Supplement

Utilization of Industrial *Rosa damascena* Mill. By-products and Cocoa Pod Husks as Natural Preservatives in Muffins

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Table S1 GC-MS analysis of RDCO2 and CPH extracts: aroma substances

Compound	RI	RDCO2	CPH
		% of TIC	
Hexanal	800	-	9.26 ± 0.21
α-Pinene	940	0.80 ± 0.05[a]	7.06 ± 0.33[b]
Benzaldehyde	961	-	1.42 ± 0.08
Sabinene	976	-	7.12 ± 0.12
β-Pinene	980	0.57 ± 0.06[a]	2.53 ± 0.10[b]
β-Myrcene	991	0.31 ± 0.10	-
3-Octanol	993	-	0.60 ± 0.06
2-Octanol	998	-	0.34 ± 0.08
α-Phellandrene	1005	-	7.40 ± 0.15
o-Cymene	1022	-	2.85 ± 0.13
Limonene	1029	-	1.50 ± 0.10
β-Phellandrene	1031	-	5.32 ± 0.18
γ-Terpinene	1062	0.83 ± 0.08	-
Terpinolene	1087	0.62 ± 0.11	-
β-Linalool	1097	2.47 ± 0.10[a]	3.25 ± 0.21[b]
Phenethyl alcohol	1110	17.22 ± 0.16	-
cis-Rose oxide	1112	0.40 ± 0.07	-
trans-Rose oxide	1127	0.23±0.04	-
Terpin-4-ol	1178	1.24 ± 0.10	-
β-Citronellol	1228	6.45 ± 0.15	-
Nerol	1230	3.47 ± 0.09	-
Geraniol	1255	2.50 ± 0.12	
Thymol	1289	-	1.62 ± 0.06
Eugenol	1356	0.18 ± 0.04	-
Geranyl acetate	1383	2.60 ± 0.14	-

Compound	RI	RDCO2	CPH
		% of TIC	
Neryl acetate	1365	1.92 ± 0.18	-
Methyl eugenol	1401	0.40 ± 0.04	-
β-Bourbonene	1383	2.90 ± 0.09	-
β-Cubebene	1389	5.41 ± 0.12	-
β-Elemene	1390	0.46 ± 0.06	-
β-Caryophyllene	1419	1.45 ± 0.11[a]	1.25 ± 0.14[a]
α-Humulene (*α*-Caryophyllene)	1454	0.31 ± 0.07	-
Germacrene D	1479	0.36 ± 0.09	-
α-Farnesene	1508	0.52 ± 0.10	-
β-Bisabolene	1510	0.17 ± 0.02	-
trans-Nerolidol	1564	4.39 ± 0.06	-
Spathulenol	1575	1.50 ± 0.14	-
Caryophyllene oxide	1580	0.30 ± 0.07[a]	0.15 ± 0.04[b]
γ-Eudesmol	1631	0.27 ± 0.05	-
β-Eudesmol	1649	0.23 ± 0.06	-
α-Eudesmol	1652	0.81 ± 0.11	-
Farnesol	1714	0.31 ± 0.03	-
n-Nonadecane	1901	16.69 ± 0.16	-
n-Eicosane	2000	0.12 ± 0.04	-
10-Heneicosene	2093	3.51 ± 0.08	-
n-Heneicosane	2100	5.25 ± 0.15	-
n-Docosane	2200	0.68 ± 0.18	-
n-Tricosane	2300	4.09 ± 0.21	-
n-Tetracosane	2400	1.47 ± 0.14	-
n-Pentacosane	2500	1.30 ± 0.10	-
n-Hexacosane	2600	1.30 ± 0.09	-

RDCO2 - waste from CO_2 extracted *Rosa damascena* Mill.
CPH - Cocoa Pod Husks
RI - Relativ Index (Kovats retention index)
% of TIC - percent of Total Ion Current
The results were expressed as mean ±SD (n = 3)
[a, b] - Values with different letters in superscript (a, b) in a column are statistically significant (ANOVA, Tuckey's post hoc test, $p < 0.05$). With the letter a are denoted the highest determined value, and with the letter b – the lowest value. The values denoted with different letters (a, b) are different with level of significance $p < 0.05$, meaning that 95 % of the determined results differ.

Table S2 GC-MS analysis of RDCO2 and CPH extracts: non-volatile substances

Compound	RI	RDCO2	CPH
		% of TIC	
L-Valine	1228	0.67 ± 0.12[a]	1.83 ± 0.14[b]
Glycerol	1266	0.80 ± 0.14[a]	2.91 ± 0.09[b]
L-Leucine	1272	0.44 ± 0.08[a]	2.00 ± 0.10[b]
Phosphoric acid	1278	7.56 ± 0.32	-
L-Isoleucine	1299	0.31 ± 0.04[a]	1.55 ± 0.08[b]
L-Proline	1307	1.74 ± 0.09[a]	2.88 ± 0.15[b]
Succinic acid	1310	5.02 ± 0.11[a]	9.94 ± 0.19[b]
o-Hydroxybenzoic acid	1326	-	7.76 ± 0.12
Fumaric acid	1355	1.11 ± 0.06[a]	5.10 ± 0.10[b]
Serine	1362	0.81 ± 0.10[a]	1.53 ± 0.11[b]
L-Threonine	1390	0.37 ± 0.07[a]	1.19 ± 0.09[b]
L-Homoserine	1446	0.19 ± 0.03	-
Malic acid	1488	8.38 ± 0.15[a]	6.68 ± 0.19[b]
Salycilic acid	1516	0.51 ± 0.10	-

Compound	RI	RDCO2	CPH
		% of TIC	
Pyroglutamic acid	1512	0.63 ± 0.06[a]	8.49 ± 0.08[b]
L-Aspartic acid	1531	0.69 ± 0.09[a]	7.84 ± 0.12[b]
L-Threonic acid	1528	0.33 ± 0.04	-
4-Aminobutyric acid	1542	-	15.43 ± 0.18
p-Hydroxybenzoic acid	1621	-	7.66 ± 0.21
L-Glutamic acid	1629	-	10.41 ± 0.16
L-Phenylalanine	1646	1.17 ± 0.11[a]	6.18 ± 0.19[b]
L-Asparagine	1682	0.11 ± 0.02	-
L-Lysine	1737	0.17 ± 0.05	-
Ribonic acid	1756	0.71 ± 0.09	-
Vanillic acid	1758	0.53 ± 0.10[a]	16.11 ± 0.17[b]
Protocatechuic acid	1813	0.65 ± 0.08[a]	32.51 ± 0.28[b]
Isocitric acid	1839	-	7.22 ± 0.17
Quinic acid	1843	0.34 ± 0.07	-
Fructose isomer	1862	25.06 ± 0.23[a]	7.78 ± 0.34[b]
Fructose isomer	1868	38.55 ± 0.41[a]	4.49 ± 0.47[b]
Fructose isomer	1875	13.04 ± 0.20	-
Galactose isomer	1884	26.37 ± 0.19[a]	6.55 ± 0.29[b]
Syringic acid	1888	8.65 ± 0.11	-
Glucose isomer	1896	90.09 ± 0.28[a]	17.77 ± 0.34[b]
Galactose isomer	1907	14.42 ± 0.21[a]	3.67 ± 0.35[b]
Glucose isomer	1916	12.63 ± 0.19[a]	13.40 ± 0.30[a]
p-Coumaric acid	1920	-	15.91 ± 0.18
Glucitol	1930	64.65 ± 0.24[a]	9.72 ± 0.29[b]
Gallic acid	1968	35.96 ± 0.18	-
Gluconic acid	1991	26.57 ± 0.26	-
Palmitic acid	2039	5.61 ± 0.17[a]	8.46 ± 0.26[b]
Glucaric acid	2013	10.58 ± 0.15[a]	8.75 ± 0.24[b]
Ferulic acid	2069	-	23.16 ± 0.31
Myo-Inositol	2090	19.42 ± 0.20	-
Stearic acid	2132	0.99 ± 0.14[a]	7.43±0.19[b]
Caffeic acid	2140	4.61 ± 0.16[a]	16.32 ± 0.24[b]
Linoleic acid	2209	8.41 ± 0.26	-
Linolenic acid	2217	6.73 ± 0.12	-
Sucrose isomer; α-D-Glc-(1,2)-β-D-Fru	2649	2.17 ± 0.14[a]	39.01 ± 0.31[b]
Sucrose isomer; α-D-Glc-(1,2)-β-D-Fru	2660	4.24 ± 0.10[a]	15.76 ± 0.29[b]
Sucrose isomer; α-D-Glc-(1,2)-β-D-Fru	2674	1.31 ± 0.11	-
Catechin	3222	3.64 ± 0.14[a]	55.38 ± 0.41[b]
Epicatechin	3228	-	45.71 ± 0.21
Stigmasterol	3315	1.91 ± 0.12	-
β-Sitosterol	3355	2.05 ± 0.13	-

RDCO2 - waste from CO_2 extracted *Rosa damascena* Mill.
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RI - Relativ Index (Kovats retention index)
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Table S3 Inhibition of microorganisms' development in presence of extracts of RDCO2 and CPH waste

Microorganism		Control	RDCO2	CPH
Escherichia coli ATCC 25922, 1.0×10^{12} cfu/cm^3	IZ, mm	-	10.0 ± 0.3^a	9.0 ± 0.5^a
	MIC, µg/ml	-	60	600
Proteus vulgaris ATCC 6380, 5.0×10^{11} cfu/cm^3	IZ, mm	-	10.0 ± 0.3^a	9.0 ± 0.0^b
	MIC, µg/ml	-	> 60	600
Pseudomonas aeruginosa NBIMCC 1370, 7.5×10^{11} cfu/cm^3	IZ, mm	-	9.0 ± 0.0^a	10.0 ± 0.2^b
	MIC, µg/ml	-	600	600
Staphylococcus aureus ATCC 25923, 4.0×10^8 cfu/cm^3	IZ, mm	-	11.0 ± 1.0^a	9.0 ± 0.5^b
	MIC, µg/ml	-	< 600	600
Enterococcus faecalis ATCC 19433, 8.0×10^{11} cfu/cm^3	IZ, mm	-	10.5 ± 0.5^a	10.0 ± 0.7^a
	MIC, µg/ml	-	60	600
Listeria monocytogenes ATCC 19111, 4.9×10^9 cfu/cm^3	IZ, mm	-	17.0 ± 1.0^a	10.0 ± 0.2^b
	MIC, µg/ml	-	60	600
Salmonella abony NTCC 6017, 2.0×10^8 cfu/cm^3	IZ, mm	-	10.0 ± 0.2^a	9.0 ± 0.5^a
	MIC, µg/ml	-	600	600
Candida albicans NBIMCC 74, 2.0×10^{10} cfu/cm^3	IZ, mm	-	9.5 ± 0.5^a	9.0 ± 0.0^a
	MIC, µg/ml	-	600	600
Candida utilis ATCC 42402, 4.6×10^8 cfu/cm^3	IZ, mm	-	13.5 ± 0.2^a	10.0 ± 0.2^b
	MIC, µg/ml	-	< 600	600
Aspergillus niger ATCC 1015, 1.4×10^7 cfu/cm^3	IZ, mm	-	10.0 ± 0.0^a	9.5 ± 0.5^a
	MIC, µg/ml	-	600	600
Penicillium chrysogenum ATCC 28089, 1.5×10^7 cfu/cm^3	IZ, mm	-	9.5 ± 0.5^a	9.5 ± 0.5^a
	MIC, µg/ml	-	600	600
Bacillus subtilis ATCC 19659, 1.0×10^9 cfu/cm^3	IZ, mm	-	10.5 ± 0.5^a	11.0 ± 0.0^a
	MIC, µg/ml	-	60	60
Fusarium moniliforme ATCC 38932, 1.0×10^7 cfu/cm^3	IZ, mm	-	10.0 ± 0.0^a	11.0 ± 0.2^b
	MIC, µg/ml	-	600	< 600
Rhizopus arrhizus ATCC 11145, 4.0×10^6 cfu/cm^3	IZ, mm		9.5 ± 0.5^a	9.5 ± 0.5^a
	MIC, µg/ml		600	600

RDCO2 - waste from CO_2 extracted *Rosa damascena* Mill.
CPH - Cocoa Pod Husks
IZ - Inhibition Zone
MIC - Minimal Inhibition Concentration
cfu - colony forming units
The results were averaged of 4 repetitions ±SD
$^{a, b}$ - Values with different letters in superscript (a, b) in a column are statistically significant (ANOVA, Tuckey's post hoc test, $p < 0.05$). With the letter a are denoted the highest determined value, and with the letter b – the lowest value. The values denoted with different letters (a, b) are different with level of significance $p < 0.05$, meaning that 95 % of the determined results differ.

Table S4 Shear stress range (D); yield stress (τ_0), consistency index (k), flow index (n) and coefficient of determination (R^2) of muffin batters

Sample	D, s^{-1}	τ_0, Pa	k, Pa · s^n	n	R^2, %
C1	0.17 ÷ 3.4	5.45 ± 0.11^a	68.53 ± 0.26^a	0.49 ± 0.08	99.8
C2	0.17 ÷ 3.4	3.26 ± 0.08^b	46.21 ± 0.33^b	0.43 ± 0.07	99.9
V1	0.17 ÷ 3.4	3.23 ± 0.10^b	44.31 ± 0.35^b	0.44 ± 0.06	99.9
V2	0.17 ÷ 3.4	6.39 ± 0.11^c	51.43 ± 0.29^c	0.45 ± 0.09	99.9
V3	0.17 ÷ 3.4	7.18 ± 0.12^d	50.75 ± 0.28^c	0.51 ± 0.08	99.8

The results were expressed as mean ±SD ($n = 3$)
$^{a, b, c, d}$ - Values with different letters in superscript (a, b, c, d) in a column are statistically significant (ANOVA, Tuckey's post hoc test, $p < 0.05$). With the letter a are denoted the highest determined value, and with the letter d – the lowest value; the others denotes values in between a and d. The values denoted with different letters (a, b, c, d) are different with level of significance $p < 0.05$, meaning that 95 % of the determined results differ.

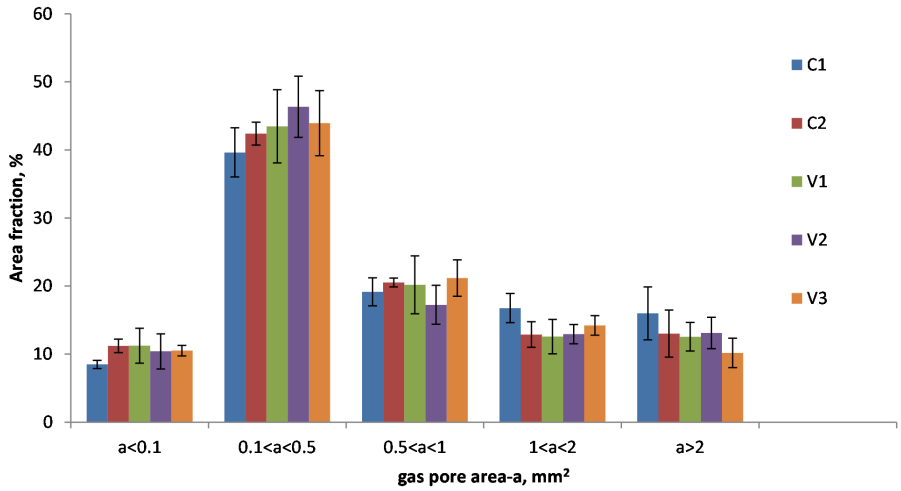

Fig. S1 Image analysis of muffins: gas pore area distribution pattern