

# Application of Atmospheric Plasma on mediation of nutrient

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## Introduction

The atmospheric pressure plasma or atmospheric plasma (AP) generates plasma ionizing gas to damage biological targets (e.g. cancer cell) without increasing the temperature in the treated regions by formation of free radicals, photons, positive ions, free electrons, and electromagnetic field. AP has been widely applied to medical therapy, biomedical materials, and food technology for decades. Djulis, commonly referred to as Taiwanese red quinoa, is a traditional pseudocereal crop that is an endemic species and a local flora in Taiwan. Botanically speaking, Djulis belongs to the Amaranthaceae family under the genus Chenopodium and has a close botanical similarity to quinoa (*Chenopodium quinoa*). Djulis has been documented to be a rich source of minerals, vitamins, high-quality proteins, and provides all eight essential amino acids.

## Materials and methods

The Djulis seed was directly harvested from the sustainable agricultural farms at National Pingtung University of Science and Technology (SAF/NPUST) or purchased from a retail store indirectly provided by SAF/NPUST. Djulis seed from the NPUST retail store was treated with air AP (air-AP), and the seed from SAF/NPUST was treated with N<sub>2</sub> AP (N<sub>2</sub>-AP). The AP-mediated gaseous ionization and plasma electronics on the seed surface were determined based on the plasma nozzle parameters (A50 (50 mm), A30 (30 mm), and A10 (10 mm)), sweep speed, or contact time (100 and 150 mm/s), input power (600 and 800 W), the distance from the seed to the plasma nozzles (5, 10, 15 mm), and the working gas.

**Table 1** Parameters of the AP-treated djulis seed in this study.

Method	Plasma nozzle A50/A30/A10	Distance <sup>a</sup> 5/10/15m	Plasma gas Air/N <sub>2</sub>	Power input 0.6/0.8 kW	Sweep speed 100/150m m/s	Temperature <sup>b</sup> (°C)	Torch diameter <sup>c</sup> (mm)	Treatment time (sec)
Control	None	None	None	None	None	None	None	None
Method A	A50	5	Air/N <sub>2</sub>	0.6	100	49	42	1.02
Method B	A50	5	Air/N <sub>2</sub>	0.8	100	59	42	1.02
Method C	A50	5	Air/N <sub>2</sub>	0.8	150	46	42	0.68
Method D	A50	10	Air/N <sub>2</sub>	0.8	100	54	42	1.02
Method E	A30	5	Air/N <sub>2</sub>	0.8	100	55	30	0.90
Method F	A30	10	Air/N <sub>2</sub>	0.8	100	52	30	0.90
Method G	A30	5	Air/N <sub>2</sub>	0.8	150	47	30	0.60
Method H	A30	5	Air/N <sub>2</sub>	0.6	100	49	30	0.90
Method I	A10	15	Air/N <sub>2</sub>	0.8	100	75	17	0.77
Method J	A10	15	Air/N <sub>2</sub>	0.8	150	57	17	0.51
Method K	A10	15	Air/N <sub>2</sub>	0.6	100	67	17	0.77
Method L	A10	10	Air/N <sub>2</sub>	0.8	100	77	17	0.77

<sup>a</sup> Distance from the seed surface to the plasma nozzle.

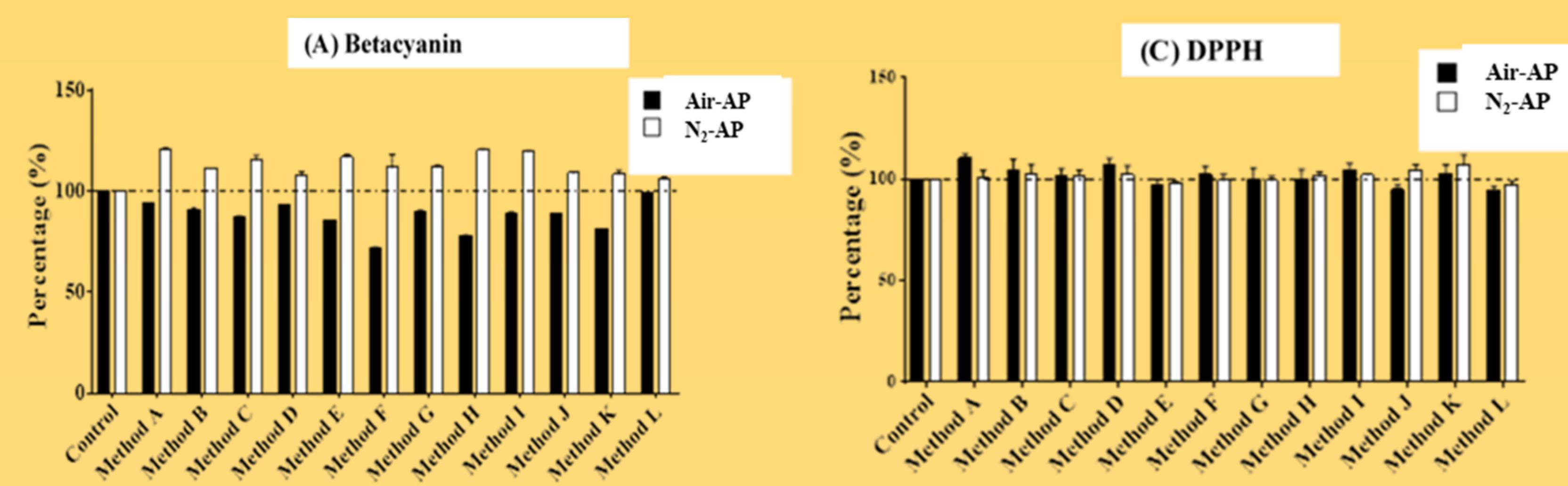
<sup>b</sup> Surface temperature on the djulis seed.

<sup>c</sup> Diameter of the AP torch.

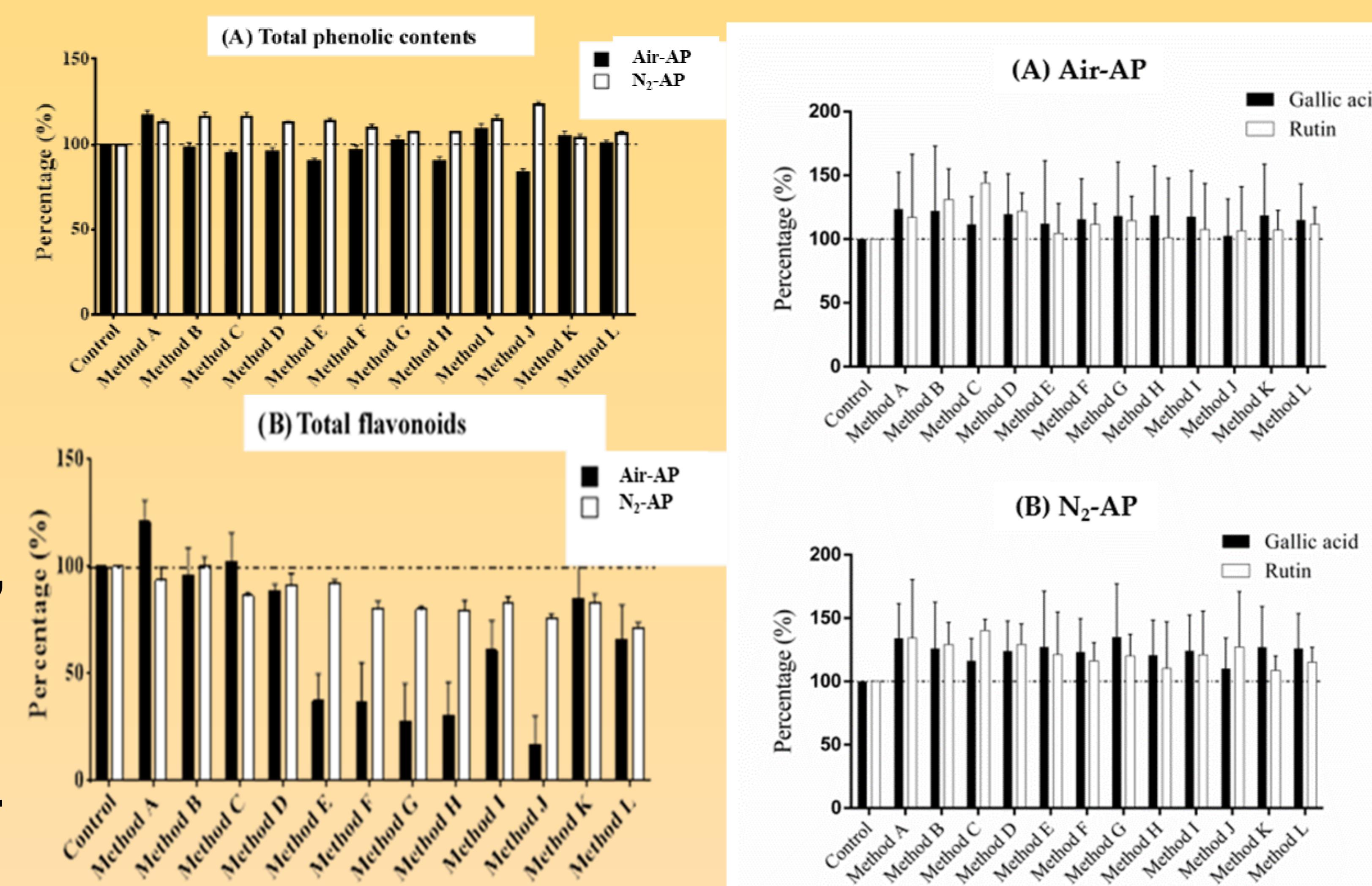
## Results and Discussion

**Table 2** Levels of natural bioactive compounds in the djulis seed without the AP treatment.

Compounds	Air-AP (n=3) <sup>a</sup> (retail store)			N <sub>2</sub> -AP (n=6) <sup>b</sup> (SAF/NPUST)		
	Range	Median	Mean	Range	Median	Mean
Betacyanin (mg/100g)	9.50-9.06	9.50	9.50±0.005	3.99-4.03	4.00	4.01±0.019
Anthocyanin (mg/100g)	24.5-25.6	24.5	24.8±0.633	25.3-25.8	25.7	25.6±0.633
Total phenolic content (mg GAE/100g)	34.6-36.1	35.9	35.55±0.830	86.8-89.0	88.2	88.0±1.12
Total flavonoids (mg QU/100g)	1.39-1.89	1.79	1.69±0.265	4.85-5.66	5.25	5.25±0.401
DPPH <sup>c</sup> (Percentage, %)	72.5-81.2	79.1	77.6±4.52	85.5-86.2	86.0	85.9±0.355



**Fig. 1** Variations in betacyanin (A), and DPPH radical scavenging effects (B) in djulis seed after air-AP or N<sub>2</sub>-AP treatment compared with the untreated control



**Fig. 2** Levels of gallic acid and rutin in the seeds before and after AP treatment: (A) air-AP treatment and (B) N<sub>2</sub>-AP treatment.

## Conclusion

The present study indicated that several natural bioactive compounds, betacyanin, anthocyanin, TPCs, gallic acid, and rutin, which have potential antioxidant abilities in Djulis seed, were activated by N<sub>2</sub>-AP treatment and inhibited by air-AP treatment.