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Lactobacillus gasseri Growth after Microwave Irradiation

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ABSTRACT

Lactobacillus gasseri is a bacteria found in the gastrointestinal tract and vagina and is essential for digestion and absorbing important nutrients. Some studies have experimented to find the effect of pulsed 2.4-GHz microwave irradiation on the growth of various *Lactobacilli* strains, while others have used continuous radiation at a similar frequency. Different studies have concluded that such radiation could kill other gut bacteria like *Escherichia coli*. We tested the effect of continuous microwave irradiation on the growth of *Lactobacillus gasseri*. We first irradiated four groups of the bacteria with a 10.5-GHz microwave transmitter for different amounts of time (0 minutes, 10 minutes, 20 minutes, 30 minutes). There was a significant difference between the control group and each irradiated group. There was no significant difference between the three irradiated groups. Our results agree with past research that has studied the effect of both microwave irradiation and radiation on *Lactobacillus*. We may have found such results because the electric field created by microwave radiation can disrupt the function of oxidative defense. This defense is needed to counteract oxidative stress, which could damage bacterial cell DNA, causing cell death. Therefore, microwaves at frequencies capable of penetrating the human body could cause the inactivation of multiple gut microbiota.

Introduction

Microwaves are a type of electromagnetic radiation capable of harming human bacteria growth (Crabtree et al., 2017). Taheri et al. (2017) found that microwave frequencies similar to those of mobile devices and Wi-Fi routers (2.4-GHz) could slow the growth of gut bacteria, specifically. Although Goldblith and Wang (1967) concluded that 2.45-GHz microwaves do not affect *Escherichia coli* growth, Janković et al. (2014) showed that slightly higher frequency microwaves *can*. However, the processes of the two studies differed in that the former used thermal radiation while the latter found these effects with non-thermal radiation frequencies between 8 and 19 GHz.

Lactobacillus gasseri is a strain of *Lactobacillus* found in the gastrointestinal tract and vagina that is, similarly to *E. coli*, essential for digestion and absorbing important nutrients (Xiang et al., 2019). Although the effect of 2.4-GHz microwaves on different *Lactobacillus* strains have been studied before, a higher frequency, such as one between the range tested by Janković et al., has not been used to evaluate its effect on growth (Shin & Pyun, 1997; Amanat et al., 2020). Many radar systems that operate on higher scales than mobile phones and Wi-Fi routers fall into this range (Ohring & Kasprzak, 2015). Thus, we measured whether *L. gasseri* growth was affected when it was exposed to continuous 10.5-GHz microwave irradiation.

Methodology

We first filled 40 16 by 150 mm test tubes with 5 ml of lysogeny broth each and sterilized them. Then, we added 6 billion CFU of *Lactobacillus gasseri* to each one. We split up the test tubes into four equal sample groups. For each test tube, we analyzed light absorbance using a spectrophotometer set at a 508.3 nm wavelength and calculated the average over 50 seconds. Three sample groups were irradiated with microwaves from a 10.5-GHz microwave transmitter 31 cm away for 10 minutes, 20 minutes, and 30 minutes, while the fourth group was not irradiated. All groups were maintained at room temperature for the same amount of time. Then, we incubated all of them for 24 hours at 37°C. We remeasured light absorbance for all of the test tubes. Another trial was conducted using this process. We took the difference in the average light absorbance of each test tube and performed a one-way ANOVA test to see if there was a significant difference in the absorbance changes between the four groups.

Results

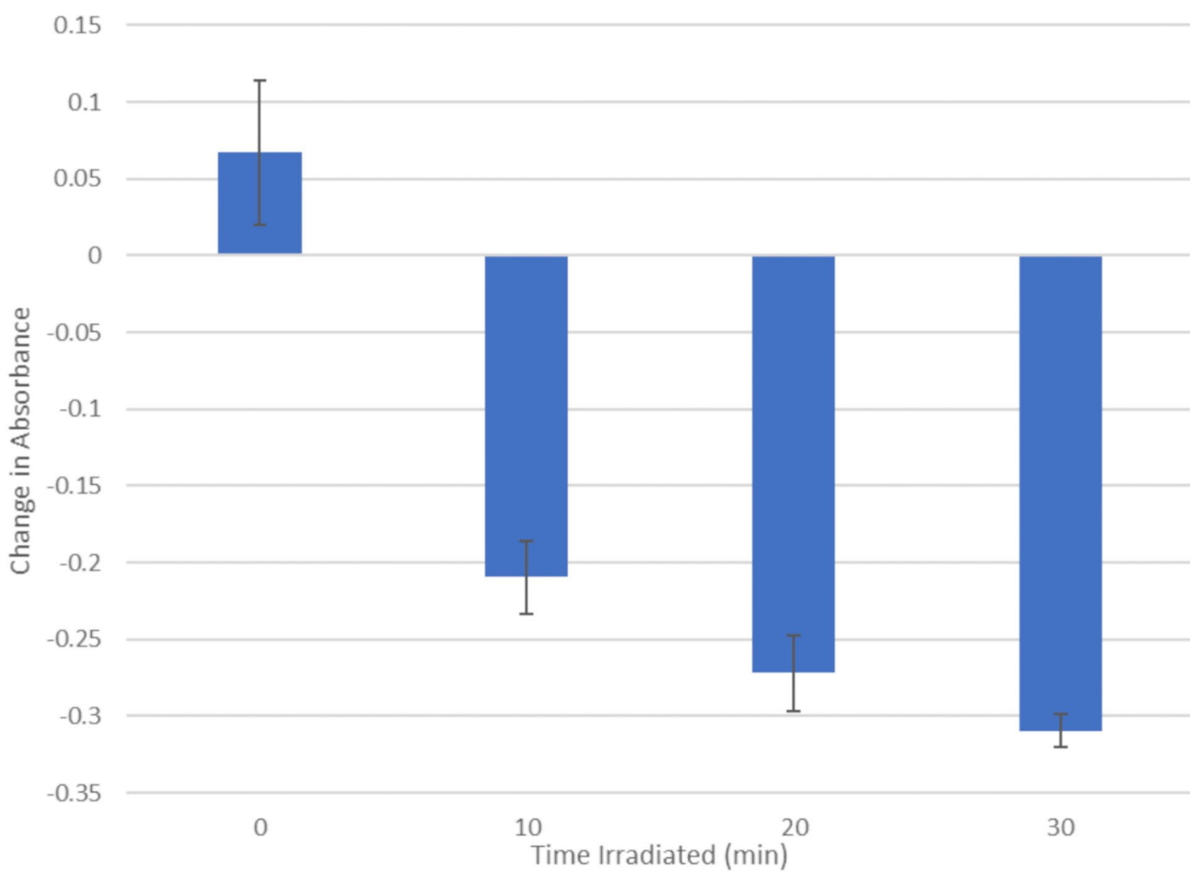

Figure 1. The average change in absorbance of Lactobacillus gasseri *solutions after various durations of microwave irradiation. Eighty test tubes each filled with 5 ml of lysogeny broth and 6 billion CFU of* L. gasseri *were split into four equal groups. The groups were irradiated with a 10.5-GHz microwave transmitter 31 cm away and then incubated for 24 hours at 37 °C. The average absorbances of each test tube before and after were measured to calculate the difference. Error bars represent standard error.*

The results of our study are shown in Figure 1. The absorbance increased in the group that was not irradiated and decreased in the other three groups. Of these three groups, the absorbance of the group irradiated for 10 minutes decreased the least while that of the group irradiated for 30 minutes decreased the most. There was a significant difference between the groups ($F = 32.2$; df = 3, 75; $p < .0001$). The Tukey test showed a significant difference between the absorbance changes in the non-irradiated group and each of the other groups but no significant difference between solely the three irradiated groups.

Discussion

We found a significant difference between the change in average light absorbance of the non-irradiated group and each of the other groups. This agrees with other studies (Shin & Pyun, 1997; Amanat et al., 2020), which obtained similar results with *Lactobacillus plantarum, L. acidophilus,* and *L. casei* after certain durations of irradiation and radiation specifically between 15 and 30 minutes. Additionally, while we utilized a 10.5-GHz microwave transmitter, these studies showed that even 2.4-GHz microwaves can cause inactivation of the strains of *Lactobacillus* used, meaning a wide range of microwave frequencies may cause *Lactobacillus* death. Although we found no significant difference between the changes in absorbance among the three irradiated groups, our data shows that there is enough suggestion of there being a trend, which means our experiment may be worth conducting with a larger sample in the future.

Goldblith and Wang (1967) concluded that inactivation of *Escherichia coli* and *Bacillus subtilis* by exposure to microwaves is solely due to the thermal energy. However, Shin and Pyun (1997) found that the inactivation of *L. plantarum* irradiated with microwaves was greater than that of when the bacteria was exposed to conventional heating, meaning microwaves may have non-thermal effects on *Lactobacillus*. Shaw et al. (2021) found that the electric field generated by microwave radiation can disrupt the function of oxidative defense in bacterial cells by interacting with certain polar molecules on the cells' surfaces. Oxidative defense is a crucial mechanism used to counteract oxidative stress, which is the abnormal reduction of antioxidants or collection of reactive oxygen species (Birben et al., 2012). Oxidative stress particularly damages DNA (Gonzalez-Hunt et al., 2018), causing cell loss and impairing the ability of cells to replicate (Holmes & Cohen, 2014). This could explain the inactivation of the irradiated *Lactobacilli.*

The fact that our results align with those of Shin and Pyun (1997) and Amanat et al. (2020), who studied *Lactobacillus plantarum, L. acidophilus,* and *L. casei*, indicates that they may generalize to a wide variety of *Lactobacilli* strains. Also, since Shaw et al. (2021) discovered *Escherichia coli* and *Staphylococcus aureus* inactivation caused by microwave radiation, our results can be used to suggest that microwaves at a frequency allowing them to penetrate the human body could slow the growth of gut microbiota responsible for maintaining proper gut health. This may raise a concern as to whether technology that emits microwaves of similar frequencies is harmful to human health. An example of such technology is satellite television systems. These systems have a microwave frequency close to that of the microwave transmitter we used (Ohring & Kasprzak, 2015). Thus, further research could study the specific effects of devices like direct broadcast satellites on gut bacteria.

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