

Supplementary Materials

Calculation of RA sweetness:

Step 1: The main components contributing to sweetness of RA were determined. The results are shown in Table S1.

Table S1. Qualitative and quantitative analysis of sweetness of RA.

No.	Glc (µg/g)	Fru (µg/g)	Ino (µg/g)	Sor (µg/g)	Dul (µg/g)	Suc (mg/g)	Betaine (mg/g)
	R.S. = 0.75	R.S. = 1.7	R.S. = 0.5	R.S. = 0.55	R.S. = 0.3	R.S. = 1.0	R.S. = 0.5
1	0.773 ± 0.122	2.98 ± 0.027	12.348 ± 3.983	6.116 ± 1.658	7.46 ± 0.245	11.204 ± 1.991	2.55 ± 0.333
2	1.955 ± 0.104	ND	9.408 ± 5.759	0.636 ± 0.74	3.602 ± 0.12	14.02 ± 1.292	2.03 ± 0.663
3	1.659 ± 0.116	0.98 ± 0.028	46.573 ± 0.998	3.344 ± 0.24	6.937 ± 0.077	11.012 ± 1.216	3.793 ± 0.183
4	0.994 ± 0.342	0.102 ± 0.013	10.096 ± 4.724	2.414 ± 1.514	3.512 ± 0.247	14.001 ± 1.179	3.587 ± 0.628
5	0.248 ± 0.016	0.102 ± 0.039	3.363 ± 5.144	2.346 ± 1.433	4.092 ± 0.553	14.173 ± 0.582	2.32 ± 0.447
6	0.181 ± 0.335	0.143 ± 0.044	4.117 ± 4.45	0.25 ± 0.26	2.456 ± 0.051	12.174 ± 0.582	2.556 ± 0.447
7	0.804 ± 0.122	0.454 ± 0.028	1.529 ± 0.793	1.309 ± 0.085	1.8 ± 0.022	11.066 ± 1.143	3.681 ± 0.887
8	1.218 ± 0.116	0.758 ± 0.038	21.162 ± 5.281	0.853 ± 0.789	1.837 ± 0.21	12.071 ± 0.997	1.325 ± 0.036
9	0.803 ± 0.335	0.312 ± 0.011	40.371 ± 5.894	8.564 ± 1.309	10.275 ± 0.804	11.105 ± 1.329	2.15 ± 0.552
10	1.326 ± 0.122	0.146 ± 0.028	14.793 ± 6.628	1.792 ± 0.25	4.265 ± 0.181	13.512 ± 0.699	2.105 ± 0.567
11	0.553 ± 0.317	0.469 ± 0.02	26.217 ± 3.306	4.491 ± 3.344	2.261 ± 1.346	13.099 ± 1.487	1.621 ± 1.142
12	0.656 ± 0.204	0.091 ± 0.032	19.734 ± 2.269	3.281 ± 5.354	3.326 ± 1.514	14.158 ± 2.013	0.826 ± 3.271
13	0.901 ± 0.104	0.057 ± 0.002	27.976 ± 3.191	0.74 ± 1.219	4.731 ± 2.101	12.438 ± 0.787	2.611 ± 0.333
14	0.865 ± 0.301	0.026 ± 0.016	20.616 ± 3.433	5.039 ± 3.444	3.305 ± 0.789	14.426 ± 1.195	0.958 ± 1.017
15	1.509 ± 0.282	0.752 ± 0.05	28.492 ± 2.237	7.421 ± 2.288	10.553 ± 1.325	12.113 ± 1.137	1.783 ± 0.003
16	1.521 ± 0.162	0.768 ± 0.011	6.943 ± 1.778	1.128 ± 0.467	5.556 ± 0.097	10.03 ± 1.44	2.07 ± 0.001
17	1.05 ± 0.158	0.314 ± 0.006	16.253 ± 5.264	4.418 ± 0.26	19.868 ± 2.661	12.328 ± 0.877	3.816 ± 0.183
18	0.116 ± 0.077	0.023 ± 0.014	10.994 ± 1.532	4.418 ± 0.976	0.538 ± 0.093	9.953 ± 0.546	2.035 ± 0.149
19	1.473 ± 0.122	0.058 ± 0.016	25.802 ± 7.318	3.29 ± 1.8	2.542 ± 0.252	13.733 ± 0.997	4.385 ± 0.257
20	0.116 ± 0.097	0.056 ± 0.048	1.16 ± 3.199	1.433 ± 0.467	0.447 ± 0.248	12.178 ± 1.366	3.211 ± 0.22
21	2.101 ± 0.238	0.338 ± 0.017	39.393 ± 1.176	1.219 ± 0.24	6.982 ± 1.05	10.027 ± 0.847	1.974 ± 0.22
22	0.144 ± 0.051	0.803 ± 0.015	2.869 ± 0.842	5.199 ± 3.326	1.035 ± 0.689	14.155 ± 0.847	2.574 ± 0.11
23	2.792 ± 0.22	ND	37.028 ± 8.412	2.954 ± 0.465	6.599 ± 0.558	9.43 ± 1.29	2.724 ± 0.776
24	0.523 ± 0.236	0.226 ± 0.015	4.031 ± 1.544	3.29 ± 1.128	12.071 ± 1.521	12.013 ± 0.699	2.037 ± 0.567
25	0.6 ± 0.225	0.203 ± 0.049	6.786 ± 5.031	2.264 ± 4.93	4.785 ± 4.705	17.654 ± 0.732	0.621 ± 2.605
26	0.245 ± 0.171	0.076 ± 0.05	3.59 ± 4.174	1.658 ± 3.937	4.564 ± 4.69	16.157 ± 0.381	2.342 ± 0.957
27	2.177 ± 0.059	1.161 ± 0.014	46.315 ± 4.524	3.933 ± 9.077	34.564 ± 3.767	17.589 ± 0.44	1.567 ± 0.123
28	0.44 ± 0.116	0.102 ± 0.011	10.813 ± 6.618	1.271 ± 2.004	11.16 ± 7.236	15.761 ± 0.319	2.115 ± 1.436

Table S1. Cont.

No.	Glc (µg/g) R.S. = 0.75	Fru (µg/g) R.S. = 1.7	Ino (µg/g) R.S. = 0.5	Sor (µg/g) R.S. = 0.55	Dul (µg/g) R.S. = 0.3	Suc (mg/g) R.S. = 1.0	Betaine (mg/g) R.S. = 0.5
29	1.689 ± 0.263	0.242 ± 0.017	12.596 ± 4.884	3.326 ± 0.338	6.54 ± 1.933	16.354 ± 0.177	1.163 ± 1.406
30	0.558 ± 0.274	0.248 ± 0.011	10.331 ± 4.1	2.177 ± 3.933	8.541 ± 0.465	15.104 ± 0.991	2.354 ± 0.782
31	0.531 ± 0.089	0.152 ± 0.043	7.864 ± 3.937	6.543 ± 2.668	16.553 ± 0.976	15.096 ± 1.108	4.276 ± 0.477
32	2.589 ± 0.176	0.129 ± 0.023	67.166 ± 4.44	3.71 ± 1.856	7.931 ± 1.595	18.529 ± 0.44	0.831 ± 0.087
33	1.325 ± 0.031	0.698 ± 0.041	35.997 ± 5.407	26.217 ± 2.414	18.562 ± 0.994	16.619 ± 0.732	2.29 ± 0.093
34	4.69 ± 0.216	ND	32.051 ± 4.796	3.937 ± 6.116	28.616 ± 0.773	17.83 ± 1.491	0.946 ± 0.027
35	2.661 ± 0.065	0.357 ± 0.039	66.47 ± 5.989	5.199 ± 2.264	16.924 ± 0.6	16.235 ± 0.761	0.913 ± 0.423
36	4.705 ± 0.059	0.203 ± 0.044	45.472 ± 5.213	4.93 ± 1.8	67.719 ± 1.473	18.681 ± 0.79	2.553 ± 0.512
37	5.039 ± 0.278	1.758 ± 0.014	87.085 ± 4.088	21.162 ± 1.792	36.454 ± 1.326	18.727 ± 0.761	1.688 ± 1.412
38	7.236 ± 0.086	1.855 ± 0.036	86.481 ± 5.309	8.004 ± 2.954	52.532 ± 2.792	19.189 ± 0.148	1.26 ± 0.063
39	3.281 ± 0.462	1.668 ± 0.044	46.249 ± 3.8	5.354 ± 3.71	35.124 ± 2.589	18.075 ± 0.644	0.667 ± 0.363
40	4.491 ± 0.912	0.679 ± 0.032	111.769 ± 5.358	20.616 ± 3.344	18.102 ± 1.659	16.241 ± 0.936	2.066 ± 0.423
41	6.543 ± 0.316	3.009 ± 0.028	70.262 ± 4.619	19.734 ± 1.559	35.369 ± 2.103	17.79 ± 2.192	1.976 ± 0.093
42	0.517 ± 0.082	ND	22.774 ± 4.917	4.256 ± 1.421	14.91 ± 1.509	16.151 ± 0.732	2.099 ± 0.602
43	3.767 ± 0.766	2.514 ± 0.045	90.073 ± 4.299	9.077 ± 2.955	58.83 ± 3.708	16.777 ± 0.381	2.401 ± 0.213
44	1.933 ± 0.038	1.323 ± 0.032	33.567 ± 4.331	27.976 ± 0.636	42.429 ± 1.955	17.837 ± 0.703	1.694 ± 0.363
45	3.708 ± 0.036	1.131 ± 0.036	74.842 ± 5.629	2.955 ± 1.271	5.346 ± 0.44	16.201 ± 0.261	2.963 ± 0.777
46	2.103 ± 0.125	0.6 ± 0.04	37.598 ± 7.342	11.559 ± 4.256	36.658 ± 0.517	17.76 ± 1.17	0.659 ± 0.063
47	1.595 ± 0.569	0.308 ± 0.029	15.739 ± 5.054	1.856 ± 8.564	8.999 ± 0.803	16.446 ± 1.75	2.311 ± 0.542
48	1.925 ± 0.034	0.159 ± 0.013	7.596 ± 0.134	1.68 ± 0.096	5.264 ± 0.234	13.57 ± 0.017	4.179 ± 0.099

ND means 'not detected'.

Step 2: The equation used to calculate the integrated sweetness of the seven components is indicated below:

$$S_{(i)} = SUM (T_i * c_i)$$

where T_i indicates relative sweetness of the components with the sweetness of 10% sucrose defined as 1.0, and c_i represents the content of other sweet components in RA.

Thus, the formula of integrated RA sweetness was obtained as follows:

$$S_{(i)} = 0.75 * c_{Glc} + 1.7 * c_{Fru} + 0.5 * c_{Ino} + 0.55 * c_{Sor} + 0.3 * c_{Dul} + 1 * c_{Suc} + 0.5 * c_{betaine}$$

Analytical procedure for comprehensive quality evaluation of RA samples:

Step 1: The original experimental data, including the contents of calycosin-glycoside, astragaloside IV, polysaccharides, and extracts in RA samples, were calculated.

Table S2. Raw data on the contents of calycosin-glycoside, astragaloside IV, polysaccharides, and extracts in RA samples (Mean $\pm$ SD).

No.	Calycosin-glycoside (mg/g)	Astragaloside IV (mg/g)	Polysaccharides (g/g)	Extracts (g/g)
1	0.76 $\pm$ 0.006	0.23 $\pm$ 0.034	0.043 $\pm$ 0.001	0.24 $\pm$ 0.012
2	0.89 $\pm$ 0.023	0.77 $\pm$ 0.01	0.102 $\pm$ 0.01	0.425 $\pm$ 0.035
3	1.2 $\pm$ 0.009	1.23 $\pm$ 0.023	0.171 $\pm$ 0.002	0.357 $\pm$ 0.017
4	0.67 $\pm$ 0.017	0.34 $\pm$ 0.025	0.131 $\pm$ 0.02	0.321 $\pm$ 0.021
5	0.53 $\pm$ 0.02	0.68 $\pm$ 0.039	0.104 $\pm$ 0.006	0.357 $\pm$ 0.009
6	0.32 $\pm$ 0.011	0.89 $\pm$ 0.014	0.047 $\pm$ 0	0.314 $\pm$ 0.011
7	0.53 $\pm$ 0.009	0.7 $\pm$ 0.024	0.114 $\pm$ 0.004	0.389 $\pm$ 0.019
8	0.37 $\pm$ 0.034	0.69 $\pm$ 0.003	0.056 $\pm$ 0.002	0.363 $\pm$ 0.006
9	1.55 $\pm$ 0.187	0.93 $\pm$ 0.024	0.095 $\pm$ 0.004	0.338 $\pm$ 0.013
10	0.7 $\pm$ 0.13	1.15 $\pm$ 0.043	0.072 $\pm$ 0.005	0.285 $\pm$ 0.011
11	0.56 $\pm$ 0.011	0.7 $\pm$ 0.027	0.072 $\pm$ 0.004	0.303 $\pm$ 0.001
12	0.58 $\pm$ 0.008	1.04 $\pm$ 0.034	0.111 $\pm$ 0.001	0.293 $\pm$ 0.009
13	0.73 $\pm$ 0.265	0.85 $\pm$ 0.02	0.084 $\pm$ 0.007	0.253 $\pm$ 0.025
14	0.81 $\pm$ 0.057	0.63 $\pm$ 0.013	0.133 $\pm$ 0.012	0.286 $\pm$ 0.016
15	1.03 $\pm$ 0.112	1.18 $\pm$ 0.028	0.101 $\pm$ 0.003	0.316 $\pm$ 0.021
16	1.3 $\pm$ 0.131	0.69 $\pm$ 0.079	0.122 $\pm$ 0.007	0.335 $\pm$ 0.02
17	0.51 $\pm$ 0.1	1.5 $\pm$ 0.019	0.102 $\pm$ 0.004	0.329 $\pm$ 0.006
18	0.63 $\pm$ 0.137	0.61 $\pm$ 0.014	0.073 $\pm$ 0.005	0.374 $\pm$ 0.008
19	0.31 $\pm$ 0.253	1.16 $\pm$ 0.002	0.094 $\pm$ 0.001	0.32 $\pm$ 0.006
20	0.77 $\pm$ 0.034	0.89 $\pm$ 0.042	0.102 $\pm$ 0.008	0.322 $\pm$ 0.011
21	0.63 $\pm$ 0.022	1.3 $\pm$ 0.002	0.104 $\pm$ 0.001	0.231 $\pm$ 0.003
22	0.59 $\pm$ 0.035	0.88 $\pm$ 0.097	0.102 $\pm$ 0.005	0.378 $\pm$ 0.004
23	0.46 $\pm$ 0.071	1.42 $\pm$ 0.013	0.144 $\pm$ 0.013	0.216 $\pm$ 0.008
24	0.28 $\pm$ 0.092	2.13 $\pm$ 0.011	0.146 $\pm$ 0.006	0.297 $\pm$ 0.014
25	1.22 $\pm$ 0.074	0.17 $\pm$ 0.058	0.134 $\pm$ 0.009	0.263 $\pm$ 0.018
26	1.1 $\pm$ 0.008	0.72 $\pm$ 0.185	0.142 $\pm$ 0.018	0.267 $\pm$ 0.008
27	1.12 $\pm$ 0.033	1.08 $\pm$ 0.055	0.075 $\pm$ 0.011	0.191 $\pm$ 0.012
28	0.86 $\pm$ 0.003	0.56 $\pm$ 0.023	0.143 $\pm$ 0.019	0.171 $\pm$ 0.02
29	1.03 $\pm$ 0.221	0.57 $\pm$ 0.031	0.053 $\pm$ 0.001	0.267 $\pm$ 0.015
30	0.37 $\pm$ 0.002	0.69 $\pm$ 0.034	0.056 $\pm$ 0.002	0.333 $\pm$ 0.022
31	1.55 $\pm$ 0.026	0.97 $\pm$ 0.047	0.095 $\pm$ 0.003	0.338 $\pm$ 0.016
32	1.3 $\pm$ 0.008	1.2 $\pm$ 0.063	0.189 $\pm$ 0.007	0.328 $\pm$ 0.011
33	1.1 $\pm$ 0.194	1.11 $\pm$ 0.051	0.116 $\pm$ 0.006	0.32 $\pm$ 0.023
34	1.21 $\pm$ 0.031	1.16 $\pm$ 0.048	0.102 $\pm$ 0.005	0.331 $\pm$ 0.037

Table S2. Cont.

No.	Calycosin-glycoside (mg/g)	Astragaloside IV (mg/g)	Polysaccharides (g/g)	Extracts (g/g)
35	1.37 ± 0.004	1.06 ± 0.042	0.1 ± 0.001	0.323 ± 0.005
36	1.48 ± 0.065	1.03 ± 0.021	0.101 ± 0.005	0.348 ± 0.013
37	1.23 ± 0.01	1.18 ± 0.064	0.172 ± 0.002	0.327 ± 0.028
38	1.24 ± 0.167	1.21 ± 0.053	0.107 ± 0.01	0.321 ± 0.01
39	1.23 ± 0.177	1.51 ± 0.066	0.128 ± 0.023	0.322 ± 0.016
40	1.02 ± 0.053	1.06 ± 0.004	0.101 ± 0.019	0.313 ± 0.039
41	1.72 ± 0.011	1.07 ± 0.026	0.134 ± 0.006	0.332 ± 0.025
42	0.88 ± 0.023	0.78 ± 0.003	0.074 ± 0.02	0.327 ± 0.123
43	0.37 ± 0.079	1.22 ± 0.042	0.076 ± 0.03	0.339 ± 0.041
44	1.12 ± 0.04	1.01 ± 0.028	0.131 ± 0.003	0.302 ± 0.011
45	1.22 ± 0.003	1.07 ± 0.047	0.106 ± 0.002	0.343 ± 0.02
46	1.19 ± 0.086	1.16 ± 0.053	0.089 ± 0.001	0.328 ± 0.022
47	1.29 ± 0.084	1.18 ± 0.008	0.124 ± 0.005	0.331 ± 0.003
48	1.22 ± 0.09	1.24 ± 0.03	0.092 ± 0.007	0.337 ± 0.011

Step 2: The original experimental data were standardized by SPSS 16.0 for principal component analysis, and the results are shown in Table S3.

Table S3. Standardized information of the data in Table S2.

No.	Calycosin-glycoside	Astragaloside IV	Polysaccharides	Extracts	No.	Calycosin-glycoside	Astragaloside IV	Polysaccharides	Extracts
1	-0.419	-2.129	-1.935	-1.518	20	-0.393	-0.232	-0.109	0.177
2	-0.078	-0.577	-0.109	2.307	21	-0.761	0.946	-0.047	-1.704
3	0.735	0.745	2.027	0.901	22	-0.866	-0.261	-0.109	1.335
4	-0.656	-1.813	0.789	0.157	23	-1.207	1.291	1.191	-2.014
5	-1.023	-0.836	-0.047	0.901	24	-1.679	3.331	1.253	-0.339
6	-1.574	-0.232	-1.811	0.012	25	0.788	-2.301	0.881	-1.042
7	-1.023	-0.778	0.262	1.563	26	0.473	-0.721	1.129	-0.960
8	-1.443	-0.807	-1.533	1.025	27	0.525	0.314	-0.945	-2.531
9	1.654	-0.117	-0.326	0.508	28	-0.157	-1.181	1.160	-2.944
10	-0.577	0.515	-1.037	-0.587	29	0.289	-1.152	-1.625	-0.960
11	-0.944	-0.778	-1.037	-0.215	30	-1.443	-0.807	-1.533	0.405
12	-0.892	0.199	0.170	-0.422	31	1.654	-0.002	-0.326	0.508
13	-0.498	-0.347	-0.666	-1.249	32	0.998	0.658	2.584	0.301
14	-0.288	-0.979	0.850	-0.567	33	0.473	0.400	0.324	0.136
15	0.289	0.601	-0.140	0.053	34	0.762	0.544	-0.109	0.363
16	0.998	-0.807	0.510	0.446	35	1.182	0.256	-0.171	0.198
17	-1.076	1.521	-0.109	0.322	36	1.470	0.170	-0.140	0.715
18	-0.761	-1.037	-1.006	1.252	37	0.814	0.601	2.057	0.281
19	-1.600	0.544	-0.357	0.136	38	0.840	0.687	0.046	0.157

Table S3. Cont.

No. Calycosin-glycoside		Astragaloside IV	Polysaccharides	Extracts	No. Calycosin-glycoside		Astragaloside IV	Polysaccharides	Extracts
39	0.814	1.549	0.696	0.177	44	0.525	0.113	0.789	-0.236
40	0.263	0.256	-0.140	-0.009	45	0.788	0.285	0.015	0.612
41	2.100	0.285	0.881	0.384	46	0.709	0.544	-0.511	0.301
42	-0.104	-0.548	-0.976	0.281	47	0.972	0.601	0.572	0.363
43	-1.443	0.716	-0.914	0.529	48	0.788	0.773	-0.418	0.488

Step 3: Principal component analysis was applied to carry out a dimension reduction process of the standardizing date and the results are shown in Table S4.

Table S4. Eigenvalue, contribution rate, accumulated contribution rate and eigenvector of principle component analysis.

Component	Initial Eigenvalues			Eigenvector			
	Total	% of Variance	Cumulative %	X_1	X_2	X_3	X_4
C_1	1.327	33.165	33.165	0.4566	0.4132	0.5174	0.5938
C_2	1.207	30.187	63.352	0.3486	0.6881	-0.5953	-0.2276
C_3	1.036	25.911	89.263	0.6907	-0.2859	0.3006	-0.5934

C_1 , C_2 , C_3 indicate the principal components 1, 2, and 3, respectively; X_1 , X_2 , X_3 , X_4 indicate calycosin-glycoside, astragaloside IV, polysaccharides, and extracts, respectively.

The linear equations of the three principal components based on the eigenvectors are indicated below:

$$C_1 = 0.4566 X_1 + 0.4132 X_2 + 0.5174 X_3 + 0.5938 X_4$$

$$C_2 = 0.3486 X_1 + 0.6881 X_2 - 0.5953 X_3 - 0.2276 X_4$$

$$C_3 = 0.6907 X_1 - 0.2859 X_2 + 0.3006 X_3 - 0.5934 X_4$$

Step 4: The contribution of each principal component was used to derive the comprehensive evaluation function as described below:

$$\begin{aligned}
 F &= 33.165 C_1 + 30.187 C_2 + 25.911 C_3 \\
 &= 33.165 * (0.4566 X_1 + 0.4132 X_2 + 0.5174 X_3 + 0.5938 X_4) \\
 &\quad + 30.187 * (0.3486 X_1 + 0.6881 X_2 - 0.5953 X_3 - 0.2276 X_4) \\
 &\quad + 25.911 * (0.6907 X_1 - 0.2859 X_2 + 0.3006 X_3 - 0.5934 X_4)
 \end{aligned}$$

The above analysis shows that the design formula for F can be expressed as follows:

$$F = 43.563 X_1 + 27.067 X_2 + 6.978 X_3 - 2.553 X_4$$