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Plasma-activated water enhances growth, antioxidant activity and sensory quality of hydroponically grown lettuce

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Cold atmospheric plasma generates multiple reactive oxygen and nitrogen species (RONS), which dissolve in water to form plasma-activated water (PAW), resulting in its subsequent chemical modifications. Due to the presence of RONS, PAW shows considerable potential in agriculture, as these species act as signaling molecules in plant metabolic pathways and enhance nutrient availability. This study evaluates the effects of PAW produced via a transient spark (TS) discharge system on the growth and physiological responses of hydroponically cultivated lettuce (Lactuca sativa). Four experimental treatments were established: (1) a control group grown in ½ Hoagland's nutrient solution; (2) plants from seeds primed in PAW for 1.5 hours, then transferred to Hoagland's nutrient solution; (3) plants from seeds primed in PAW and subsequently cultivated in PAW supplemented with ½ Hoagland's nutrient solution; and (4) plants cultivated solely in PAW enriched with ½ Hoagland's nutrients. Plant development was monitored over a 10-week period. At harvest, central rosette leaves (3–5 per plant) were analyzed for concentration of selected antioxidants, specifically soluble phenols and quercetin from flavonoids. Another important parameter was the activity of several antioxidant enzymes (superoxide dismutase, ascorbate peroxidase, guaiacol peroxidase, and glutathione reductase), which was measured in the mixture of two oldest and youngest leaves of plants. A sensory evaluation involving 15 participants assessed visual appearance, aroma, flavor, and texture. Our results showed that the combination of PAW treatment and seed priming led to increased biomass accumulation and enhanced activity of antioxidant enzymes. These plants also had higher concentrations of key antioxidant compounds. Among these antioxidants, flavonoids (in our case, quercetin) are the most powerful scavengers of free radicals and possess anti-inflammatory, antidiabetic, antiatherosclerotic, antihypertensive, and anti-aging properties. Sensory panel participants consistently rated the PAW-treated lettuce as more appealing and tastier, indicating strong potential for consumer acceptance and commercial application.

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