Journal of Applied Biological Sciences 9 (3): 45-48, 2015
ISSN: 1307-1130, E-ISSN: 2146-0108, www.nobel.gen.tr

Effects of Electromagnetic Waves Emitted by Mobile Phones on DNA of Bacteria

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Received: October 02, 2015
Accepted: November 11, 2015

Abstract
In this study, the effects of electromagnetic waves emitted by mobile phones on DNA of bacteria were searched. For this purpose, the obtained pure DNAs were exposed to electromagnetic waves emitted by mobile phone, and a sample was taken each hour and preserved in the fridge. By the end of 12 hours, these samples were taken and subjected to agarose gel electrophoresis operation. Prior to test, it was observed for control that the electrophoresis images of DNA samples not exposed to electromagnetic radiation emitted by mobile phones and gel images of DNA samples exposed to electromagnetic radiation emitted by mobile phones were the same, and within the frame of tests performed, it wasn't determined that the electromagnetic radiation emitted by mobile phones have significant effects on DNA.
Keywords: Mobile Phones, Electromagnetic Waves, Biological Effects, DNA.

INTRODUCTION

The DNA is known as macro molecules managing many biological facts in cells such as physiological, biochemical and genetic facts and playing an important role in transferring to future generations of this genetic information through heredity. The vital properties of DNAs and transfer of genetic information to future generations by them through heredity had increased the importance of DNA [1, 2]. Thus, while searching for the biologic effects of electromagnetic waves, it was dwelled at most on their effects on DNA. The studies regarding the effects on DNA of radiation emitted by low and high frequency electromagnetic waves had increased by the increase of devices which operate by electromagnetic waves and which enter daily lives [5, 6 - 20].

The increase of studies regarding rapid spreading of mobile phones and determination of the effects of radiation emitted by mobile phones had also accelerated the studies regarding effects on DNA of radiation emitted by mobile phones.

In a study performed, 900 MHz electromagnetic field was applied on the blood cells of human for two hours, and no direct or direct effect of radiation emitted by mobile phones could be determined in genetic aspect [19, 20]. Again in another study, it was examined whether the signals in radio frequency damages the DNA or not. For this purpose, 837 MHz TDM signal was applied to human blood cell through signal generator. The marker, whose SAR value is 1-10 W/kg, was applied for a period in between 3-14 hours at fixed temperature of 37 oC. As the result of the study, no distinct effect on DNA could be determined [21]. And in another study, it was examined whether the radiation emitted by mobile phones operating at 1800 MHz cause breaking of DNA or not. For this purpose, continuous marker whose SAR value was 2 W/kg, and frequency was 1800 MHz was applied. And then the mobile phone, where the 1800 MHz modulation was realized, was applied for 4, 16 and 24 hours. It was determined that the electromagnetic radiation emitted by mobile phones encourages the breakage of DNA [22, 23]. In another study, it was examined whether the electromagnetic field -whose frequency was 1800 MHz and whose SAR value was 3 W/kg- applied for 0, 1.5 and 4 hours on the lymphocytes taken from three healthy young donors affects the nucleotide sequence of DNA during replication and whether it opens the helical structure of DNA. As the result of the study performed, no significant effect was determined on DNA being exposed to electromagnetic field [24]. And in a study performed, the damages caused on DNA by the radio signals with a frequency of 1800 MHz being used in GSM systems, and their effects on protein expression were examined. For this purpose GSM signal, whose SAR value vary in between 1.2 - 3 W/kg and which is modulated by 217 Hz at 1800 MHz, was applied to epithelium cells being available in human eye. As the result of implementation, two different conditions were determined. In the first determined condition, it couldn't be determined that the marker -having a SAR value of 2 W/kg and a frequency of 1800 MHz- causes any damage on DNA. And in the second case, when the signal –having a SAR value of 3 W/kg and a frequency of 1800 MHz- was applied for 60 minutes, it was observed that determinable damages was caused on DNA [25].

As also observed from the studies performed, while it was determined by the result of some researches that electromagnetic radiation damages the DNA, no damage could be determined in some studies. The main reason of this condition is due to the physical and pathologic activity of DNA being different within the cell [26]. The electromagnetic waves being applied on biological systems being different, the examined biological systems being involved in different activities during test arises from the condition that the applied electromagnetic radiation interact differently by he live cells [19, 20, 27].

In this study, the effects of electromagnetic radiation emitted by mobile phones on DNA were searched. The images of DNA samples exposed to electromagnetic radiation were obtained by electrophoresis method. The most preferred method for the determination of the effects of electromagnetic radiation emitted by mobile phones on the plasmid DNA is electrophoresis [28]. For this purpose,

E. coli pUC18 plasmid DNA was used. The bacterial culture was developed, and its DNA was separated by the Midiprep method. In electrophoresis, electromagnetic radiation was applied for 10 hours, and samples taken each hour were displayed.

MATERIALS AND METHODS

Mobile Phone Testing Setup

In the determinations of the biological effects of electromagnetic waves, a testing setup as in Figure 1 was established. In the test, a mobile phone, which was operating at GSM 1800 MHz and whose antenna output power was 1 mW, was used. It was enabled for calls to be made through mobile phones. The reason of it was the operation of mobile phones as DTX (Discontinuous Transmission). DTX systems are ones which enable data transmission only during call. As there is no data transmission at other times on these system (when there is no call), the receiver party doesn't hear anything (data transmission doesn't realize). Thus, information marker was sent in the test for the realization of modulation during call. This information marker of 4.6 ms is being compressed to 0.58 and being sent through the mobile phone. Mobile phones and base stations send a pulse of 0.58 ms once in each 4.6 ms (in other words 217 pulse/second = 217 Hz). Thus, energy transfer is also being realized [29].

The SAR value generated by the mobile phone being used in the test at 2.2 cm distance during use around the ear is 0,76 W/kg [3].

The antenna of mobile phones being used in the formed mobile phone testing setup was placed at special locations in a manner that they would be directed to the biological substances which would be subjected to radiation. Signal generator was connected to the audio input of the mobile phone. Then the testing setup was placed inside incubator for the heat –generated by the mobile phones during data transmission- not to change the ambient temperature, and for the heat to remain fixed. Randomly generated signals were applied to mobile phones placed in the incubator by the help of the computer used as signal generator, and the realization of data transmission was ensured.

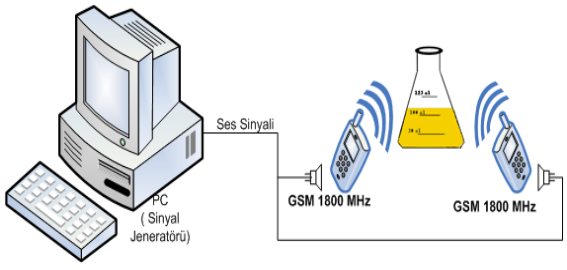

Figure 1 Demonstration of testing setup

Electromagnetic wave treatment of DNA

In this study, it was worked on *E. colip*UC *18* plasmid DNA. 2xYT agar medium, which was prepared in order to obtain culture from this bacterium –which is being taken commercially- was poured on petris. And then, smear inoculation was made on these petris by the help of loop, and they were kept waiting. The next day one colony from the bacteria cultivated in the petris –which were kept waiting for one night- was taken to 2xYT broth in which 100 µg/ml ampiciline was added, and it was kept for one night in shaking incubtor at 37 oC and at 150 rpm for incubation. *E. coli.* 1.4 ml culture, which was kept for one night and which included plasmid DNA, was taken to microcentrifuge of 1.5 ml, and DNA QIAprep®Midiprep kit was isolated by using QIAGEN [4].

In order to determine the purity and amount of the isolated DNA -obtained as the result of Midiprep prepared with a culture of 50 ml-, the obtained isolated DNA concentration was measured with spectrophotometer. For this measurement operation, 100 µl DNA was left in quartz spectro pan along with 900 µl pure water, and measurement was performed at OD_{260} and at OD_{280}. And then, the obtained DNAs –which were exposed to electromagnetic wave for 12 hours and whose samples were taken by each hour and were preserved in fridge- were subjected to agarose gel electrophoresis operation, and gel images were obtained.

RESULTS AND DISCUSSION

Gel images of various amounts of DNA obtained after Midiprep were obtained for the purpose of control of test. In the preliminary image of obtained gel, it was determined which DNA forms existed prior to test.

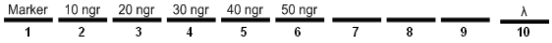

Figure 2 Preliminary image electrophoresis pattern (1), Marker; 10 ng Midiprep DNA; (3) 20 ng Midiprep DNA; (4) 30 ng Midiprep DNA; (5) 40 ng Midiprep DNA; (6) 50 ng Midiprep DNA; (7-9) commercial pUC18; (10) lambda marker

The samples for pits prepared in gel were placed in the order in Figure 2, and electrophoresis image was obtained as in Figure 3.

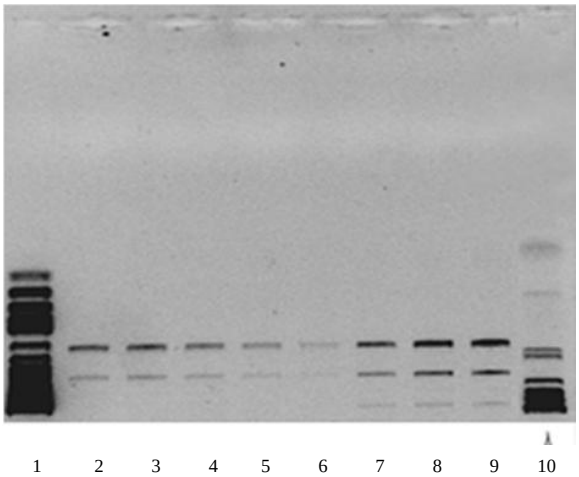

Figure 3. Isolated DNA gel image after Midiprep (1), Marker; 50 ngr Midiprep DNA; (3) 40 ngr Midiprep DNA; (4) 30 ng Midiprep DNA; (5) 20 ngr Midiprep DNA; (6) 10 ngr Midiprep DNA; (7-9) commercial pUC18; (10) lambda marker

As seen in Figure 3, two forms of DNA were observed in the samples, and three forms of DNA were observed in *pUC*18.

After these obtained results, 12x30 µl DNA sample was taken from among the samples within the tubes, and it was put in 12 units of PCR tubes. Moreover, the *pUC18, pKK223-3, pET41a, pET5a* –which were available in stock-

and these PCR tubes were then placed in the electromagnetic wave setup emitted by specially prepared mobile phones, and they were exposed to this electromagnetic radiation at 37°C for 12 hours. One PCR tube was taken in the fridge by the beginning of test, and then one PCR tube was taken from the radiation setup each hour and was stored in fridge.

By the end of 12 hours, PCR tubes -taken to the fridge- were subjected to agarose gel electrophoresis operation. Gel images obtained after electrophoresis were examined in order to determine the effects on DNA of electromagnetic radiation emitted by mobile phones.

$6\mu l\ dH_2O + 2\ SAB + 2\mu l\ \ DNA = 50\ ng$ was used from among samples exposed to electromagnetic radiation emitted by mobile phones. The samples were subjected to electrophoresis operation by agarose gel electrophoresis again in the order in Figure 4

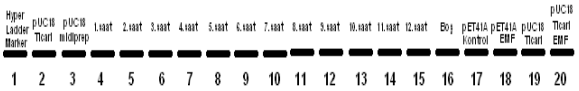

Figure 4. DNA electrophoresis pattern;(1) Markır (HyperLadder); (2) Commercially sold pUC18; (3) pUC18 obtained after Midiprep; (4-15) pUC18 after Midiprep exposed to electromagnetic radiation; (17) pET41a gene;(18) pET41a exposed to electromagnetic radiation; (19) pUC18 Commercial; (20) pUC18 exposed to electromagnetic radiation

This test was repeated for three times. The gel image obtained after the first repetition electrophoresis operation is given in Figure 5.

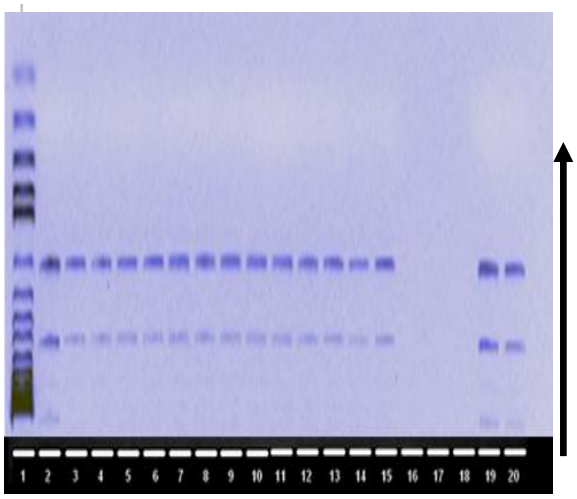

Figure 5. First repetition test results DNA electrophoresis gel image;(1) Markır (HyperLadder); (2) Commercially sold pUC18; (3) pUC18 obtained after Midiprep; (4-15) pUC18 after Midiprep exposed to electromagnetic radiation; (17) pET41a vector; (18) pET41a exposed to electromagnetic radiation; (19) pUC18 Commercial; (20) pUC18 exposed to electromagnetic radiation

The aforementioned test was repeated in order to determine the effects on DNA of electromagnetic radiation emitted by mobile phones. In the repeated test, the concentration of sample was increased for it to appear clearer than the DNA bands in the previous agarose gel electrophoresis image. For this, $4\mu l\ dH_2O + 2\ SAB + 4\mu l\ \ DNA = 50\ ng\ \ pUC18$ and $4{,}6\mu l\ dH_2O + 2\ SAB + 3{,}4\mu l\ commercial\ pUC18 = 50\ ng$ was used from among samples exposed to electromagnetic radiation emitted by mobile phones, from *pUC18*. The samples of the newly composed density were subjected to electrophoresis operation by agarose gel electrophoresis again in the order in Figure 4, and the images were obtained again. The obtained gel image is given in Figure 6.

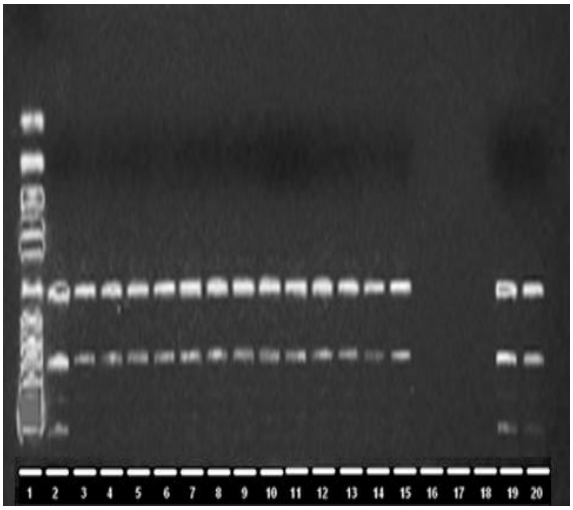

Figure 6. Second repetition test results DNA electrophoresis gel image;(1) Markır (HyperLadder); (2) Commercially sold pUC18; (3) pUC18 obtained after Midiprep; (4-15) pUC18 after Midiprep exposed to electromagnetic radiation; (17) pET41a gene; (18) pET41a exposed to electromagnetic radiation; (19) pUC18 Commercial; (20) pUC18 exposed to electromagnetic radiation

CONCLUSION

Consequently, the effects of electromagnetic radiation emitted by mobile phones on DNA were searched in this study. The images of DNA samples exposed to electromagnetic radiation were obtained by electrophoresis method. The bacterial culture was developed, and its DNA was separated by the Midiprep method. In electrophoresis, electromagnetic radiation was applied for 10 hours, and samples taken each hour were displayed. No change was determined in the DNA samples whose images were obtained after electrophoresis. It was observed that the electrophoresis images of DNA samples not exposed to electromagnetic radiation emitted by mobile phones prior to test for control and the gel images of DNA samples exposed to electromagnetic radiation emitted by mobile phones were the same.

Within the frame of tests performed, significant effects on DNA of electromagnetic radiation emitted by mobile phones were not determined.

Acknowledgements

Within the frame of the studies performed, many thanks to Prof. Dr. Dilek TURGUT BALIK and Asst. Prof. Dr. Venhar CELİIK who didn't hesitate in helping.

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