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Indoor pollution: Dysregulations of Mitochondrial Functions Induced by Formaldehyde & Study of the Protective Effect of a Multimineral Active Ingredient

246

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INTRODUCTION

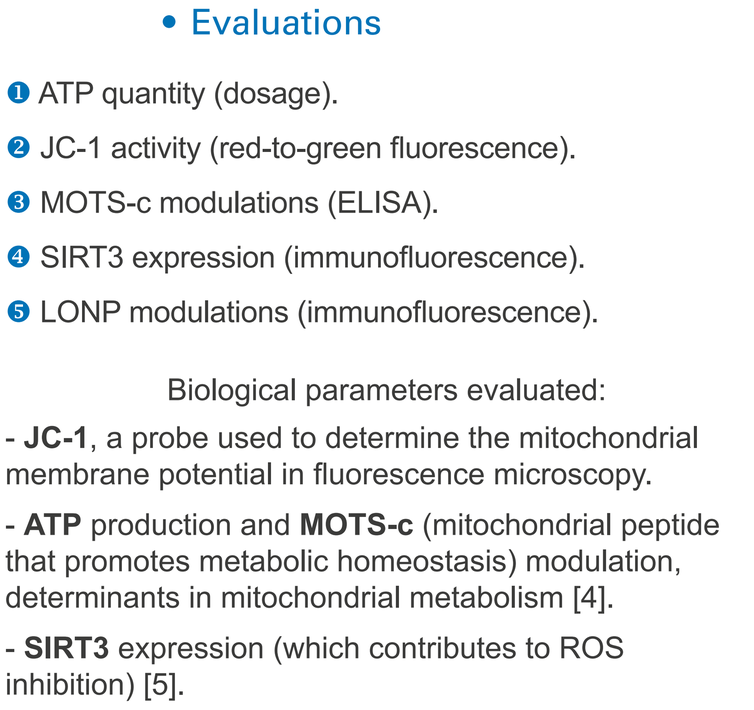
People spend about 90% of their time indoors where they are exposed to chemicals, such as volatile organic compounds (VOCs). These pollutants are known to have a negative impact on skin health especially on mitochondrial functions, leading or contributing to some disorders such as accelerated skin aging [1, 2]. Among these agents, formaldehyde has been classified as priority indoor pollutants [3].

In this context, the aim of this study was to investigate the effects of formaldehyde on mitochondrial functions on primary human keratinocytes and the effects of SM3, a multimineral active ingredient, on these alterations induced by formaldehyde exposure.

Materials & Methods

- Hypothesis: Indoor pollution induced skin damage

We supposed that formaldehyde exposure induced mitochondrial dysfunctions:



- Evaluations

❶ ATP quantity (dosage).

❷ JC-1 activity (red-to-green fluorescence).

❸ MOTS-c modulations (ELISA).

❹ SIRT3 expression (immunofluorescence).

❺ LONP modulations (immunofluorescence).

Biological parameters evaluated:

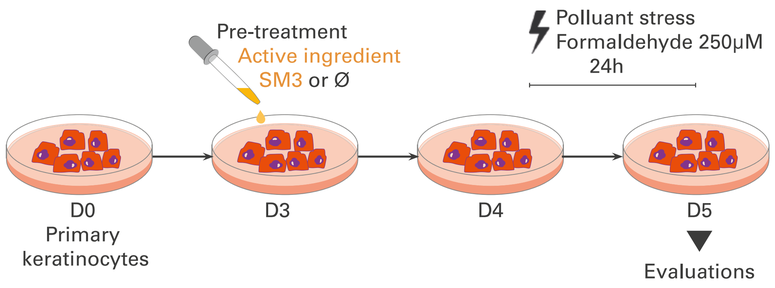
- **JC-1**, a probe used to determine the mitochondrial membrane potential in fluorescence microscopy.

- **ATP** production and **MOTS-c** (mitochondrial peptide that promotes metabolic homeostasis) modulation, determinants in mitochondrial metabolism [4].

- **SIRT3** expression (which contributes to ROS inhibition) [5].

- **LONP** activity (main protease for the degradation of oxidized proteins) [6].

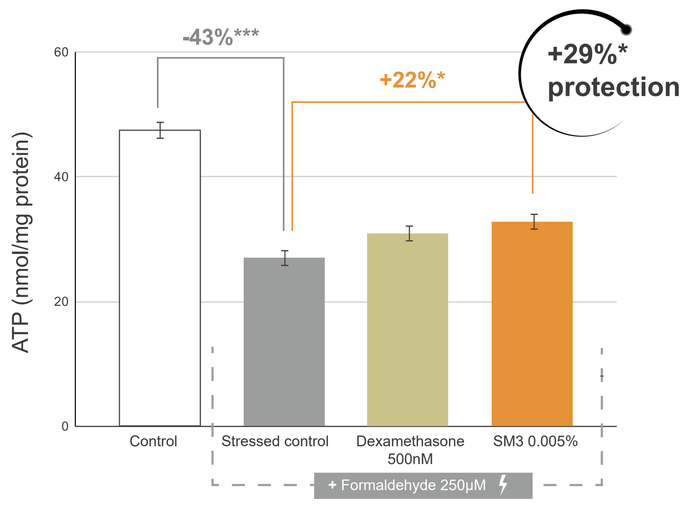
- *In vitro* protocol



Results & Discussion

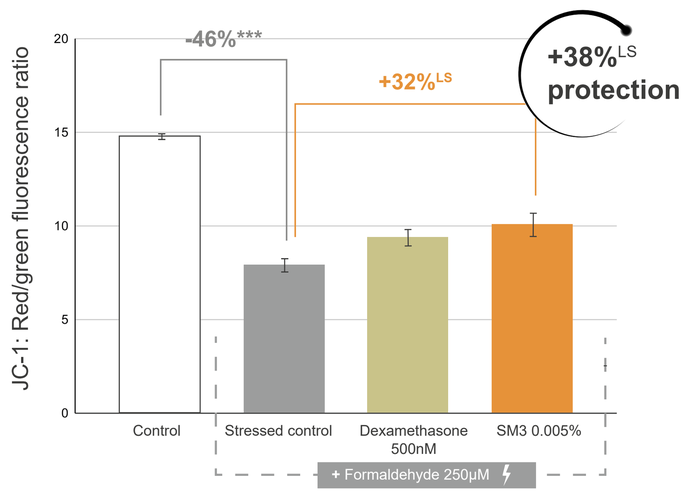
Student's t-test
[LS]: limit of significance p<0.1
* p<0.05; ** p<0.01; *** p<0.001

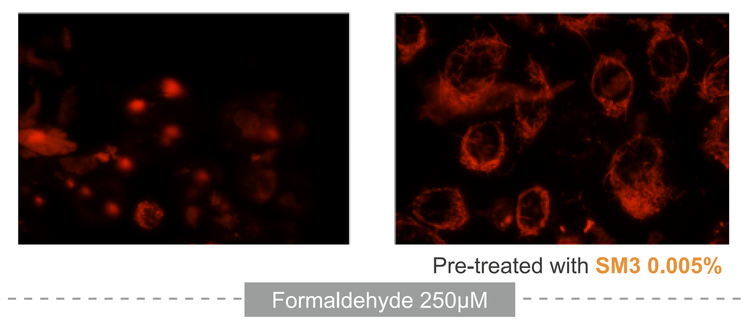
❶ ATP



- ATP production was significantly reduced after exposure to formaldehyde by 43% (p<0.001).
- SM3 0.005% induced a protection of ATP production by 29% (p<0.05).

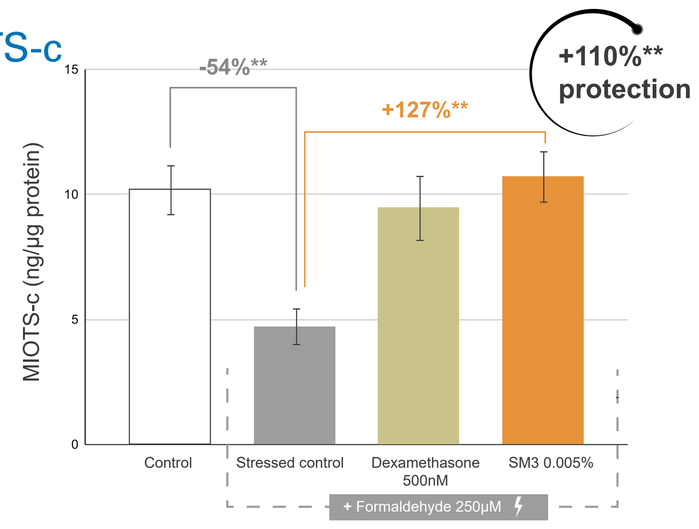
❷ JC-1





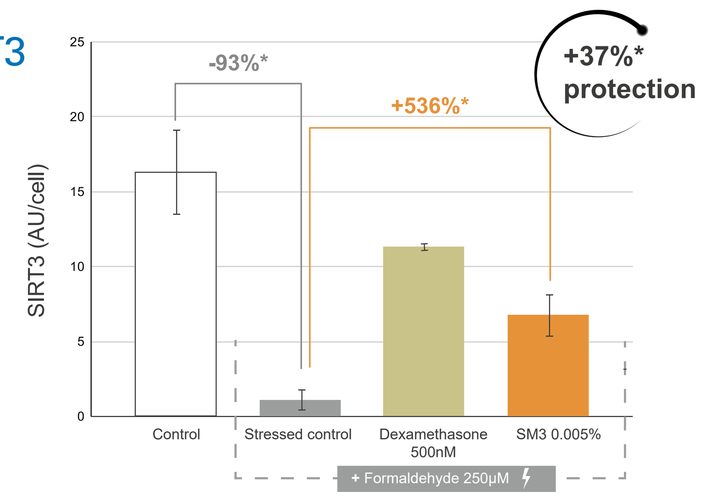
- Formaldehyde demonstrated a significant decrease in JC-1 red-to-green fluorescence following treatment by 46% (p<0.001).
- SM3 0.005% protected keratinocytes from the drop in mitochondrial membrane potential induced by formaldehyde treatment by 38% (+32% *vs* formaldehyde-stressed cells, p<0.1).

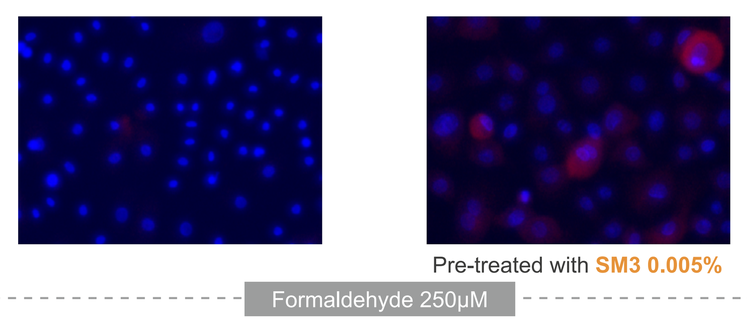
❸ MOTS-c



- Formaldehyde treatment induced a significant decrease in MOTS-c level in keratinocytes (-54%, p<0.001).
- SM3 0.005% permitted the reverse of the down-regulation of MOTS-c protein level induced by formaldehyde by 127% (p<0.01, protection of 110%).

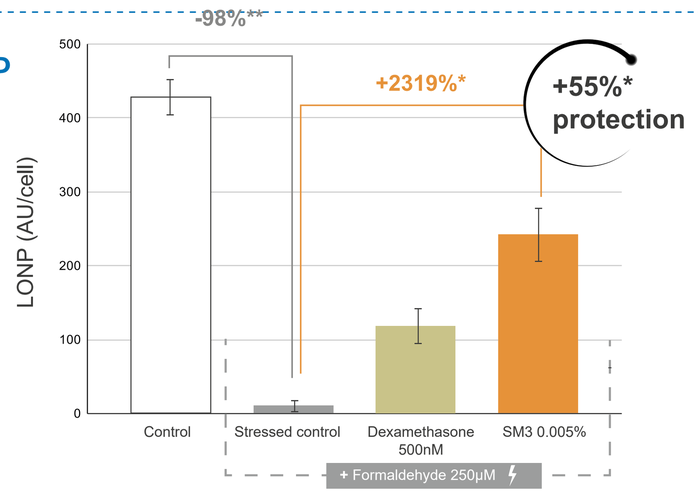
❹ SIRT3

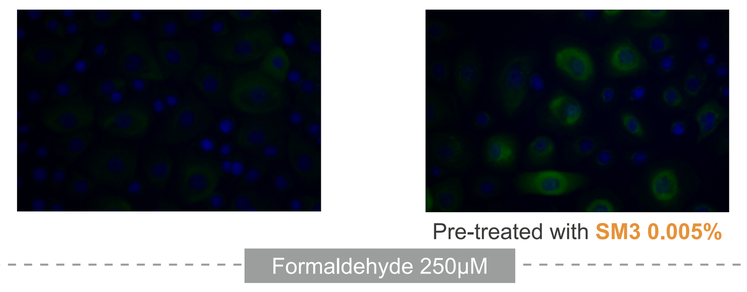




- Formaldehyde drastically reduced SIRT3 protein level in keratinocytes by 93% (p<0.05).
- SM3 0.005% induced a protection of SIRT3 by 37% (p<0.05).

❺ LONP





- Formaldehyde treatment induced a drastic significant decrease in LONP level in keratinocytes (-98%, p<0.01).
- SM3 0.005% induced a significant protection of LONP protein level by 55% (p<0.05)..

References

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CONCLUSION

In summary, our results confirm that indoor pollution induced skin damage.

Formaldehyde exposure induced mitochondrial dysfunctions: drops in ATP production and in mitochondrial membrane potential, as well as the decrease of MOTS-c protein level, a mitochondrial-derived peptide involved in metabolism. Moreover, formaldehyde exposure induced the downregulation of SIRT3 and alterations of mitochondrial proteasome as LONP content.

Data on formaldehyde-stressed keratinocytes showed an interesting protection capacity of SM3 on mitochondrial functions, protecting mitochondrial metabolism, its antioxidant activity and mitochondrial proteolysis. Then, SM3 is a promising active ingredient for protecting skin from damage induced by indoor pollution.