

Combined effect of microwave and hydrothermal treatment on anti-nutritional factors, antioxidant potential and bioactive compounds of plum (*Prunus domestica. L.*) kernels

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ABSTRACT

The effect of microwave heating (450 W for 6 min), hydrothermal treatment (45 °C for 6, 9, 12 h) and their combination on antioxidant potential, anti-nutritional factors, and phenolic compounds of plum kernels were studied. Results revealed that amygdalin and hydrocyanic acid content were reduced to undetectable amounts, while the phytic acid and tannins were reduced to 89.50 and 84.71 %, respectively, when combined effects of microwave and hydrothermal (45 °C for 12 h) treatments were employed. Antioxidant activity and phenolic content were higher in microwave treated samples than hydrothermal and combined treatments. HPLC results revealed that combined treated samples have considerable amounts of phenolic compounds, particularly gallic acid, chlorogenic acid, (+)-catechin, syringic acid, rutin, 3,4-dihydroxy benzoic acid, tannic acid, and quercetin, opening up possibilities for its use in food formulations.

INTRODUCTION

- Plum (*Prunus domestica. L.*) kernels are nutritionally rich and inexpensive source of substantial amounts of oils, dietary proteins, carbohydrates, fibers, vitamins, minerals and other bioactive components
- The oil content is about 45.95 %, mainly unsaturated fatty acids, and the protein content is about 35.9 %
- They also contain a naturally aromatic cyanogenic glycosidic compound (amygdalin = 0.1 - 17.5 mg g⁻¹) responsible for the bitterness and cyanide toxicity.
- The paucity of data regarding the impact of microwave heating combined with hydrothermal treatment on anti-nutritional factors, antioxidant activity and polyphenols and of plum kernels stimulated this study

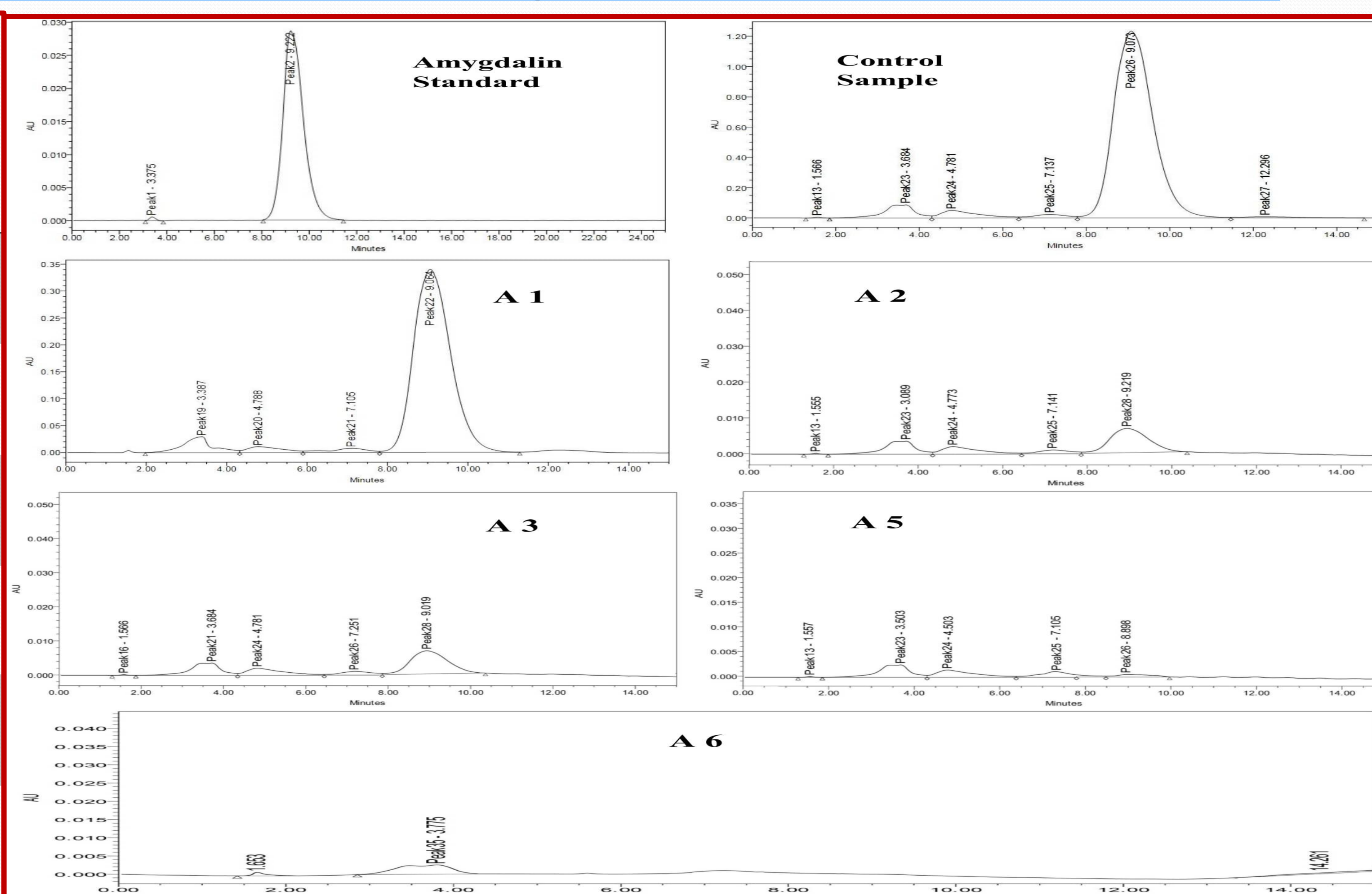
Methodology

- Hydrothermal treatment**
Plum kernels were ground into grits and allowed to soak (1:10 ratio) in distilled water at 45 °C for 6, 9, 10 and 12 hours. Soaked grits were dried in a tray drier at 40 ± 2 °C and ground to a fine powder followed by freezing in air-tight containers till further analysis.
- Microwave heat-treatment**
100 g raw and hydrothermally (6, 9 & 12 h) treated plum kernels was spread on 16 cm petri-plate in a thin layer and positioned on a vorticular platter of the microwave oven and heated at 450 W for 6 min. An untreated sample was used as a control

RESULTS

Table: Anti-nutritional factors and antioxidant potential of the plum kernels treated with microwave, hydrothermal and their combined treatments.

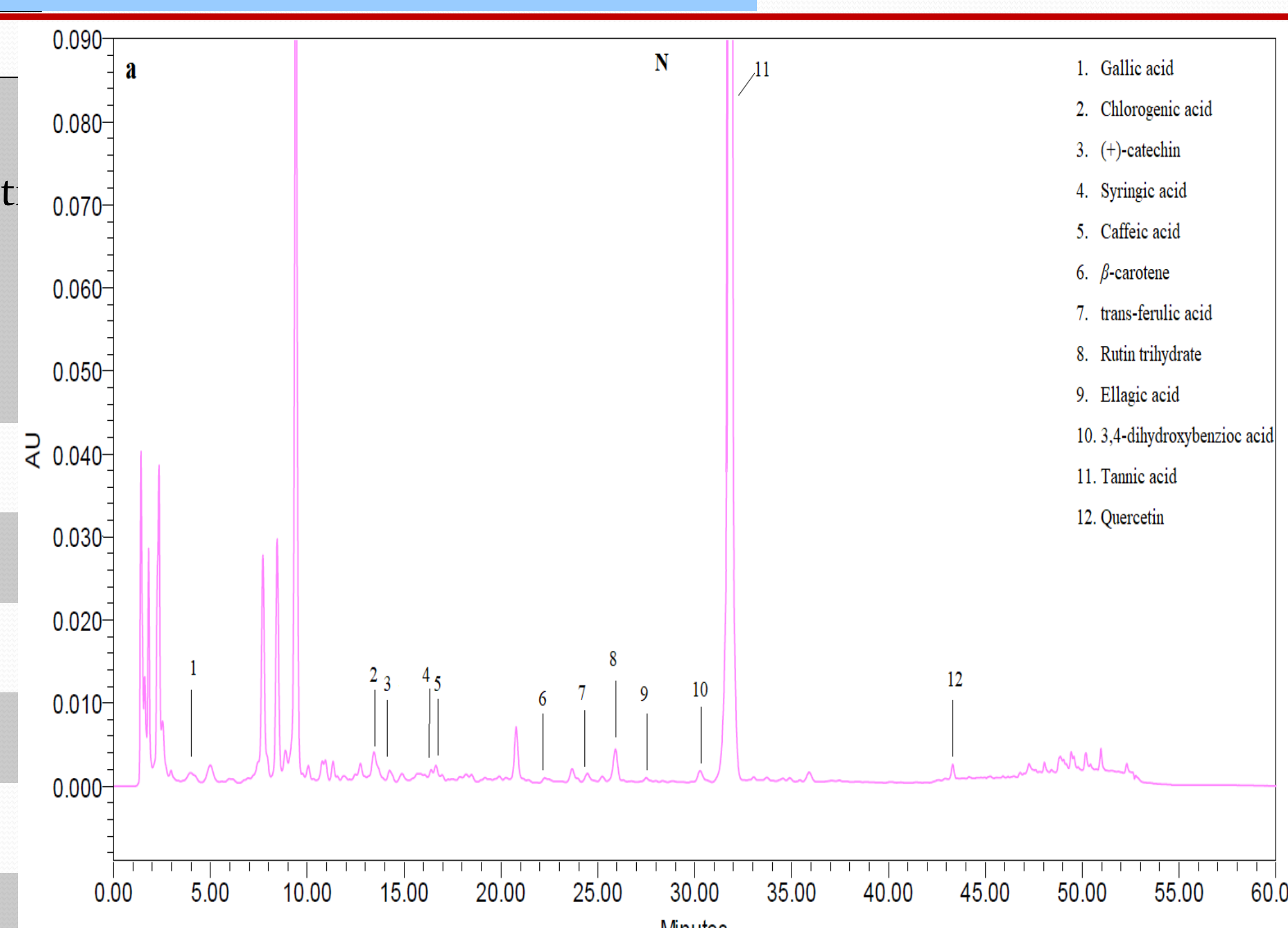
Sample	Amygdalin content (mg/g)	HCN content (mg/Kg)	Phytic acid (mg/100g)	Tannin Content (mg/100g)	DPPH Method (% Inhibition)	PRA (mg AAE / mL)	FRAP (µg AAE / mL)
N	9.44 ± 0.45 ^a	594.0 ± 2.44 ^a	162 ± 1.87 ^a	13.60 ± 0.87 ^a	28.43 ± 0.39 ^d	0.510 ± 0.007 ^b	0.206 ± 0.009 ^b
A1	3.03 ± 0.17 ^b	129.6 ± 1.96 ^b	140 ± 1.32 ^b	9.01 ± 0.45 ^b	36.20 ± 1.07 ^a	0.559 ± 0.005 ^a	0.253 ± 0.014 ^a
A2	1.64 ± 0.15 ^d	27.0 ± 1.19 ^d	58 ± 1.59 ^d	3.71 ± 0.55 ^d	26.33 ± 0.19 ^e	0.368 ± 0.012 ^f	0.109 ± 0.017 ^e
A3	1.92 ± 0.09 ^c	45.0 ± 1.43 ^c	69 ± 1.74 ^c	4.12 ± 0.32 ^c	33.65 ± 0.49 ^b	0.478 ± 0.010 ^c	0.166 ± 0.011 ^c
A4	0.51 ± 0.11 ^f	17.6 ± 0.98 ^e	36 ± 1.96 ^e	2.21 ± 0.11 ^f	31.16 ± 0.56 ^c	0.421 ± 0.011 ^d	0.147 ± 0.013 ^{cd}
A5	ND	ND	17 ± 0.46 ^f	2.08 ± 0.09 ^f	27.12 ± 0.22 ^d	0.396 ± 0.009 ^e	0.139 ± 0.003 ^d

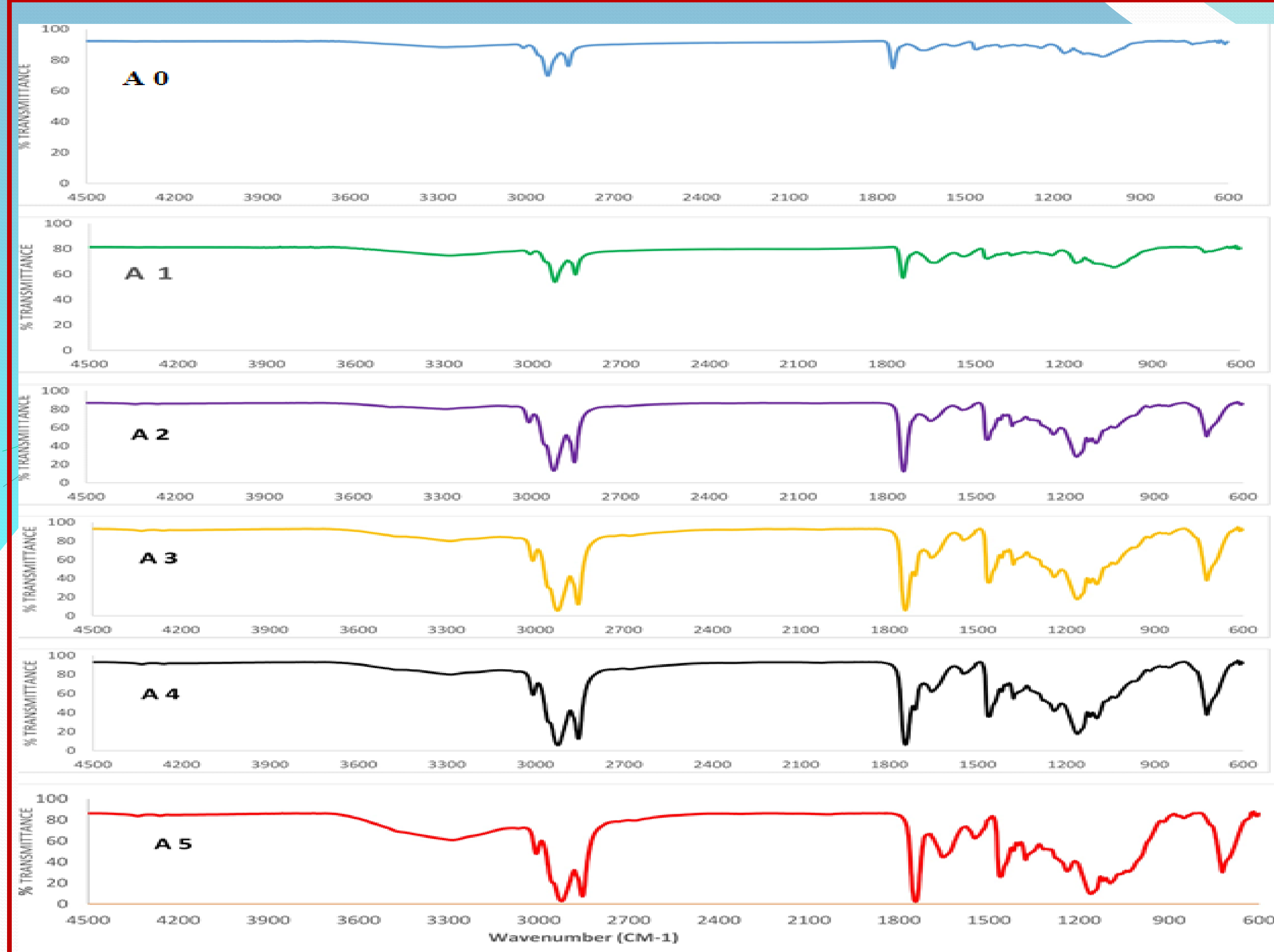


N: Native plum kernel sample; A1: Plum kernel sample microwaved at 450 W for 6 min; A2: Plum kernel sample soaked for 9 h at 45 °C; A3: Plum kernel sample soaked for 6 h at 45 °C and microwaved at 450 W for 6 min; A4: Plum kernel sample soaked for 9 h at 45 °C and microwaved at 450 W for 6 min and A5: Plum kernel sample soaked for 12 h at 45 °C and microwaved at 450 W for 6 min

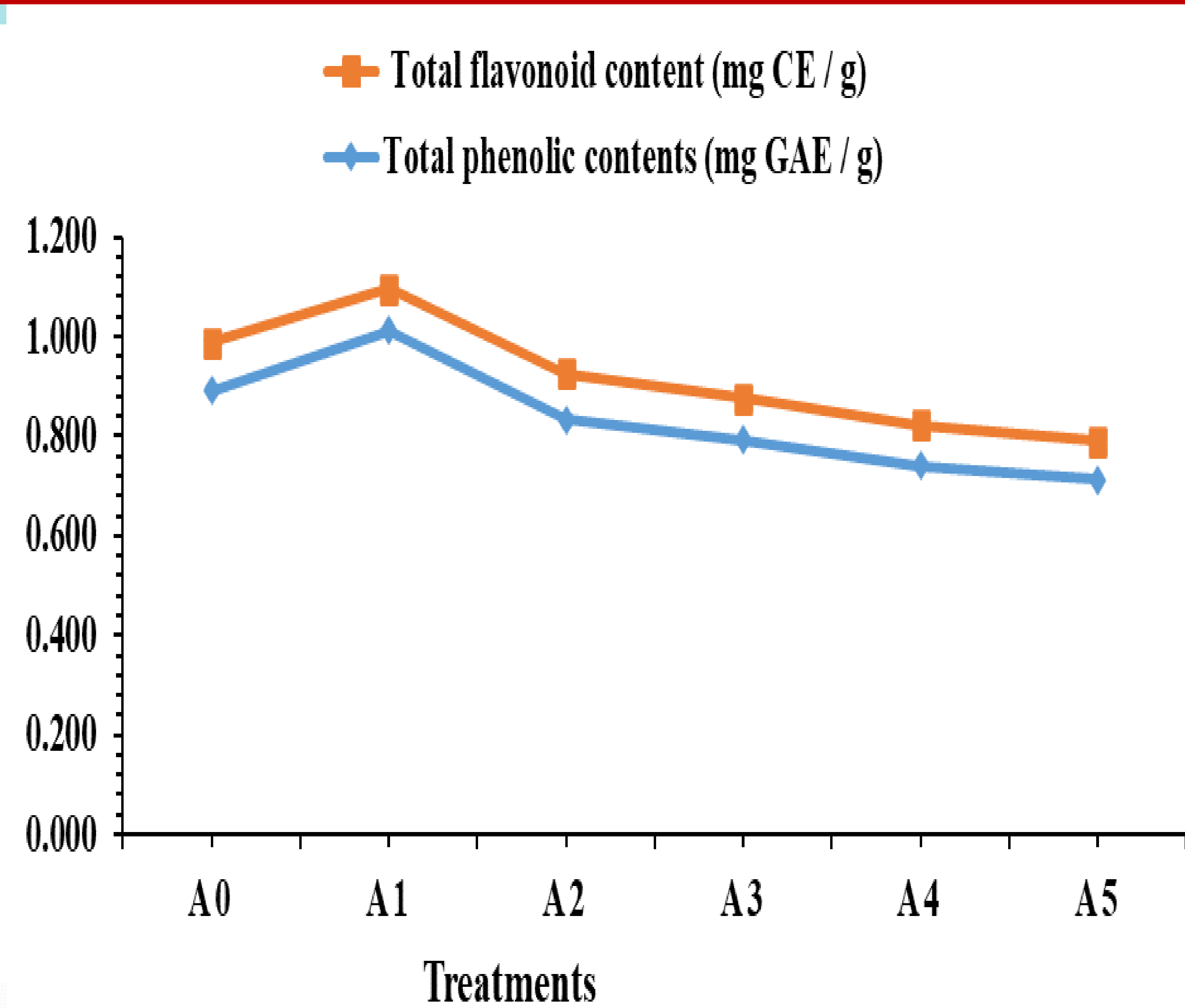
Table 2: Quantification of the phenolic profile of plum kernels treated with microwave, hydrothermal and their combined treatments

Sample	Phenolic compounds											
	Gallic acid (mg/g)	Chlorogenic acid (mg/g)	(+)-Catechin (mg/g)	Syringic acid (mg/g)	Caffeic acid (mg/g)	β-carotene (mg/g)	trans-Ferulic acid (mg/g)	Rutin trihydrate (mg/g)	Ellagic acid (mg/g)	3,4-dihydroxy benzoic acid (mg/g)	Tannic acid (mg/g)	Quercetin (mg/g)
N	1.89	0.25	1.07	0.90	0.33	0.20	0.26	5.67	0.48	3.78	13.07	0.16
A1	1.95	0.38	1.98	1.02	0.55	0.28	0.25	7.29	0.30	4.60	11.83	0.20
A2	1.23	0.22	0.85	0.65	0.29	0.19	0.23	3.45	0.35	3.62	8.23	0.09
A3	1.26	0.27	0.95	0.68	0.31	0.19	0.24	3.05	0.52	3.53	7.88	0.11
A4	0.29	0.17	0.15	0.18	0.01	ND	ND	1.97	ND	0.16	5.13	0.08
A5	0.29	0.15	0.13	0.16	ND	ND	ND	1.91	ND	0.17	4.61	0.03





FT-IR Spectra of microwave and hydrothermal treatments on structural properties of plum kernels



Effect of microwave and hydrothermal treatments on bioactive compounds

DISCUSSION

- Raw plum kernel sample had the highest mean amygdalin content of 9.44 mg/g, while all the treatments in the present study (A₁, A₂, A₃, A₄ and A₅) induced significant ($p < 0.05$) reduction in amygdalin content of plum kernel samples (Table 1).
- The results from chromatograms revealed that application of hydrothermal and microwave heat treatment had a significant ($p < 0.05$) impact on the destruction of amygdalin content of the plum kernel.
- The combined treatment of soaking for 12 hours at 45 °C and microwaved at 450 W for 6 min (A₅) reduces the amygdalin content under the allowed limits as set by European Commission Regulation (EU) (2017/ 123712) (EFSA CONTAM Panel, 2019).
- In comparison to the native sample, A₁, A₂, A₃, and A₄ treatments led to a reduction of 78.18, 95.45, 92.42 and 97.13 % in HCN content of plum kernel samples respectively.
- The TPC and TFC of the plum kernel samples obtained at different hydrothermal and microwave treatments exhibited significant ($p < 0.05$) variations (Table 1).
- The observed reduction of antioxidant property in all these four samples (A₂, A₃, A₄ and A₅) was attributed to the leaching out of bioactive compounds into the soaking medium.
- The combined hydrothermal and microwave treatment (A₃, A₄ and A₅) induced considerable reduction of 57.40, 77.78 and 89.50 % in phytic acid levels of the plum kernel samples respectively (Table 1).
- The combined hydrothermal and microwave treatment (A₃, A₄ and A₅) caused considerable reduction of 69.70, 83.75 and 84.71 % in tannin content of the plum kernel samples respectively (Table 1).
- The larger shifts in the FT-IR spectra of sample with combined treatment of soaking for 12 hours at 45 °C and microwaved at 450 W for 6 min (A₅) were reflected in the greater changes in the functional groups, such as aromatic groups of the plum kernel samples.
- The increased loss of phenolic compounds in hydrothermal treatment (A₂) and combined hydrothermal and microwave treatment (A₃, A₄ and A₅) could be explained by an increase in the free forms with hydrolysis, due to dismantling of the cell matrix during hydrothermal and microwave treatment.

CONCLUSIONS

- The results revealed that when only microwave treatment was given to plum kernels, it significantly increased the levels of phenolic compounds and antioxidant potential.
- On the contrary, prolonged exposure to hydrothermal (A₂) and combined treatments of hydrothermal and microwave (A₃, A₄ and A₅) treatment led to a considerable reduction in anti-nutritional factors, as compared to the native sample (N).
- The decreased value of lightness in combined hydrothermal and microwave treatment might be attributed to leakage of colored compounds from the cell compartments due to cell rupturing.
- FT-IR spectra revealed the insights of treatment induced major changes in anti-nutritional factors of plum kernel samples.
- Combined treatment of soaking for 12 hours at 45 °C and microwaved at 450 W for 6 min appeared to be most effective in improving the nutritional profile of plum kernel samples and reducing the amygdalin content to undetectable amounts, opening up possibilities for its use in food industries.

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