283 in the third discriminant function.



**Figure S5.** Classification of fermentation temperature (batches 1-22) based on volatile compounds and LDA.

### Factor analysis

The Keiser-Meyer-Olkin (KMO) index in this case was 0.678, while Bartlett's Test of Sphericity index had the values  $X^2 = 98.337$ ,  $df = 15$ ,  $p < 0.001$ . The main volatile compounds that showed the highest absolute correlation (factors) were amyl alcohol (absolute correlation value of 0.939 and contribution 58.076% to the total variance) and propanol (absolute correlation value of 0.943 and contribution 20.601% to the total variance). The two principal components explained 78.677% of the total variance, considered as a very satisfactory rate (Figure S6).



**Figure S6.** Volatile compounds correlated with the fermentation temperature in batches 1-22 as principal components during factor analysis.

#### Polyphenolic content and antioxidant activity (EC<sub>50</sub>)

The polyphenolic content and EC<sub>50</sub> values varied significantly during the fermentation using immobilized and free cells with respect to the fermentation temperature (Table 6). For the polyphenolic content, ANOVA showed significant differences in each case ( $F=20.335, p<0.001$  and  $F=10.461, p=0.001$ , respectively). Similarly, for the EC<sub>50</sub> values the respective ANOVA results were  $F=15,243.327, p<0.001$ , and  $F=26,347.877, p<0.001$ .

#### Volatile acidity

The volatile acidity during the fermentation using immobilized cells varied significantly only for the fermentation carried out  $> 30$  days, with respect to the fermentation temperature (Table 7). The ANOVA results in this case were  $F=20.464$  and  $p<0.001$ . On the other hand, the volatile acidity during the fermentation using free cells varied significantly for the fermentation carried out  $> 30$

and >90 days (Table 7). The ANOVA results in these cases were  $F=8.882$ ,  $p=0.002$  and  $F=25.528$ ,  $p<0.001$ , respectively.

To investigate if any statistical differences occur between the paired samples of volatile acidity on day 0, > 30 days, and > 90 days using immobilized and free cells, paired-samples t-test was applied. Significant differences in this case were observed for the pair: i) >30 days immobilized- >30 days free cells ( $t=-20.185$ ,  $df=16$ ,  $p<0.001$ ) and ii) >90 days immobilized - >90 days free cells ( $t=-7.062$ ,  $df=16$ ,  $p<0.001$ ).

**Table S1.** Kinetic parameters of must repeated fermentation batches (12.5 °Be) using free cells at 28, 21, 14 and 7 °C.

Fermentation temperature (°C)	Fermentation batch	Fermentation time (h)	Ethanol (%v/v)	Ethanol productivity (g/L/d)	Residual sugar (g/L)	Sugar conversion (%)
28	1	112	11.85	20.03	23	89.24
	2	119	11.93	18.98	20.4	90.45
	3	126	11.61	17.45	33.2	84.46
	4	120	12.32	19.44	16.9	92.10
	5	125	11.74	17.78	24.9	88.35
	6	129	11.7	17.17	26.4	87.65
	7	128	12.2	18.05	17.1	92.00
	8	129	11.86	17.41	22.2	89.61
	9	132	11.78	16.90	24.3	88.63
Mean and Std. Deviation	1~9	124.4±6.3a	11.89±0.23e	18.14±1.10g	23.2±5.0k	89.16±2.34m
21	10	271	11.3	7.90	22.3	89.56
	11	269	10.94	7.70	29.4	86.24
	12	282	11.73	7.88	19.3	90.97
	13	298	10.28	6.53	29.5	86.19
	14	301	11.23	7.06	26.6	87.55
	15	297	11.02	7.03	28.7	86.57

<b>Mean and Std. Deviation</b>	10~15	286.3±14.3b	11.08±0.48f	7.35±0.56h	26.0±4.2k	87.85±1.99m
14	16	599	11.22	3.55	25.6	88.02
	17	605	10.99	3.44	26.0	87.83
	18	614	10.6	3.27	28.9	86.48
	19	628	10.72	3.23	29.1	86.38
<b>Mean and Std. Deviation</b>	16~19	611.5±12.6c	10.88±0.28f	3.37±0.15i	27.4±1.9k	87.18±0.87m
7	20	3557	10.52	0.56	38.9	81.80
	21	3591	10.91	0.58	40.1	81.23
	22	3653	10.67	0.55	41.7	80.49
<b>Mean and Std. Deviation</b>	20~22	3600.3±48.7d	10.70±0.20f	0.56±0.01j	40.2±1.4l	81.17±0.66n

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S2.** Kinetic parameters of must repeated fermentation batches (12.5 °Be) using immobilized biocatalyst at 28, 21, 14 and 7 °C.

Fermentation temperature (°C)	Fermentation batch	Fermentation time (h)	Ethanol (%v/v)	Ethanol productivity (g/L/d)	Residual sugar (g/L)	Sugar conversion (%)
28	1	77	12.21	30.03	11.8	94.48
	2	75	12.12	30.60	11.8	94.48
	3	81	12.15	28.40	11.7	94.52
	4	85	12.31	27.42	9.4	95.60
	5	83	12.24	27.92	10.8	94.95
	6	84	12.47	28.11	8.9	95.84
	7	81	11.89	27.80	12.1	94.34
	8	83	11.30	25.78	15.5	92.75
	9	81	11.71	27.38	13.9	93.50
	10	79	11.44	27.42	14.0	93.45
<b>Mean and Std. Deviation</b>	1~10	80.9±3.14a	11.98±0.39e	28.09±1.37f	12.0±2.1j	94.39±0.96l

21	11	162	11.35	13.27	20.5	90.41
	12	159	12.32	14.67	17.9	91.62
	13	154	11.75	14.45	18.8	91.20
	14	157	11.36	13.70	21.7	89.85
	15	149	12.37	15.72	16.0	92.51
	16	148	11.88	15.20	18.2	91.48
	17	149	10.98	13.95	22.0	89.70
<b>Mean and Std. Deviation</b>	11~17	154±5.54b	11.72±0.5 2e	14.42±0.86g	19.3±2.2k	90.97±1.03m
14	18	365	11.23	5.83	21.9	89.75
	19	347	11.57	6.32	19.8	90.73
	20	349	11.51	6.25	20.4	90.45
	21	388	11.79	5.75	21.3	90.03
	22	373	11.82	6.00	22.4	89.52
	23	352	11.91	6.41	18.1	91.53
<b>Mean and Std. Deviation</b>	18~23	362.3±16.12c	11.64±0.2 5e	6.09±0.27h	20.7±1.6k	90.34±0.74m
7	24	1643	11.38	1.31	21.5	89.94
	25	1789	11.61	1.23	22.1	89.66
	26	1862	11.45	1.16	22.8	89.33
	27	1883	11.59	1.17	29.1	86.38
<b>Mean and Std. Deviation</b>	24~27	1794.3±108.6d	11.51±0.1 1e	1.22±0.07i	23.9±3.5k	88.83±1.65m n

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S3.** Major volatile by-products of must repeated fermentation batches (12.5 °Be) using immobilized biocatalyst at 28, 21, 14 and 7 °C.

Fermentation temperature (°C)	Fermentation batch	Methanol (mg/L)	Acetaldehyde (mg/L)	Ethyl acetate (mg/L)	1-propanol (mg/L)	Isobutyl alcohol (mg/L)	Amyl alcohol (mg/L)
28°C	1	89.94	91.55	20.17	32.07	81.18	102.52
	2	92.54	97.38	20.7	31.44	74.13	91.05
	3	92.46	92.24	26.69	30.69	70.32	89.24
	4	131.66	99.98	25.61	32.77	79.17	102.29
	5	97.54	96.12	22.39	41.74	70.38	96.60
	6	135.72	98.46	24.01	39.35	66.37	105.34

	7	91.22	94.57	27.37	39.03	76.33	103.65
	8	90.79	85.88	23.17	31.39	66.49	106.04
	9	86.98	86.73	26.76	35.46	75.39	93.36
	10	105.09	98.24	20.67	42.11	71.34	100.63
<b>Mean and Std. Deviation</b>	1~10	101.39±17.75a	94.12±4.92c	23.75±2.75e	35.60±4.54i	73.11±5.011	99.07±6.08o
<b>21°C</b>	11	118.41	97.72	54.55	43.93	79.61	82.25
	12	152.12	97.46	43.23	53.08	68.90	63.76
	13	90.88	83.36	49.69	40.85	73.88	84.43
	14	101.69	91.28	52.97	32.63	62.10	61.53
	15	132.45	74.49	56.91	47.10	61.68	74.94
	16	129.44	90.65	53.32	35.23	59.91	79.61
	17	112.78	92.83	55.52	29.81	73.32	59.92
<b>Mean and Std. Deviation</b>	11~17	119.68±20.46a	89.68±8.26c	52.31±4.61f	40.38±8.34i	68.49±7.49l	72.35±1.040p
<b>14</b>	18	151.24	87.81	70.28	57.64	39.74	69.34
	19	127.29	102.25	68.49	49.24	42.27	80.41
	20	139.87	95.09	58.19	53.67	51.84	51.79
	21	112.54	109.76	62.6	55.79	52.49	49.31
	22	101.52	91.87	68.27	60.12	40.48	62.95
	23	95.75	105.21	72.46	54.38	37.57	71.57
<b>Mean and Std. Deviation</b>	18~23	121.37±21.90a	98.67±8.43c	66.72±5.31g	55.14±3.72j	44.07±6.46m	64.23±1.201p
<b>7</b>	24	121.37	101.42	35.81	20.49	12.76	31.14
	25	136.98	103.37	36.27	20.01	10.87	29.36
	26	147.54	99.78	35.97	21.00	14.21	29.55
	27	151.93	113.92	39.33	17.32	10.18	29.94
<b>Mean and Std. Deviation</b>	24~27	139.46±13.59ab	104.62±6.37cd	36.85±1.67h	19.71±1.64k	12.01±1.83n	30.00±0.80q

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S4.** Major volatile by-products of must repeated fermentation batches (12.5 °Be) using free cells at 28, 21, 14 and 7 °C.

Fermentation temperature (°C)	Fermentation batch	Methanol (mg/L)	Acetaldehyde (mg/L)	Ethyl acetate (mg/L)	1-propanol (mg/L)	Isobutyl alcohol (mg/L)	Amyl alcohol (mg/L)
<b>28</b>	1	83.80	98.21	59.02	22.95	87.61	119.82
	2	72.45	105.78	65.57	24.36	91.18	121.96
	3	139.42	89.99	59.84	23.09	88.28	99.63
	4	78.94	94.32	68.10	22.99	96.26	108.21
	5	138.95	109.51	68.90	26.21	91.32	104.14
	6	129.72	95.14	61.79	30.54	88.91	103.30

	7	140.58	90.41	74.41	31.70	97.58	105.06
	8	109.88	93.57	74.09	31.18	96.86	99.87
	9	115.54	103.69	78.00	29.07	98.34	100.96
<b>Mean and Std. Deviation</b>	1~9	112.14±27.56a	97.85±6.97c	67.75±6.80d	26.90±3.74g	92.93±4.32j	107.00±8.34n
<b>21</b>	10	180.96	112.35	28.6	36.49	71.51	88.43
	11	109.86	105.98	32.38	37.92	73.42	87.17
	12	122.13	91.24	27.98	44.84	94.94	102.49
	13	100.21	94.54	23.33	37.20	76.97	98.09
	14	114.82	111.82	26.95	41.42	76.24	90.67
	15	97.09	110.91	22.60	45.83	91.63	103.59
<b>Mean and Std. Deviation</b>	10~15	120.84±30.86a	104.47±9.31c	26.97±3.61e	40.62±4.04h	80.79±9.93k	95.07±7.25o
<b>14</b>	16	137.08	91.34	39.26	41.49	63.36	79.00
	17	145.29	118.65	35.94	36.57	49.03	69.39
	18	141.72	103.85	32.27	39.21	52.74	74.18
	19	151.31	107.12	31.45	35.54	67.28	71.44
<b>Mean and Std. Deviation</b>	16~19	143.85±6.00ab	105.24±11.23c	34.73±3.60e	38.20±2.68h	58.10±8.62l	73.50±4.16p
<b>7</b>	20	174.82	112.34	8.24	20.04	21.21	31.28
	21	181.19	108.01	9.53	17.38	18.46	39.33
	22	172.38	102.67	11.28	19.11	17.67	37.99
<b>Mean and Std. Deviation</b>	20~22	176.13±4.55b	107.67±4.84c	9.68±1.53f	18.84±1.35i	19.11±1.86m	36.2±4.31q

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S7.** Polyphenolic content of wines produced from must (12.5 °Be) using immobilized and free cells at 28, 21, 14 and 7 °C.

Fermentation temperature (°C)	Fermentation using immobilized cells		Fermentation using free cells	
	Fermentation batch	Polyphenolic content (mg GAE/L)	Fermentation batch	Polyphenolic content (mg GAE/L)
<b>28</b>	1	391.6	1	279.9
	3	358.8	3	327.9
	5	363.5	5	263.5

	7	414.8	7	317
	9	357.1	8	325.2
<b>Mean and Std. Deviation</b>	-----	377.2±25.3a	-----	302.7±29.2A
<b>21</b>	10	404.4	9	263.4
	12	381	10	259.6
	14	388.8	11	279.9
	16	412.2	13	231.8
	17	377.2	15	295.5
<b>Mean and Std. Deviation</b>	-----	392.7±15.1a	-----	266.1±23.9A
<b>14</b>	19	323.6	16	250
	20	312.8	17	236.6
	21	320.9	18	232.8
	23	339.9	19	252.2
<b>Mean and Std. Deviation</b>	-----	324.3±11.4b	-----	242.9±9.7AB
<b>7</b>	25	288.8	20	214.3
	26	309.9	21	228.8
	27	317.7	22	222.1
<b>Mean and Std. Deviation</b>	-----	305.4±15b	-----	221.7±7.2AB

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S8.** Antioxidant activity of wines produced from must (12.5 °Be) using immobilized and free cells at 28, 21, 14 and 7 °C.

Fermentation temperarute (°C)	Fermentation using immobilized cells		Fermentation using free cells	
	Fermentation batch	EC <sub>50</sub> (mL wine/g DPPH <sup>·</sup> )	Fermentation batch	EC <sub>50</sub> (mL wine/g DPPH <sup>·</sup> )
<b>28</b>	1	544.3	1	700.2
	3	544	3	701
	5	545.1	5	701.5
	7	543.5	7	698.7
	9	544	8	701.1
<b>Mean and Std. Deviation</b>	-----	544.2±0.6a	-----	700.5±1.1A
<b>21</b>	10	538.1	9	761.3
	12	537.7	10	760.6
	14	537.1	11	760.1
	16	536.8	13	760.9
	17	539.5	15	761.9
<b>Mean and Std. Deviation</b>	-----	537.8±1.1b	-----	761±0.7B
<b>14</b>	19	597.39	16	918.3

	20	596.51	17	918
	21	597.64	18	915.1
	23	598.46	19	922.3
<b>Mean and Std. Deviation</b>	-----	597.5±0.8c	-----	918.4±3C
	25	653.9	20	989.2
7	26	653.6	21	989.7
	27	655.2	22	991.2
<b>Mean and Std. Deviation</b>	-----	654.2±0.8d	-----	990.1±1D

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S9.** Total acidity of wines produced from must (12.5 °Be) using immobilized and free cells at 28, 21, 14 and 7 °C and analyzed after storage at 22-28 °C and 4 °C of their production.

-----		Fermentation using immobilized cells			Fermentation using free cells			
Fermentation temperature (°C)	Fermentation batch	Total acidity (g tartaric acid / L)			Fermentation batch	Total acidity (g tartaric acid / L)		
		0 days	>30 days (22-28 °C)	>90 days (4 °C)		0 days	>30 days (22-28 °C)	>90 days (4 °C)
28	1	5.4	5.3	5.1	1	5.6	5.3	5.0
	3	5.9	5.7	5.2	3	5.4	5.1	4.9
	5	5.9	5.6	5.2	5	5.0	4.7	4.4
	7	6.1	5.9	5.7	7	5.4	5.1	4.7
	9	6.5	6.2	5.9	8	5.3	5.2	4.8
<b>Mean and Std. Deviation</b>	-----	6.0±0 .4a	5.7±0.3c	5.4±0 .4e	-----	5.3±0 .2a	5.1±0.2c	4.8±0. 2d
21	10	5.4	5.2	4.9	9	5.1	4.9	4.5
	12	5.9	5.7	5.2	10	5.4	5.2	4.9
	14	5.5	5.4	5.1	11	5.3	5.1	4.8
	16	4.6	4.5	4.1	13	5.0	4.7	4.1
	17	5.0	4.9	4.4	15	5.5	5.3	4.9
<b>Mean and Std. Deviation</b>	-----	5.3±0 .5a	5.1±0.5c	4.7±0 .5e	-----	5.3±0 .2a	5.0±0.2c	4.6±0. 3d
14	19	4.3	4.3	4.0	16	5.6	5.7	5.0
	20	5.5	5.4	4.9	17	5.8	5.5	5.1
	21	5.6	5.5	5.0	18	4.4	4.2	4.2
	23	4.5	4.5	4.1	19	4.9	4.5	4.3
<b>Mean and Std. Deviation</b>	-----	5.0±0 .7ab	4.9±0.6c	4.5±0 .5ef	-----	5.2 ±0.6a	5.0±0.7c	4.7±0. 5d
7	25	4.5	4.4	4.4	20	4.6	4.5	4.4
	26	4.9	4.7	4.6	21	4.5	4.4	4.3

	27	5.0	4.9	4.8	22	4.5	4.4	4.3
<b>Mean and Std. Deviation</b>	-----	4.8±0 .3ab	4.7±0.3d	4.6±0 .2ef	-----	4.5±0 .1ab	4.4±0.1c	4.3±0. 1d

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

**Table S10.** Volatile acidity of wines produced from must (12.5 °Be) using immobilized and free cells at 28, 21, 14 and 7 °C and analyzed after storage at 22-28 °C and 4 °C of their production.

-----		Fermentation using immobilized cells				Fermentation using free cells			
Fermentation temperature (°C)	-----	Volatile acidity (g acetic acid / L)			-----	Volatile acidity (g acetic acid / L)			-----
		Fermentation batch	0 days	>30 days (22-28 °C)		Fermentation batch	0 days	>30 days (22-28 °C)	
28	1	0.26	0.31	0.28	1	0.27	1.52	0.32	-----
	3	0.34	0.39	0.35	3	0.34	1.61	0.38	-----
	5	0.26	0.32	0.27	5	0.32	1.69	0.34	-----
	7	0.30	0.35	0.31	7	0.26	1.82	0.32	-----
	9	0.32	0.37	0.34	8	0.34	1.93	0.39	-----
<b>Mean and Std. Deviation</b>	-----	0.30±0. 04a	0.35±0.03b	0.31± 0.04d	-----	0.31±0. 04a	1.71±0.1 6b	0.35±0 .03d	-----
21	10	0.25	0.31	0.30	9	0.32	1.79	0.41	-----
	12	0.31	0.39	0.33	10	0.27	1.64	0.34	-----
	14	0.29	0.38	0.32	11	0.31	1.81	0.41	-----
	16	0.30	0.39	0.32	13	0.28	1.93	0.42	-----
	17	0.28	0.36	0.33	15	0.29	1.82	0.44	-----
<b>Mean and Std. Deviation</b>	-----	0.29±0. 02a	0.37±0.03b	0.32± 0.01d	-----	0.29±0. 02a	1.80±0.1 0b	0.40±0 .04d	-----
14	19	0.32	0.42	0.34	16	0.28	1.92	0.45	-----
	20	0.27	0.40	0.33	17	0.29	1.68	0.47	-----
	21	0.30	0.45	0.33	18	0.31	2.11	0.47	-----
	23	0.28	0.38	0.32	19	0.34	2.33	0.49	-----
<b>Mean and Std. Deviation</b>	-----	0.29±0. 02a	0.41±0.03b	0.33± 0.01d	-----	0.31±0. 03a	2.01±0.2 8b	0.47±0 .02e	-----
7	25	0.29	0.52	0.34	20	0.28	2.87	0.52	-----
	26	0.25	0.50	0.35	21	0.31	2.09	0.55	-----
	27	0.26	0.51	0.38	22	0.27	2.65	0.51	-----
<b>Mean and Std. Deviation</b>	-----	0.27±0. 02a	0.51±0.01c	0.36± 0.02d	-----	0.29±0. 02a	2.54±0.4 0c	0.53±0 .02f	-----

Different letters in each column indicate statistically significant differences at the confidence level p<0.05.

## Volatile compounds of *P. terebinthus* resin

As shown in Table S11 the detected volatile compounds of the resin by HS-SPME GS-MS were mainly terpenes and increasing the concentration of methanol as extracting medium the number of volatile compounds was increased. Specifically, 97, 86, 75, 71 and 51 volatile compounds were detected using 20, 15, 10, 5, and 0% methanolic solution respectively (Table S12). Totally 92 terpenes were detected from the extraction of *P. terebinthus* in the 5 extracting media. Among these 22, 29, 28 and 13 were monoterpenes, monoterpenoids, sesquiterpenes and sesquiterpenoids correspondingly. More precisely  $\alpha$ - and  $\beta$ -pinene, p-cymene,  $\alpha$ - and  $\beta$ -thujene, 1,8-cineole, terpinolene, p-1,3,8-menthatriene,  $\alpha$ -campholenal, linalool, isopinocamphone, 4-terpineol, myrtenal, L-trans-pinocarveol,  $\alpha$ -phellandren-8-ol,  $\alpha$ -terpineol, verbenone, myrtenol, trans-carveol, p-cymen-8-ol, cis-carveol, p-cresol, 14-hydroxy-9-epi- $\beta$ -caryophyllene, and spathulenol were extracted by all extracting media. Caputo et al. 1974 studied about triterpene components of galls on the leaves of *P. terebinthus* produced by *Pemphigus utricularius* (3).

**Table S11.** Volatile compounds extracted from *Pistacia terebinthus* resin in methanolic solutions (20, 15, 10, 5 and 0%).

No	Compound	R.I	R.I.B	20%	15%	10%	5%	0%	Identification method
				v/v MeOH	v/v MeOH	v/v MeOH	v/v MeOH	v/v MeOH	
1	Tricyclene	976	1001	+	+	+	-	-	b
2	$\alpha$ -Pinene	999	1017	+	+	+	+	+	b
3	$\alpha$ -Thujene	1012	1022	+	+	+	+	+	b
4	Toluene	1015	1043	+	+	+	+	+	b
5	Z- $\beta$ -Ocimene	1019	1035	+	+	-	-	-	b
6	Camphene	1033	1056	+	+	+	+	-	b
7	$\beta$ -Pinene	1085	1100	+	+	+	+	+	b
8	Sabinene	1106	1117	+	+	+	+	-	b
9	$\delta$ -2-Carene	1108	-	+	-	-	-	-	c
10	$\beta$ -Thujene	1119	1131	+	+	+	+	+	b

11	Phellandrene	1135	1159	+	+	+	+	+	-	b	
	ne										
12	$\delta$ -3-Carene	1139	1141	+	+	+	+	+	-	b	
13	$\beta$ -Myrcene	1141	1172	+	+	+	+	+	-	b	
14	$\alpha$ -Terpinene	1149	1177	+	-	-	-	-	-	b	
15	Limonene	1167	1200	+	+	+	+	+	-	b	
16	$\beta$ -Phellandrene	1176	1204	+	+	+	+	+	-	b	
	2,6-Dimethyl-										
17	1,3,5,7-Octatetraen	1188	e	-	+	+	+	+	+	c	
18	1,8-Cineole	1205	1208	+	+	+	+	+	+	b	
19	p-Cymene	1246	1275	+	+	+	+	+	+	b	
20	Terpinolene	1252	1283	+	+	+	+	+	+	b	
21	o-Cymene	1270	1291	+	+	+	+	+	-	b	
22	2-Heptenal	1293	1319	+	+	+	+	+	+	b	
	6-Methyl-5-										
23	Hepten-2-One	1305	1319	+	+	+	+	+	+	b	
24	1-Hexanol	1332	1354	+	+	+	+	+	+	b	
	p-1,3,8-										
25	Menthatriene	1346	ne	-	+	+	+	+	+	c	
26	$\alpha$ -Methylanisole	1369	1393	+	+	+	+	+	-	b	
27	$\alpha$ -Santalene	1409	1418	+	-	-	-	-	-	b	
28	$\gamma$ -Elemene	1425	1441	+	+	+	+	-	-	b	
29	Dehydro-p-Cymene	1442	1432	+	+	+	+	+	+	b	
30	$\alpha$ -Cubebene	1444	1446	+	+	+	+	+	-	b	
	3-										
31	Cyclohexene-1-Carboxaldehyde	1452	e-1-	-	+	+	+	+	+	c	
32	Linalool Oxide	1464	1460	-	-	+	+	+	+	b	
33	$\alpha$ -Copaene	1467	1470	+	+	+	+	+	-	b	
34	Germacrene A	1483	1496	+	+	+	+	+	-	b	
	$\alpha$ -Campholenal	1485	1482	+	+	+	+	+	+	b	

36	$\beta$ -Bourbonene	1488	1397	+	+	+	+	+	-	b
37	$\alpha$ -Cubebene	1490	1446	+	+	+	-	-	-	b
38	$\beta$ -Cubebene	1492	1518	+	+	-	-	-	-	b
39	Pinocamphone	1495	-	-	-	+	+	+	c	
40	$\gamma$ -Cadinene	1520	1520	+	-	-	-	-	-	b
41	Pinocarvone	1521	1561	+	+	+	+	+	+	b
42	Linalool	1536	1552	+	+	+	+	+	+	b
43	Bornyl Acetate	1545	1565	+	+	+	+	+	+	b
44	$\beta$ -Elemene	1548	1557	+	+	+	+	+	-	b
45	$\beta$ -Caryophyllene	1550	1571	+	+	+	+	+	-	b
46	6-Methyl-3,5-Heptadiene-2-one	1552	-	-	-	-	+	+	c	
47	Cedrene	1553	1545	+	+	-	-	-	-	b
48	$\beta$ -Selinene	1554	1507	+	+	-	-	-	-	b
49	Isopinocamphone	1557	1562	+	+	+	+	+	+	b
50	4-Terpineol	1562	1593	+	+	+	+	+	+	b
51	Aromadendrene	1563	-	+	+	+	-	-	-	c
52	$\gamma$ -Gurjunene	1577	-	+	+	-	-	-	-	c
53	Myrtenal	1588	1602	+	+	+	+	+	+	b
54	$\gamma$ -Muurolene	1595	-	+	+	+	-	-	-	c
55	Longipinenene	1602	-	+	+	-	-	-	-	c
56	L-trans-Pinocarveol	1618	1632	+	+	+	+	+	+	b
57	$\epsilon$ -Muurolene	1621	-	+	+	-	-	-	-	c
58	$\alpha$ -Phellandren-8-ol	1626	1710	+	+	+	+	+	+	b
59	$\alpha$ -Caryophyllene	1629	1657	+	-	-	-	-	-	b
60	Pinocarvyl Acetate	1631	1661	-	-	-	+	+	+	b
61	cis-Verbenol	1642	-	+	+	+	+	+	+	c

62	$\beta$ -Farnesene	1650	1654	+	+	-	-	-	b
	2-								
63	Isopropenyl-1-5-methyl-4-hexenal	1653	-	+	+	-	-	-	c
64	$\alpha$ -Terpineol	1665	1669	+	+	+	+	+	b
65	Borneol	1668	1677	+	-	+	+	+	b
66	Germacrene D	1677	1733	+	+	+	+	-	b
67	trans-Verbenol	1679	1679	-	-	-	+	+	b
68	$\alpha$ -Muurolene	1697	1738	+	+	-	-	-	b
69	Verbenone	1705	1695	+	+	+	+	+	b
70	Carvone	1707	1711	-	-	+	+	+	b
	exo-2-								
71	Hydroxycineol	1719	1723	+	+	+	+	+	b
72	Citral	1739	1741	-	-	+	+	+	b
73	$\delta$ -Cadinene	1750	1743	+	+	+	-	-	b
74	p-Methyl-Acetophenone	1754	1763	+	+	+	+	+	b
75	Bicyclogermacrene	1756	1755	+	+	+	+	-	b
76	$\alpha$ -Cadinene	1772	1767	+	+	-	-	-	b
77	Myrtenol	1777	1788	+	+	+	+	+	b
78	trans,trans-2,4-Decadienal	1786	1780	+	+	+	+	-	b
79	Germacrene B	1789	1800	+	+	-	-	-	b
80	trans-Carveol	1812	1825	+	+	+	+	+	b
81	Calamenene e	1816	1799	+	+	-	-	-	b
82	p-cymen-8-ol	1828	1833	+	+	+	+	+	b
83	cis-Carveol	1845	1848	+	+	+	+	+	b
84	$\alpha$ -Calacorene	1907	1893	+	+	-	-	-	b
85	Isogeraniol	1919	-	+	+	+	+	-	c
86	Caryophyllene Oxide	1981	1953	+	+	+	+	+	b
87	p-menth-3-en-9-ol	2009	-	+	+	+	+	+	c
88	3,3'-Bicyclohexenyl	2015	-	+	-	-	-	-	c
89	Ledol	2020	2057	+	+	-	-	-	b

90	Isohujol	2024	-	+	-	-	-	-	-	c
			17-							
91	Octadecen-14-yn-1-ol	2033	-	+	+	+	+	+	+	c
92	Germacrene D-4-ol	2043	-	+	+	+	+	+	+	c
93	1-epi-Cubenol	2057	2088	+	+	-	-	-	-	b
94	Humulane-1,6-dien-3-ol	2060	-	+	+	+	-	-	-	c
95	p-Cresol	2071	2076	+	+	+	+	+	+	b
96	14-Hydroxy-9-epi- $\beta$ -Caryophyllene	2101	-	+	+	+	+	+	+	c
97	Spathuleno-1	2103	2104	+	+	+	+	+	+	b
98	Longipinanol	2119	-	+	+	+	+	+	+	c
	Aromaden									
99	drrene Oxide	2140	-	+	+	+	+	+	-	c
100	Cedrane	2152	-	+	-	-	-	-	-	c
101	$\delta$ -Cadinol	2171	2169	+	-	-	-	-	-	b
102	$\alpha$ -Cadinol	2237	2232	+	-	-	-	-	-	b
103	14-Hydroxy- $\alpha$ -Muurolene	2286	-	+	+	+	+	+	+	c
104	6-isopropeny-1-4, $\alpha$ -dimethyl-1,2,3,5,6,7,8, $\alpha$ -octahydro-naphthalen-2-ol	2354	-	+	+	+	+	+	+	c

a: Positive identification from mass spectra data and retention time of standard compounds.

b: Identification from retention time and mass spectra from bibliography.

c: Mass spectrum with degree of uncertainty.

+: Detected compound.

-: Non detected compound.

R.I: Kovats Index.

R.I.B: Kovats Index from bibliography.

**Table S12.** Number of volatile compounds extracted from *Pistacia terebinthus* resin in methanolic solutions (20, 15, 10, 5 and 0%).

Compound	20% v/v MeOH	15% v/v MeOH	10% v/v MeOH	5% v/v MeOH	0% v/v MeOH	Total
Monoterpenes	22	19	18	17	9	22
Monoterpenoids	22	20	25	28	27	29
Sesquiterpenes	28	25	13	8	-	28
Sesquiterpenoids	13	11	9	8	7	13
Other compounds	12	11	10	10	8	12
Total compounds	97	86	75	71	51	104

## References

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