Supplementary Information

A1- Preparation of Beer´s Wort

A pilot brew (10 L) of an India Pale Ale (IPA) base recipe, was produced in a 65L MK3 Mega brewing system (HopCat, United Kingdom). All-malt wort was brewed using 2.67 kg of Pale Ale malt and 220 g of Munich Light malt, following a two-step infusion process: 60 min at 68 °C (saccharification rest), and 10 min at 77 °C (mash-out rest). Wort was boiled for 15 min, to ensure microbiological stability, reaching a final original gravity of 1.056 and stored in 50 mL falcon tubes, at 5 °C in the fridge, prior to hop boiling.

A2 - Plant Material

For this study, Simcoe® Brand YCR14 hop pellets (Yakima Chief Hops, USA), a well-known bittering hop variety, known by its high content in alpha-acids, was used. 100 ± 10 mg of hop pellet were weighed for addition to the beginning of the boiling stage of each treatment.

	Principle	**Advantages**	**Disadvantages**
Fire Heating	Open flame or gas burner heat the kettle through combustion	Fast heating; Ease-of-use, Low installation investments	Low efficiency; Safety risks; Wort scorching; Inaccurate control
Steam Heating	Steam heats the wort through a jacketed kettle or internal coils	Efficient; Precise temperature control; Uniform heating	Costly equipment; High energy input; High boiler maintenance
Electrical Heating	Immersed resistances heat the wort via electrical conversion	Efficient; Precise temperature control; Easily automated	Costly equipment; High energy input; Power supply issues
Ohmic Heating	Electrical current flows across the wort creating internal heat	Efficient; Heats internally; No thermal gradients; Sustainable	Costly equipment; Limited to conductive foods; Fouling issues

Table S1- Comparison of the key heating methods, highlighting their principles, advantages, and potential drawbacks.

Table S2- Values represent mean ± standard deviation (*n=3*) of International Bitterness Units (IBU) values. Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point

	C	**OH5**	**OH11**	**OH26**
0	3.43 ± 0.19 Aa	3.81 ± 0.44 Aa	3.08 ± 0.07 Aa	3.43 ± 0.94 Aa
15	74.28 ± 6.48 Ba	75.52 ± 2.43 Ba	75.78 ± 1.79 Ba	78.27 ± 3.01 Ba
30	74.97 ± 3,00 Ba	81.93± 2.18 Cb	85.33 ± 0.80 Cb	86.50 ± 0.38 Cb
45	81.38 ± 0,22 BCa	86.38 ± 0.72 Cb	89.21 ± 0.79 Cbc	90.78 ± 2.83 Cc
60	91.49 ± 4.98 Ca	95.20 ± 1.62 Da	98.81 ± 3.10 Da	99.61 ± 3.48 Da

of different boiling conditions. These were determined by one-way ANOVA with Tukey's *post hoc* test ($p < 0.05$).

Table S3- Values represent mean ± standard deviation (*n=3*) of polyphenol concentration (mg/L). Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point of different boiling conditions. These were determined by one-way ANOVA with Tukey's *post hoc* test *(p* < 0.05).

	C	**OH5**	**OH11**	**OH26**
0	120.92 ± 13.91 Aa	123.57 ± 7.30 Aa	126.40 ± 3.12 Aa	132.47 ± 6.16 Aa
15	225.38 ± 9.47 Ba	211.52 ± 12.39 Ba	216.07 ± 8.26 Ba	230.39 ± 10.40 Ba
30	226.36 ± 13.72 Ba	202.32 ± 10.60 Ba	217.78 ± 7.38 Ba	202.38 ± 9.35 BCa
45	219.68 ± 12.01 Ba	169.81 ± 16.81 Cb	196.90 ± 5.13 Cab	190.28 ± 14.35 Cab
60	210.11 ± 6.01 Ba	165.97 ± 1.36 Cb	177.09 ± 8.58 Db	175.48 ± 12.66 Cb

Table S4- Values represent mean ± standard deviation (*n=3*) of myrcene concentration, expressed in 4-nonanol equivalents (mg/L). Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point of different boiling conditions. These were determined by one-way ANOVA with Tukey's *post hoc* test (*p* < 0.05).

	C	**OH5**	**OH11**	**OH26**
20	0.07861 ± 0.010187 Aa	0.056625 ± 0.016325 Aa	0.059299 ± 0.018409 Aa	0.061541 ± 0.008215 Aa
40	0 Ba	0 Ba	0 Ba	0 Ba
60	0 Ba	0 Ba	0 Ba	0 Ba

Table S5- Values represent mean ± standard deviation (*n=3*) of linalool concentration, expressed in 4-nonanol equivalents (mg/L). Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point of different boiling conditions. These were determined by one-way ANOVA with Tukey's *post hoc* test (*p* < 0.05).

	C	**OH5**	**OH11**	**OH26**
20	0.03769 ± 0.00499 Aab	0.04254 ± 0.00097 Aa	0.03157 ± 0.00353 Ab	0.03339 ± 0.00141 Aab
40	0.02745 ± 0.00349 ABa	0.02762 ± 0.00293 Ba	0.01575 ± 0.00358 Bb	0.00989 ± 0.00043 Bb
60	0.01778 ± 0.00412 Bab	0.02356 ± 0.00254 Ba	0.00993 ± 0.00470 Bbc	0.00620 ± 0.00239 Bc

Table S6- Values represent mean ± standard deviation (*n=3*) of caryophyllene concentration, expressed in 4-nonanol equivalents (mg/L). Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point of different boiling conditions. These were determined by one-way ANOVA with Tukey's *post hoc* test ($p < 0.05$).

	C	OH5	OH11	OH26
20	0.00792 ± 0.00028 ABa	0.00891 ± 0.00273 ABa	0.00815 ± 0.00003 ABa	0.00896 ± 0.00422 Aa
40	0.00932 ± 0.00165 Aa	0.00550 ± 0.00104 Aa	0.00967 ± 0.00190 Aa	0.00865 ± 0.00404 Aa
60	0.00608 ± 0.00011 Ba	0.01293 ± 0.00147 Ba	0.00609 ± 0.00142 Ba	0.01092 ± 0.00726 Aa

Table S7- Values represent mean ± standard deviation (*n=3*) of humulene concentration, expressed in 4-nonanol equivalents (mg/L). Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point of different boiling conditions. These were determined by one-way ANOVA with *Tukey's post hoc* test ($p < 0.05$).

	C	OH5	OH11	OH26
20	0.01399 ± 0.00030 Aa	0.00690 ± 0.00255 Aa	0.01128 ± 0.00222 Aa	0.01208 ± 0.00575 Aa
40	0.00836 ± 0.00510 Aa	0.00379 ± 0.00077 Aa	0.01014 ± 0.00383 Aa	0.00744 ± 0.00253 Aa
60	0.00541 ± 0.00100 Aa	0.00517 ± 0.00128 Aa	0.00553 ± 0.00080 Aa	0.00453 ± 0.00070 Aa

Table S8- Values represent mean ± standard deviation (*n=3*) of geraniol concentration, expressed in 4-nonanol equivalents (mg/L). Different capital letters indicate statistical difference among different time points of the same boiling condition. Different lowercase letters denote statistical difference among the same time point of different boiling conditions. These were determined by one-way ANOVA with Tukey's *post hoc* test ($p < 0.05$).

	C	OH5	OH11	OH26
20	0.10473 ± 0.00900 Aa	0.11449 ± 0.00291 Aa	0.09907 ± 0.00215 Aa	0.10571 ± 0.05010 Aa
40	0.09036 ± 0.00324 Aa	0.08783 ± 0.00454 Ba	0.07812 ± 0.00862 Bab	0.06618 ± 0.00392 Ab
60	0.06284 ± 0.00784 Bab	0.07872 ± 0.00643 Ba	0.05273 ± 0.00799 Cb	0.04618 ± 0.00303 Ab

Table S9- Composition of clusters resulting from PCA analysis.

Sample	Cluster
OH11_40min	1
OH26_40min	1
OH26_40min	1
OH26_40min	1
OH26_40min	1
C_60min	1
C_60min	1
C_60min	1
OH11_60min	1
OH11_60min	1

OH11_60min	1
OH11_60min	1
OH26_60min	1
OH26_60min	1
OH26_60min	1
OH26_60min	1
OH5_20min	2
OH5_20min	2
OH5_20min	2
OH11_20min	2
OH11_20min	2
OH11_20min	2
OH26_20min	2
C_20min	3
C_20min	3
C_20min	3
C_20min	3
OH5_20min	3
OH11_20min	3
OH26_20min	3
OH26_20min	3
OH26_20min	3
C_40min	4
C_40min	4
C_40min	4
C_40min	4
OH5_40min	4
OH5_40min	4
OH5_40min	4
OH5_40min	4
OH11_40min	4
OH11_40min	4
OH11_40min	4
C_60min	4
OH5_60min	4
OH5_60min	4
OH5_60min	4
OH5_60min	4

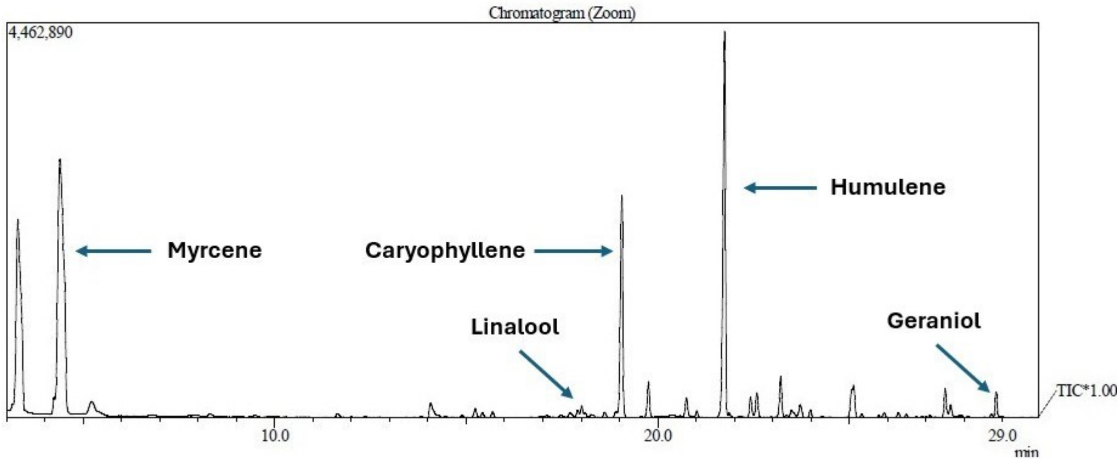

Figure S1- Exemplary chromatogram of an extract containing Simcoe® Brand YCR14 hop pellets (Yakima Chief Hops, USA), with identification of the peaks of the respective essential oils.

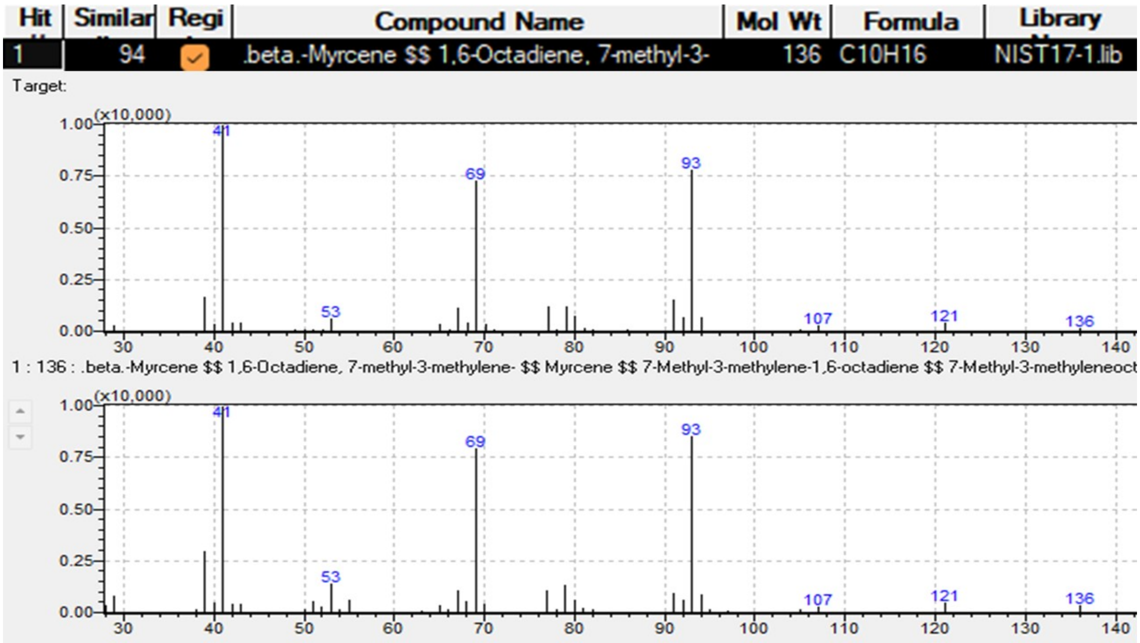

Figure S2- Myrcene identification through mass spectra comparison of identified compounds in the chromatographic analysis with those of reference myrcene available in the National Institute of Standards and Technology (NIST) database**.**

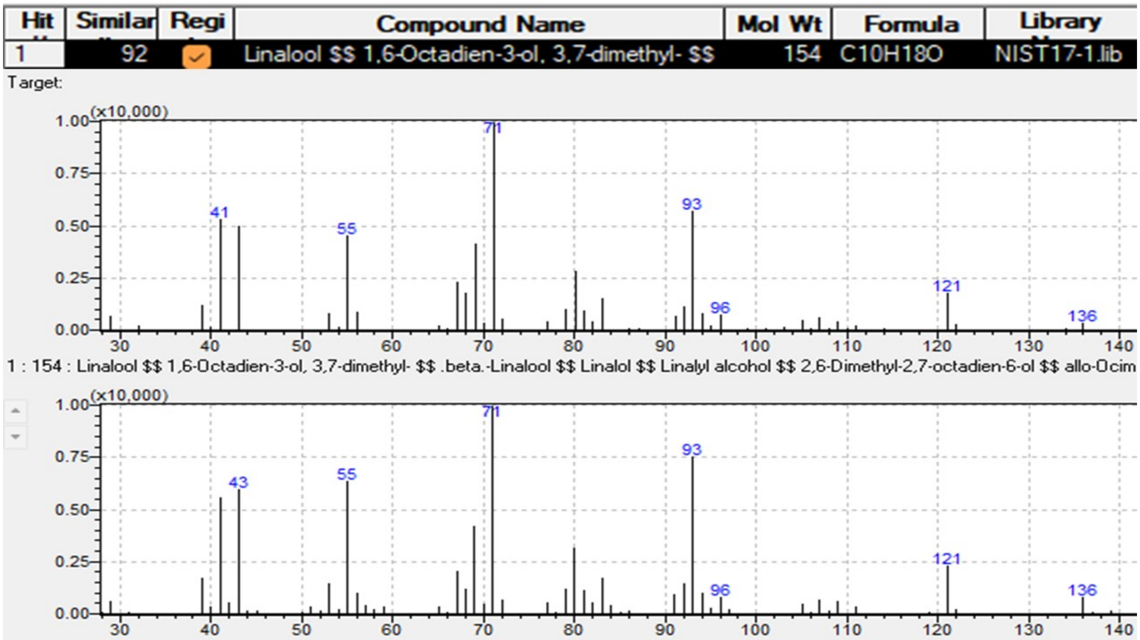

Figure S3- Linalool identification through mass spectra comparison of identified compounds in the chromatographic analysis with those of reference myrcene available in the National Institute of Standards and Technology (NIST) database.

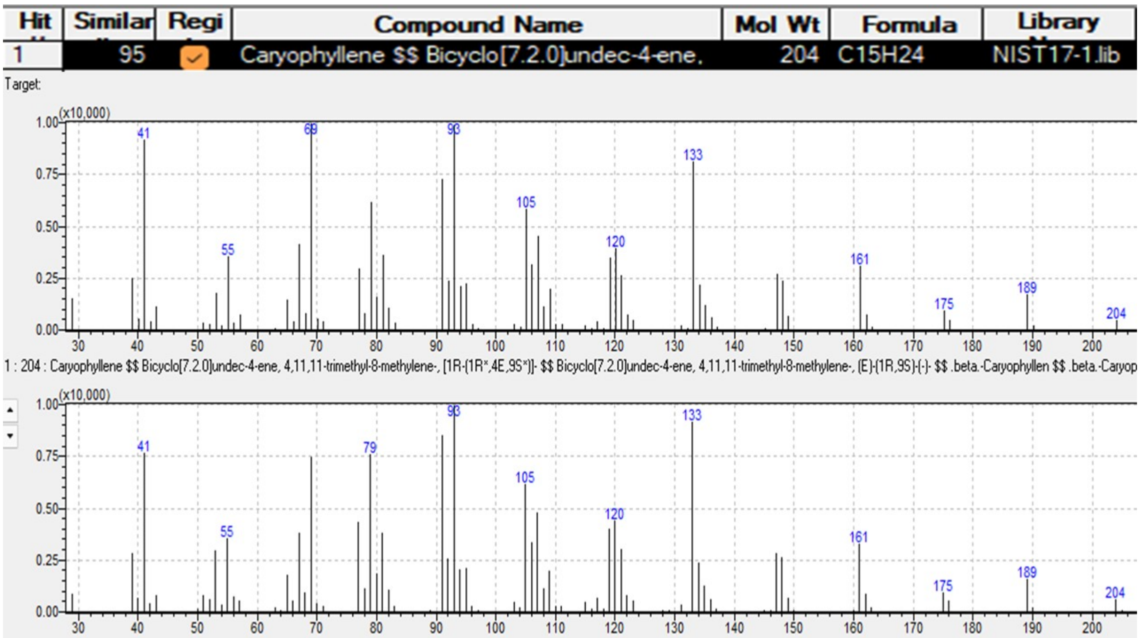

Figure S4- Caryophyllene identification through mass spectra comparison of identified compounds in the chromatographic analysis with those of reference myrcene available in the National Institute of Standards and Technology (NIST) database.

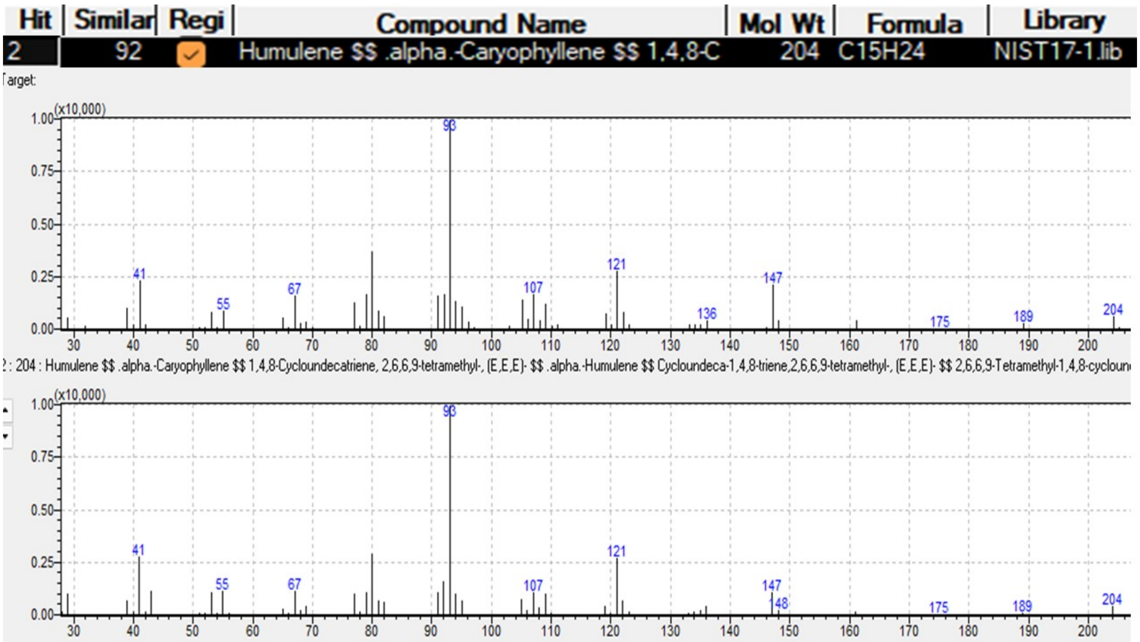

Figure S5- Humulene identification through mass spectra comparison of identified compounds in the chromatographic analysis with those of reference myrcene available in the National Institute of Standards and Technology (NIST) database.

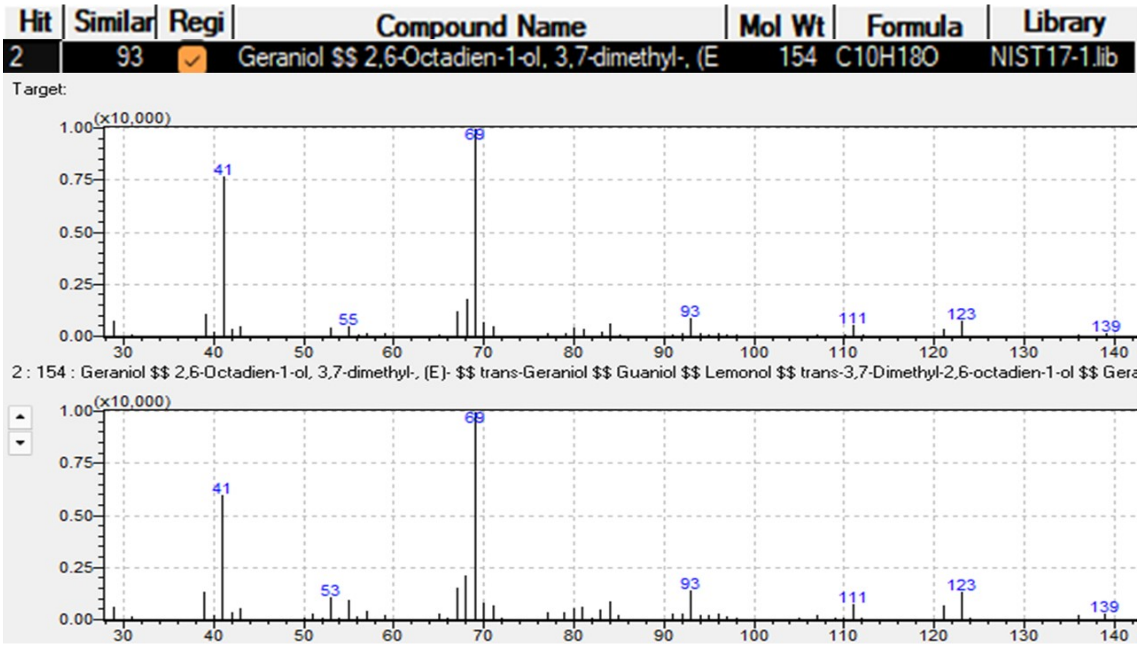

Figure S6- Geraniol identification through mass spectra comparison of identified compounds in the chromatographic analysis with those of reference myrcene available in the National Institute of Standards and Technology (NIST) database.

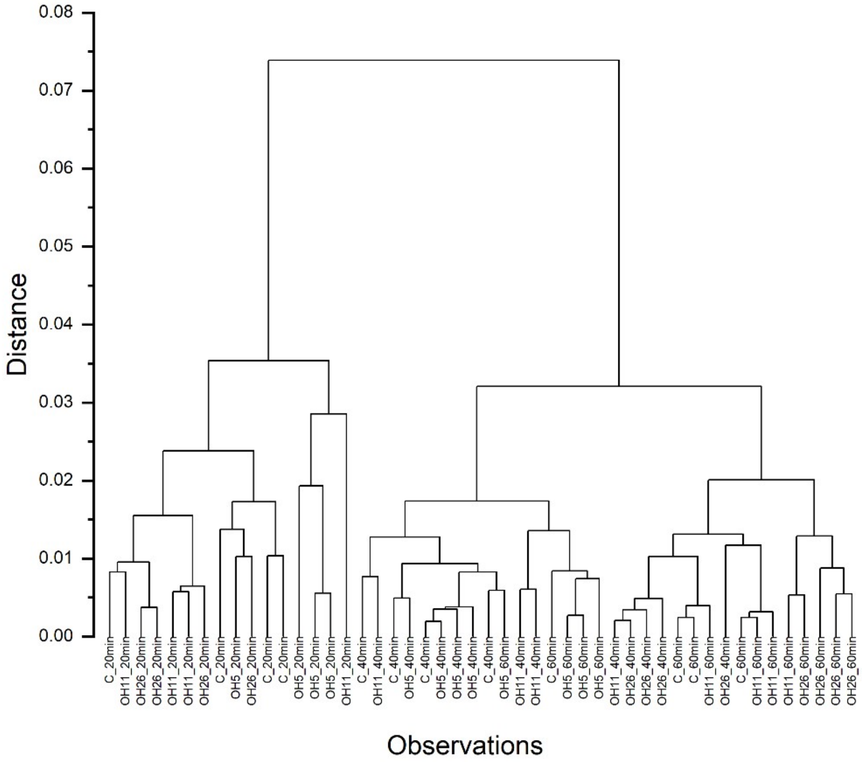

Figure S7- Hierarchical Cluster Analysis (HCA) dendrogram based on the Principal Component Analysis (PCA) of the essential oil composition of hop samples subjected to C, OH5, OH11 and OH26 boiling conditions.