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Combined Action of Ultrasound with Hyperthermia in Yeast Cells

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A variety of biological objects are inactivated more readily by a physical or chemical agent applied together with hyperthermia than by a single agent. So, heat is known to be extensively utilized to enhance cell inactivation effect induced by ionizing radiation, ultraviolet light and ultrasound.

In experiments with wild-type diploid yeast cells of *Saccharomyces cerevisiae*, three types of survival curves have been obtained: heat alone, ultrasound alone (without heating), simultaneous action of heat and ultrasound. The results show enhanced cell killing after simultaneous combined treatment with heat and ultrasound (20 kHz) in comparison with the additive effects produced by each agent applied alone.

The following peculiarities of synergistic interaction of these modalities have been revealed. First, the synergism was obtained only within a definite range of the temperature at which the sonication was carried out. Second, for a given ultrasound intensity, there was a specific temperature at which the greatest synergistic effect was determined. Third, any deviation in temperature from the optimal value resulted in a decrease in synergism. Finally, the correlation between ultrasound intensity and the temperature that ensured the maximum synergistic interaction was demonstrated. From these results, the conclusion can be drawn that the temperature at which ultrasound sonication is delivered should be elevated to obtain the maximum synergistic effect with increasing ultrasound intensity.

The synergistic effect was shown to be dependent on ultrasound intensity and temperature at which the treatment took place. The temperature range enhancing ultrasound effect was shifted toward higher temperature values with an increased ultrasound intensity. For every intensity, an optimal temperature exists which maximizes the synergy. A possible interpretation of this effect is based on the supposition that the mechanism of the synergistic effect is related to additional lethal damages produced by the interaction of sublesions induced by each agent investigated.