Development of dielectric barrier discharge for reducing microbial contamination in pepper (*Piper nigrum*) and sesame (*Sesamum indicum* Linn.) powder

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Abstract. This research is designed to determine the efficacy of DBD plasma to reduce the microbial contamination of pepper and sesame powder. The AC high voltage power supply was used with voltages of up to 20 kV and the frequency of 5.5 kHz was applied to the DBD. The gap of DBD electrodes was set at 5 mm. In raw initial samples, the total aerobic count of pepper (*Piper nigrum*) was found at quite a high level at 5.40 x10^5 CFU/g. Coliform bacteria was also found in both the sesame (*Sesamum indicum* Linn.) powder and pepper (*Piper nigrum*) powder. Both kinds of samples were treated with plasma for 2, 4, 6 and 10 minutes. Results indicated that plasma treatment at 2-10 minutes reduced the total aerobic count of pepper allowed to achieve the acceptable microbial level for spices. The plasma treatment times in this experiment were also effective in reducing faecal coliform bacteria in both pepper and sesame powders (MPN/g <3) as indicated in the standard. Plasma from dielectric barrier charge can reduce *Staphylococcus epidermidis* in sesame powder which was artificially contaminated with 3.50 x 10^2 CFU/g resulting in 0.15-0.5 log cycle reductions of microbial load.

1. Introduction

The Dielectric Barrier Discharge (DBD) Device is a cold plasma generator using electrodes. Research on the plasma generator, DBD was proposed for the first time by Ernst Werner Von Siemens in 1857 with the intention to create ozone generators [1]. In 1997 Kogelschatz and group showed that plasma can occur from the shaping of electrodes. Electrode and double dielectric plates suit both flatbed and cylinder shapes [2] because of the format and structure of the device affecting plasma generation as well [3,4]. Wang and group (2012) made a comparative study of the shapes of the different electrodes and the effect on electrical properties. It found that the shape of the electrodes had different effects on the electrical attributes [5]. There have also been studies on the type of gas that is an intermediary in the air [6,7] in recent years, Okazaki and group studied the electrical properties of the gas type occurs when using the medium as air. Argon, oxygen and nitrogen by using a 50 Hz frequency, where the

atmospheric pressure is found that when using any type of gas different intermediaries affect electrical characteristics occurring electrical characteristics of various types of gas [8], this is a major feature in sterilization [9]

The report of Misra N.N. et al in 2014 [10] tests the killing of the bacteria, fungi, and yeast contamination on the surface of fresh strawberries.

This study is a pilot project to test the capability of plasma sterilization to kill microorganisms in dried food products. The results are expected to contribute to the development of plasma sterilization devices for food and agricultural products.

2. Materials and Methods

2.1. Dielectric barrier discharge treatment

DBD Plasma generator is used with an AC high voltage power supply. The main structure of the plasma consists of two plate electrodes, two dielectric plates, and a generator. The gap between the two dielectrics is 5 mm. Thus, due to the narrow space available, the size of the samples that can be irradiated is limited. The AC high voltage power supply was used with voltage up to 20 kV and the frequency of 5.5 kHz is applied to DBD. The components of the DBD are shown in Fig. 1.

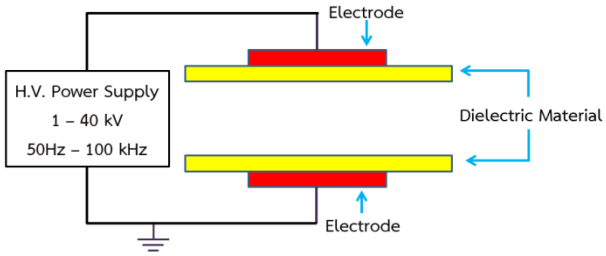

Figure 1. Diagram shows the structure of the main generator, the plasma electrode contains the 2 electrodes separated by dielectric sheet Trigg (Dielectric material) at least 1 layer.

2.2. Sample preparation

Each 10g of sesame powder and pepper powder samples were packed inside of polypropylene (PP) sealing with size 3 inch. x 2. 5 inch. In sesame samples, the artificially contamination of *Staphylococcus epidermidis* at level of 3. 50 x 10^2 CFU/g of dry sample were added before plasma treatment. Both of sample were treated with plasma at 2, 4, 6 and 10 minutes by 3 replications.

2.3. Microbial analysis

The microbial study was done to enumerate the total aerobic plate count **(**CFU/g**)**, total yeast and mold count **(**CFU/g**)**, Coliform bacteria **(**MPN/g**)**, *Clostridium perfringens* **(**CFU/g**)** [11–13] and *Escherichia coli* **(** MPN/ g**)** [14] were determined**.** All test were run in duplicate samples and mean values were used**.**

3. Results and Discussions

The efficacy of DBD plasma to reduce the microbial contamination of pepper and sesame powder with the AC high voltage power supply is applied to DBD. The sesame powder and pepper powder samples are from a market in Pathumthani, Thailand. The microbial contamination in pepper sample of untreated plasma exhibited high level. The results showed total aerobic plate count and fecal coliform

bacteria were exceed than the criteria of microbial level in spices as indicated in the standard (TCPS 491-2557). Non-treated samples were contaminated with various strains of bacteria including spore-forming bacteria such as *Bacillus* spp., the normal flora microorganisms in soil. Microorganisms are most resistant with the sanitizer, disinfectant, chemical substances, heat treatment or irradiation with spore forming conditions. However, spices are heat sensitive products, thus the application of heat treatment or steam can cause alteration of aroma and odor. In this study, non-ionizing radiation from dielectric barrier charge at plasma treatment times 2-10 minutes could be reduce total aerobic plate count and fecal coliform bacteria lead to acceptable of microbial level as in the standard (table 1). In untreated sesame sample, there are also number of detected fecal coliform bacteria exceed the standard. However, there were no found *E. coli* in both of untreat peper and sesame. The plasma treatment can reduce all of contamination of fecal coliform bacteria as indicated in the standard. Gram-positive coccus, *Staphylococcus epidermidis* are made in the round include artificial contamination of low levels (less than 500 CFU/g). Plasma reduces down some approximately 0.15-0.5 log (CFU/g).

Table 1. Results of microorganisms in pepper powder and sesame powder with plasma treatment.

Samples	**Type of microorganisms**	**Treatment**				
		control	**T1**	**T2**	**T3**	**T4**
Pepper powder	Total aerobic plate count (CFU/g)	5.40×10^5	2.80×10^5	3.80×10^5	3.20×10^5	3.00×10^5
	Total yeast and mold count (CFU/g)	60	<10	50	10	20
	Coliform (MPN/g)	23 -75	< 3	< 3	< 3	< 3
	E. coli (MPN/g)	< 3	< 3	< 3	< 3	< 3
	C. perfringens (CFU/g)	<10	<10	<10	<10	<10
Sesame powder	Total aerobic plate count (CFU/g)	9.0 x 10	ND	ND	ND	ND
	Total yeast and mold count (CFU/g)	10	<10	<10	<10	<10
	Coliform (MPN/g)	9.2 - 23	< 3	< 3	< 3	< 3
	E. coli (MPN/g)	< 3	< 3	< 3	< 3	< 3
	C. perfringens (CFU/g)	<10	<10	<10	<10	<10
	Total aerobic plate count (CFU/g) (contami-nation of *S. Epidermidis*)	4.10×10^2	2.00×10^2	2.90×10^2	1.70×10^2	1.30×10^2

Note:
T1: 2 minutes of plasma treatment,
T2: 4 minutes of plasma treatment,
T3: 6 minutes of plasma treatment,
T4: 10 minutes of plasma treatment.
Reference of pepper powder is TCPS 491-2557: Total aerobic plate count < 5.0×10^5 CFU/g, total yeast & mold count < 100 CFU/g, Coliform (MPN/g) < 3, *C. perfringens*: not found (per 0.01 g).

4. Conclusions

Dielectric discharge plasma treatment in this experiment could be effective in reducing microbial contamination in thermosensitive materials such as spices**.** In pepper and sesame powder, most of effective mean were found in gram negative-coliform bacteria**.** However, the efficacy of plasma from

dielectric barrier charge for the reduction of various types of microbial contamination in spices could be determined in the further studies**.**

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6. References

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