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Cold Plasma Technology for the Prevention of Postharvest Grain Losses

MAN. Tran[1], HAQ. Than[1], NK. Do[1], TT Nguyen[1], A. Khacef[2], TH. Pham[1]
[1] Institute of Advanced Technology, Vietnam Academy of Science and Technology
[2] GREMI, CNRS-Université D'Orléans
e-mail (speaker): ahmed.khacef@free.fr

Postharvest grain losses caused by insect pests, particularly *Sitophilus oryzae*, pose a significant threat to global food security. Conventional chemical control methods, though widely used, raise environmental concerns and contribute to the development of insect resistance [1-3]. In contrast, cold plasma presents a promising, eco-friendly alternative. It generates various reactive species capable of inducing significant biological effects. However, the influence of plasma treatment parameters, such as carrier gas type and operating frequency, on the physiology of rice weevil and the post-treatment quality of rice grains remains inadequately explored.

In this study we investigated the insecticidal effects of cold plasma on *S. oryzae* and evaluated its impact on rice grain quality. Our focus was on understanding how different carrier gases and treatment frequencies affect both insect mortality and grain properties. To elucidate the underlying mechanisms of plasma-induced mortality, we analyzed changes in insect total protein, malondialdehyde (MDA) levels, and the antioxidant enzymes includes catalase (CAT) and superoxide dismutase (SOD). In parallel, we assessed physicochemical properties of the treated rice to identify an optimal plasma dose that ensures effective pest control while minimizing quality degradation.

A DBD cold plasma system (quartz tube with high-voltage and grounded copper electrodes, 3 cm gap) was used to treat rice weevils and grains in Petri dishes. Argon or helium (2 L/min) was used as the carrier gas. A custom-built AC power supply delivered 24 kV at 2.5 kHz and 7.5 kHz for treatment durations ranging from 30 to 120 s. Insect mortality was assessed at 1 and 24 h post-treatment. Biochemical assays (total protein, CAT, SOD) were performed on 30 s plasma helium treated insects using standard spectrophotometric methods (BSA, MDA, XO/NBT). Rice grain quality parameters (total protein, starch content, water uptake ratio, cooking time, volume expansibility) were assessed using established methods.

Plasma treatment using either Ar or He carrier gases at both operating frequencies effectively controlled *S. oryzae* populations. Longer plasma exposure times resulted in higher mortality. At 2.5 kHz, complete mortality was observed 24 h after treatment with 90 s (He) and 60 s (Ar) plasma exposure. Increasing the frequency to 7.5 kHz significantly enhanced efficacy, achieving 100% mortality within just 30 seconds for both gases, highlighting the role of increased input energy.

Beyond mortality, plasma treatment induced substantial biochemical alterations in *S. oryzae*, including an 84% reduction in total protein content. Marked changes in antioxidant enzyme activity, particularly SOD and CAT, were also detected. Morphological changes such as immobility, opened elytra, retracted limbs, and exposed hindwings were consistent with observations in other plasma-treated insects (Figure 1). Additionally, plasma exposure improved certain physical properties of rice, such as water absorption and optimal cooking time, likely due to surface etching effects, while no significant changes in nutritional content were observed.

The observed biochemical and morphological changes suggest that oxidative stress is the primary mechanism underlying plasma-induced insect mortality. These findings support the potential of cold plasma as a sustainable technology for grain preservation, offering effective pest control with minimal impact on rice quality.

References

[1] GJ. Daglish et al., J. Stored Prod. Res., **59**, 237-244 (2014)
[2] TT. Nguyen et al., J. Heredity, 2016. **107,** 228-237 (2016)
[3] R. Aulicky et al., Insects, **13,** 1162 (2022)

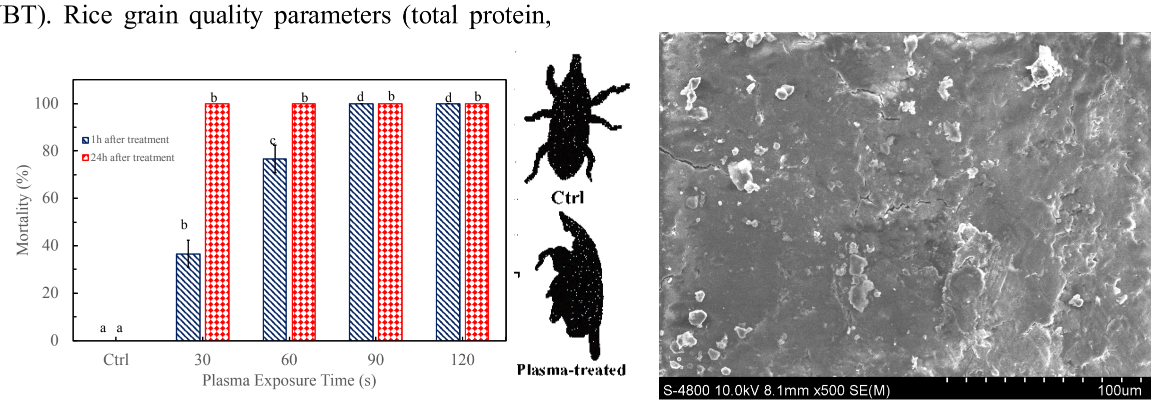

Figure 1. Effect of He DBD plasma on mortality of *Sitophilus oryza*e and rice surface morphology after treatment.