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Research Article

INPROVING OF THE QUALITY FOOD FOR ANIMALS BY PULSED POWER PLASMA DISCHARGE

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ABSTRACT
Soy beans powder mixed with water is a good food for animals. However, there are two problems with this brew. One is that soy beans powder is sunk down to fast. Parts of soy beans powder are too big and too heavy. Animals do not eat soy beans powder because after a few minutes (around 3min) is sunk down and soy beans are on the bottom case. Another negative point is a quick growth of mold, especially during summer when the temperature is highest. Mold is making food unhealthy and causes unpleasant smell. After mold appears it is difficult to clean the case. One of the solutions to eliminate these problems is to use pulse power plasma discharge and the second solution is ultra sound treatment. It was observed that pulse power discharge can decrease the size of soy beans powder a few times. Another advantage of such experiments was that the pulse power discharge killed bacteria and viruses. After our experiments we did not observe mold growing. Using pulse power discharge we can decrease sinking speed by about ten times. Ultra sound generation is useful and can decrease sinking speed even more, compared with pulse power discharge.

Keywords: ultrasounds, pulsed power plasma discharge, OH radicals, change of size, animals food.

INTRODUCTION

Pulsed power plasma discharge and ultrasounds treatment was used for the elimination two problems: the sinking of soy beans powder too fast and quick mold growing (especially during summer when the temperature is highest). The mold makes food unhealthy and causes unpleasant smell. During plasma generation in water ozone and OH radicals are generated [1–5]. OH radicals kill all the bacteria and improve the quality of food. Free radicals and OH radical are very strong oxidizers and are chemically very active[6]. During our experiments two kind of reactors were used. The first one was pulsed power plasma generation with a pin and plate electrode and the second one was an ultrasound generator. Both results differed by treatment time and input energy. Input energy is very important because it determines the costs [7]. After pulsed power discharge plasma treatment and after ultrasounds treatment part of soy beans powder was observed and measured with a microscope. It was observed that the shape and size of soy bean powder are smaller than before the experiment and we could not any bacteria inside [8–11].

EXERIMENTAL APARATUS AND PROCEDURE

An experimental set-up consisting of a discharge reactor and electrical circuit is showed in Figure 1. The diameter of pin copper electrode was 0.9 mm. Figure 2 shows the electrode and Figure 3 presents the configuration of electrodes.

All the experiments were carried out at atmospheric pressure. The current and voltage sig-

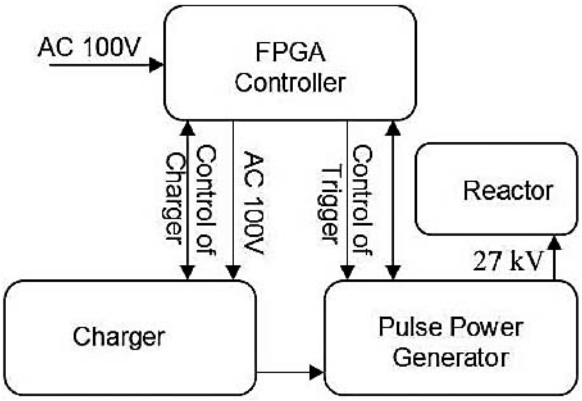

Fig. 1. Experimental setup

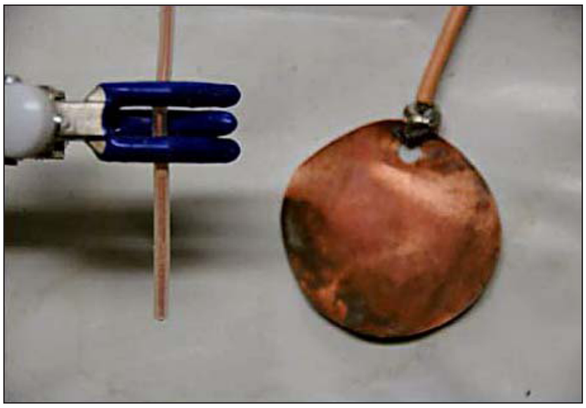

Fig. 2. Grand and high voltage electrodes

Fig. 3. Electrodes configuration

nals were processed by a digitizing oscilloscope Tektronix DPO 71604 Digital Phosphor Oscilloscope 520A (4 channels, 16 GHz, 50 GS/s) and the voltage at the reactor was measured by a high voltage probe Tektronix P6015A. The discharge current through the coaxial electrode was measured using a Rogowski coil (MODEL 6600, voltage per ampere 0.1 Pearson current monitor, Pearson Electronics, Inc., Palo Alto, CA, USA). During the experiments tap water was used. Water temperature was room temperature. During the experiment we used 9 grams of soy bean powder mixed with 91 ml water. A pulsed power generator (MPC 3000S-5J) system (developed at the Plasma and Pulsed Power Laboratory, Kumamoto University, Kumamoto, Japan) was used during our experiments. Figure 4 shows our pulse power generator.

Pulse frequency range was 50 pps (part per seconds). Charging energy was 5 Joules per shot. Figure 5 shows wave forms voltage and current of our pulse power generator. The applied voltage was 27 kV and current 10A.

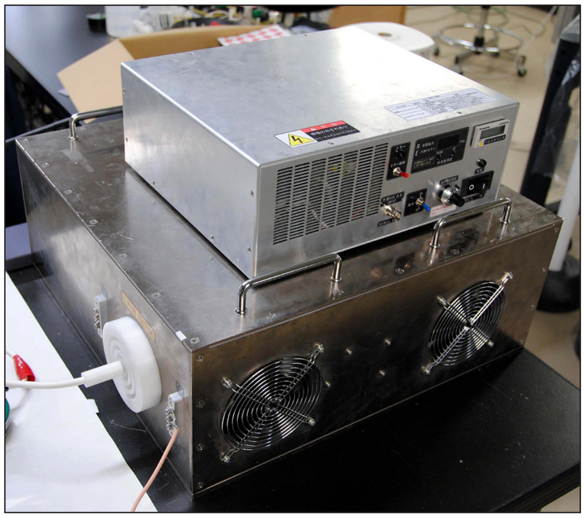

Fig. 4. Pulse power generator (MPC 3000S-5J)

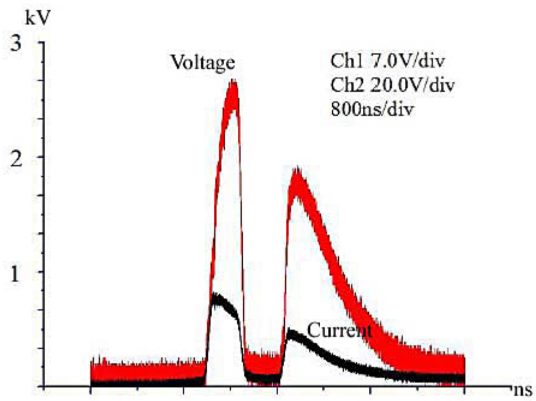

Fig. 5. Waveforms of the applied voltage to and the discharge current in the copper pin electrode

We observed the structure of soy beans powder using a microscope. It was Fluorescent Stereo Microscope Leica M165 FC. The Leica M165 FC fully panchromatic corrected stereo microscope with 16.5:1 zoom optics resolves structures down to 1.1 micron for detailed fluorescent imaging. We tried to decrease the size of soy bean powder using a standard coffee grinder.

RESULTS AND DISCUSSION

We conducted the first experiments with 50 pps, 5 J and for 20 seconds. Input energy in this case was 5000 J. Next we measured the speed of soy beans powder sinking, compared with the control tank. In the control case after 3 minutes most of soy beans powder sunk down. In the case after pulse discharge treatment most of soy beans powder sunk down after 10 minutes. The room temperature was around 30 °C and soon we observed mold growing in the control tank case. Molds are fungi that grow in a form of multicultural filaments called hyphen. A connected network of these tubular branching hyphens has a multiple, genetically identical nuclei and is considered a single organism, referred to as a colony. In contrast, fungi that grow as single cells are called yeasts. Molds are considered to be microbes and do not form a specific taxonomic or phylogenetic grouping, but can be found in the divisions of Zygomycota, Deuteromycota and Ascomycota. Some molds cause disease or food spoilage; others play an important role in biodegradation or in the production of various foods, beverages, antibiotics and enzymes. In the case after pulse discharges treatment we can not see mold. Figure 6 shows two cases.

During discharges OH radical and free radicals are produced in the water. Free radicals and OH radical are very strong oxidizers and chemically are very active. They killed bacteria and viruses in the water and in the soy beans powder and after a few days we could not see any mold. We could see three different layers of soy beans powder in the case after discharge treatment.

During discharges (plasma discharges and shock wave) destroyed soy beans powder and different size sunk down with different speed. We took samples for the microscope observation from each sunk down parts (according to Figure 7). Another important parameter was shock wave. Shock wave causes high pressure and crashed soy beans powder. During discharge we can see bubbles are produced and the mixture was mixed with a pulse discharge (Figure 8). First layer form the bottom part is presented in picture 9. We observed that the average size of soy beans powder was around 300 – 400 μm. The biggest sizes were about 500 μm. These parts were heavy and sunk down first. Next observation layer shows (Figure 10) that average size of soy beans powder were less than 100 μm. The last layer was sunk down

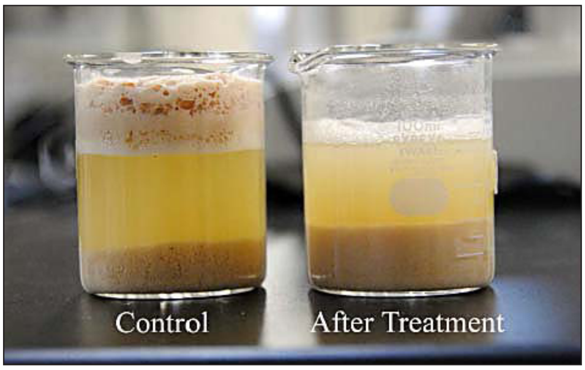

Fig. 6. Mold growing after experiment

Fig. 7. Pulse power discharge

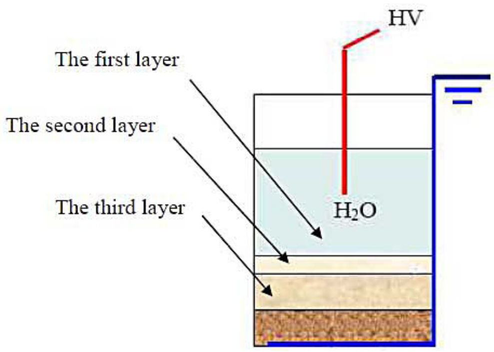

Fig. 8. Three layers of soy beans powder after pulse power generated

Fig. 9. First layer of soy beans powder 20 seconds 50pps (5J/shot)

really slowly. The average soy beans part were around 50 µm or less then 50 µm (Figure 11). The mixture of water and soy beans powder became more homogenous.

Figure 12 shows soy beans powder from the control tank. We can see very big sizes of soy beans and they are connected together and formed such shapes as colonies.

We measured sinking time. In the control tank and after 3 minutes we saw around 38 ml of soy beans powder sunk down. In pulse power discharge treatment experiment the sample was still homogenous. After about 35 minutes we saw in the discharge treatment case soy beans powder sunk down (about 33 ml). Sunk down time increased ten times compare with control tank. After 62 minutes sunk down level became the same it both cases. Figure 13 shows these experiments.

The next experiments were for decreasing sinking speed of soy beans powder. Our samples were 9 grams soy beans powder mixed with 91 ml of water. The first (form left) was the control tank. The second one was soy beans milled without discharge treatment. In the third sample shots were applied: 50 pps (5J) per 30 seconds (input energy was 7500 J) and in the third sample before mixing with water soy was grounded in a coffee mill for 4 minutes and pulse power discharge was applied. After pulse power discharge was applied to the third sample we were measured sinking time. 2 minutes after in the control thank we can see around 38 ml of soy beans powder sunk down Figure 14. 23 minutes after the experiment we observed that the powder was going down in the milled tank soy beans and volume was around 85 ml (Fig. 15).

All of the powder in the control tank sunk down after 25 min. We could see grounded powder was going to down part 25 minutes after mixed with water. Grounded powder with discharge treatment stared sinking after around 28 minutes after discharge (value of sunk down powder was 72 ml, Figure 16). With time, soy beans powder were going down more and the volume increased. 24 hours later we can see in the control tank was around 45 ml sunk down soy beans powder, milled tank was 69 ml and in the milled with discharge treatment tank it was 60 ml (Figure 17). Next day we took samples of each powder from each tank and we made microscopic observations. Figure 18 it is the control tank. We can see that powder size was over 300 µm. Next, Figure 19 is milled soy beans powder and there

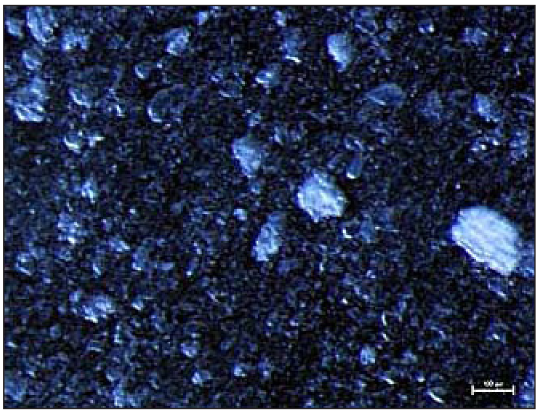

Fig. 10. Second layer of soy beans powder 20 seconds 50pps (5J/shot)

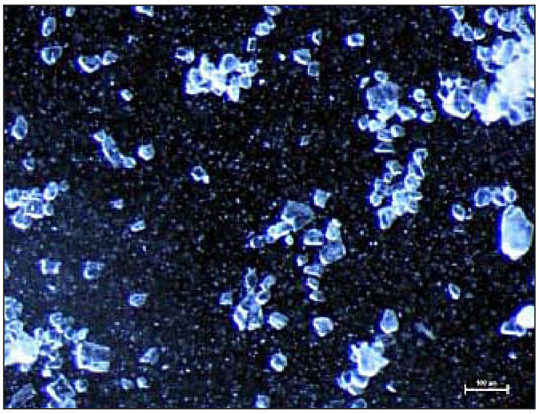

Fig. 11. Third layer of soy beans powder 20 seconds 50pps (5J/shot)

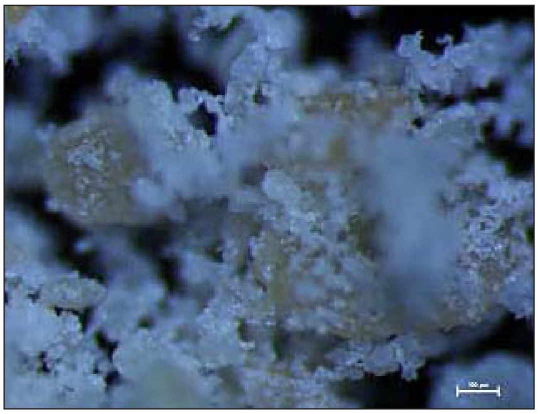

Fig. 12. Soy beans powder without discharge (control thank)

smallest size was around 50 µm. In the milled with discharge treatment case soy beans powder size were around 10µm. It is showed in Figure 20.

According to the experiments data we can see that pulse power discharge it is good way to decrease sinking speed and good protection of mold growing. If we want to decrease sinking speed we must decreased the size of soy beans powder. According to the next experiment, we should not

3 minutes

35 minutes

62 minutes

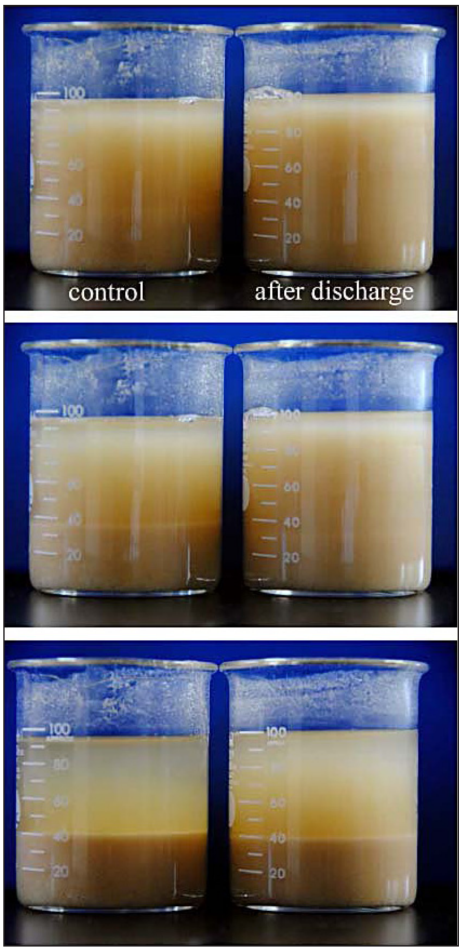

Fig. 13. Sinking time

Fig. 14. Sinking level after 2 minutes

Fig. 15. Sinking level after 23 minutes

Fig. 16. Sinking level after 28 minutes

Fig. 17. Sinking level after 24 hours later

Fig. 18. Microstructure – control tank

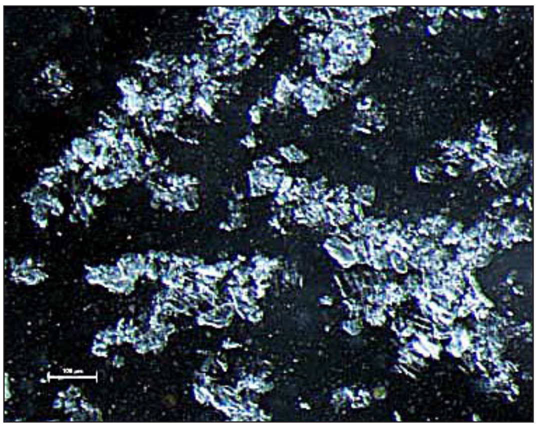

Fig. 19. Microstructure – middle tank

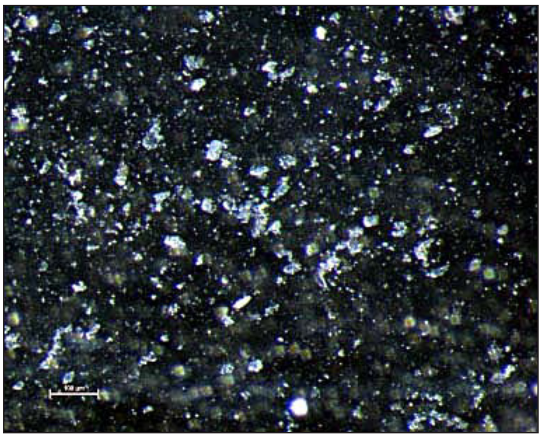

Fig. 20. Microstructure – middle tank with discharge

keep soy beans powder in the water before discharge applied. Soy beans powder absorbed water and became more flexible. The effect of applied discharge decreased. Figure 21 shows experimental results. The first sample (from left site) was soy beans powder kept in the water for 24 hours before pulse discharge application, second one 3 hours, third 2 hours, fourth 1 hour and last one it was control tank. After 3 minutes we could see in the control tank soy beans powder sunk down 42 ml and in the 24 hours tank, around 30ml. Next were sank down soy beans powder in 3 hour tank (40 ml, 6 minutes after discharge) and in the case two and one hour keeping soy beans powder in the water before experiments the start sunk down 7 minutes after the experiments and the value were same 45ml. According to this data it is more effective to make discharge immediately after mixing soy beans powder with water.

The next experiments concerned making homogenous mixture of water with soy beans powder using ultrasounds generator. We used two types setup during three experiments. The first one was applied and the input power 80W was applied 1 minute. Input energy was 4800J. During this experiment ultrasounds amplitude was 86.8µm, the horn was 1cm deep in mixture. The experimental setup is showed in Figure 22. Mixtures were same as during pulse power discharges (9 grams of soy beans powder plus 91 ml water).

a)

b)

c)

Fig. 21. Sunk down level after: a – 3 minutes, b – 6 minutes, c – 7 minutes

After the experiment we measured the speed of sinking of soy beans powder. After 4 minutes we saw 93 ml of soy beans powder was sunk down (Fig. 23). With the time soy beans powder sunk down more and after 30 minutes sunk down level was 70ml (Fig. 24) after one hour it was 60ml (Fig. 25).

We can say that this result was similar compared with milled and discharge treatment case. Next we did experiments in a different setup: 120W (input energy was 14 400 J), the amplitude

Fig. 22. Ultrasounds treatment setup

Fig. 23. Sinking level after 4 minutes

Fig. 24. Sinking level after 30 minutes

Fig. 25. Sinking level after 1 hour

Fig. 26. Sinking level after 30 minutes

Fig. 27. Decomposition of sunk soy powder after 1 hour

Fig. 28. Sinking after 24 hours

of ultrasounds was 86.8μm, horn was 2 cm deep (put in) in mixture and treatment time was 2 minutes. Such parameters increased efficiency. After 15 minutes we observed soy beans powder star going down. The level of soy beans powder was 95ml. After 30 minutes sinking level of soy beans was 88ml (Fig. 26). After one hour sunk down level of soy beans powder was 87 ml (Fig. 27)

After 24 hours the levels of soy beans powder was (Fig. 28):

- In the 80W applied tank and 1 minute was 52 ml;
- In the 120W applied tank and 2 minutes was 80 ml.

According to this data in the first case during 24 hours soy beans sunk down 48 ml and in 120W case just 20 ml.

CONCLUSIONS

1. The results showed that the pulse power discharge is useful to decrease sinking speed of soy beans powder.
2. The results also showed that the size of soy beans powder is a very important parameter.
3. We observed that pulse power discharge can decrease soy beans powder size by a few times.
4. Pulse power discharge killed bacteria and viruses and we can not observe mold growing after the experiments.
5. Using pulse power discharge we can decrease sinking speed by about ten times.
6. Ultrasounds generation is useful and can decrease sinking speed more compared with pulse power discharge.
7. Pulse power discharge and ultrasounds treatment makes mixture water with soy beans powder more homogenous.
8. According to the experiments data it is easier to decrease soy beans powder size immediately after mixing with water.
9. After pulse power plasma treatment and ultrasounds treatment mixture water and soy beans powder became more homogenous.

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