Non-Thermal Plasma as a Modulator of Cellular Stress and Aging in Yeast

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Introduction

Non-thermal plasma, also known as cold atmospheric microplasma (CAM), is a room-temperature ionized gas rich in reactive species and ultraviolet (UV) radiation. It can interact with cells to enhance biological activity and stress resistance, and it holds promise as a non-invasive therapeutic tool [1]. In our previous study, we observed that reactive species generated by a low dose of plasma can inhibit cellular senescence by maintaining cellular homeostasis in Saccharomyces cerevisiae cells [2]. In the present study, we aim to investigate the potential of CAM to influence the stress response in yeast cells. For this purpose, we assessed the expression of silent information regulator 2 (SIR2), a highly conserved NAD^+-dependent deacetylase protein. SIR2 plays a crucial role in lifespan extension by modulating stress resistance and metabolic homeostasis [3]. Overexpression of SIR2 protein indicates enhanced stress resistance and may contribute to lifespan extension.

Objectives

- To determine the effect of CAM to influences cellular stress responses in yeast cells.
- To investigate the role of microplasma for modulating aging in yeast.

Materials and Methods

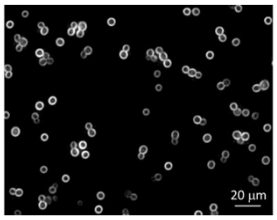

Fig. 1 Culture of *Saccharomyces cerevisiae* cells in Yeast Extract Peptone Dextrose (YPD) medium.

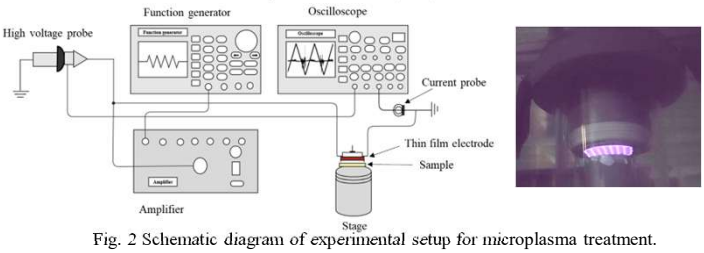

Fig. 2 Schematic diagram of experimental setup for microplasma treatment.

Experimental condition	
Frequency	1 KHz
Discharge voltage	2.5 $KV_{0\text{-}p}$
Wave form	Ramp
Treatment time	10 s, 30 s, 1 min, 3 min, 5 min
Distance	3 mm

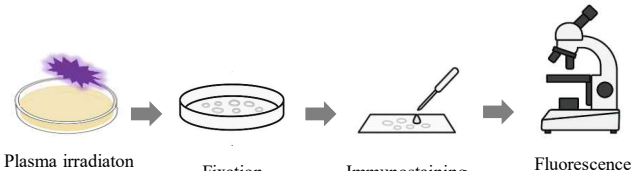

Fig. 3 Immunocytochemistry for SIR2 expression analysis.

- Chronological lifespan was analyzed after plasma treatment up to 25 days.

Results

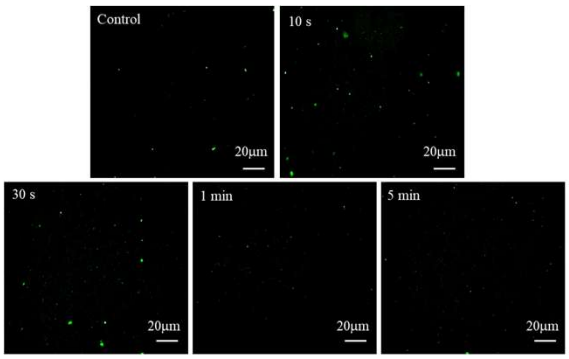

Fig. 4 Microscopic observation of cells expressing SIR2 protein (20×). Low-dose plasma treatment for 10 s and 30 showed higher SIR2 expression than the control, indicating increased stress resistance.

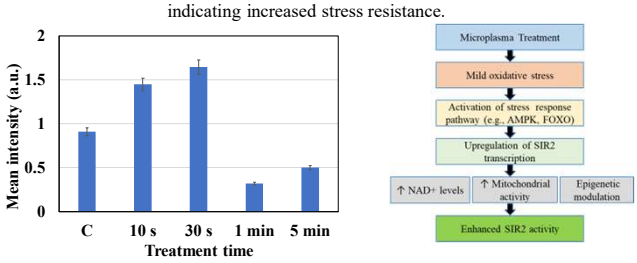

Fig. 5 Mean intensity of SIR2 protein expression in different treatment times.

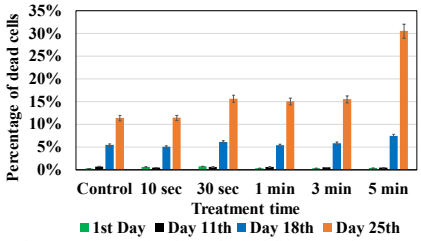

Fig. 6 Effect of microplasma treatment in chronological lifespan of yeast. No significant changes were observed between low dose of plasma treatment and the control sample.

Discussion

- In this study, we observed the effect of CAM in cellular stress response. Higher expression of SIR2 protein was observed in 10 s and 30 s of plasma treated cells compared to the control.
- Low dose of microplasma treatment can generate mild oxidative stress that can activate the oxidative stress response pathway by increasing the NAD+ level and mitochondrial activity, thus helps to enhance the SIR2 activity.
- However, no significant effect was observed in chronological aging in the following plasma treatment time.

Conclusion

- In 1 KHz frequency and 2.5 $KV_{0\text{-}p}$ discharge voltage of cold atmospheric plasma discharge at 10 s and 30 s showed higher expression of SIR2 protein in *Saccharomyces cerevisiae* cells.
- The reactive species and electrical components generated during plasma treatment may play a significant role in enhancing the cellular stress resistance and maintaining the homeostasis of the cells.

References

1. Yahaya, A.G., et al., *Molecules*, 2021, 26, 2523.
2. Begum, F., et al., *Molecules*, 2025, 30(9), 1970.
3. Santos, L., et al., *Oxidative medicine and cellular longevity*, 2016, 2016, 9831825.