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EFFECTS OF THE ATMOSPHERIC NON-THERMAL PLASMA JET ON THE NUTRIENT FACTORS AND MICROORGANISMS OF RAW MILK

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Abstract

Sterilization of raw milk is necessary because microorganisms in raw milk negatively affect the quality of milk and it can cause some diseases.Non thermal atmospheric plasma contains ultraviolet photons and reactive neutrals such as radicals, excited and ground-state molecules which are very effective for sterilization. In this study a plasma jet as a source of non-thermal glow discharge has been designed and operated at 2*2* kHz.Raw milk wastransferred to the plasma reactor and the cold plasma jet was applied. It was concluded that the cold plasma jet is very usefulin sterilization of raw milk under ambient temperatures.Also the application of the cold plasma jet is a very fastthat operatesat low temperature with noexpensive initial investment.During applying the plasma jet on raw milk, it might be placed in strong electric field and numerous reactive gas species that could a negative effect on nutrient factors quality. It was found that the nutrients in milk are significantly reduced after the plasma jet application.

Keyword: raw milk, Non thermal plasma, Plasma jet, Sterilization,nutrient factors.

1. Introduction

Microorganisms in raw milk negatively affect the quality of milk and dairy products and may affect the health of customers. Some of serious diseases caused by milk include malaria,tuberculosis and typhoid [1]

Several methods exist for sterilization of raw milk, including thermal and non-thermal methods.Thermal pasteurization and sterilization is a well-known method for reducing or killing bacteria. However, when the operating temperature is sufficiently higher, these applications have adverse effect both nutritional and organoleptic properties.Non-thermal applications like UV and ozone treatments, beta and gamma irradiations, high hydrostatic pressure, pulsed electric field and power ultrasound are limited in action and involve an expensive initial investment.

In recent years, plasma research has expanded rapidly in various fields such as ecology, health, materials, food industry and biomedical studies [2, 3]. Plasma is classified according to its temperature of ions, neutrons and electrons as “thermal” or “non-thermal”. In case of thermal plasma, the heavy particles and the electrons are in same temperature whereas in the case of non-thermal plasma electrons are much hotter than the ions and neutrals; also these heavy particles are close to room temperature. [4]. Cold atmospheric plasma (CAP) can be generating by microwave frequency, radio frequency, high voltage AC or DC [5]. Cold plasma contains ultraviolet photons and reactive neutrals such as radicals, excited and ground-state molecules which are very effective for sterilization. [6]. in recent years, CAP has received special attention in the field of food industries due to the non-thermal, economical and environmentally friendly nature of this technology. The usage of CAP for food industries have been indicated for food sterilization [7], toxin elimination [8], enzyme inactivation [9], waste water treatment [10] and food packaging modifications [11]. In the field of food processing, CAP has been shown to be a good candidate for killing and sterilizing food-borne pathogenic microorganisms such asSalmonella typhimurium [12], Escherichia coli [13], Listeria monocytogenes [14], andStaphylococcus aureus [15]. Quality is a very important factor for the success of any food product in terms of health and customer attraction [16].

The aim of this study is to investigateeffects of theplasma jet technology on the microorganisms that found in raw milk and analyze the impact of CAP processing on the quality andnutrient factors of raw milk.

2. Materials and Methods

In this study the plasma jet device was designed. This system was operated at 22 kHz as power. plasma temperature was measured byinfrared camera and obtained around T = 29˚C. Helium (He)was used as flow of gas.The plasma jet system and the action of the plasma jetunder Heliumgasare shown in Figure1.

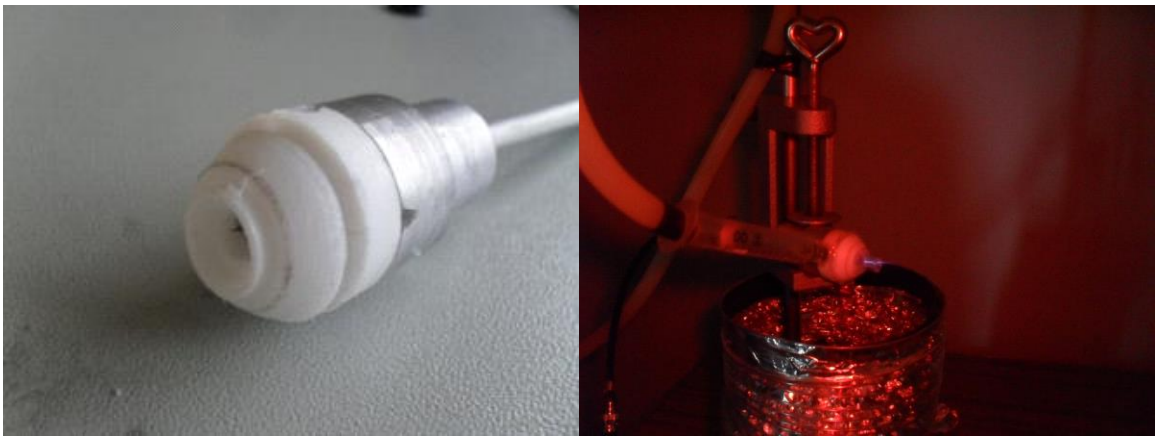

Fig1.The Plasma jet device (left) the plasma jet works with Helium gas (right)

50 Raw milk as sampleswere collected from the local supermarkets.Samplesweretransferred to the laboratory for quality andmicroorganisms analysis.Raw milk sampleswere analyzedfor quality valueand total viable bacterial count (TVBC), total coliform count (TCC) and presence of severalpathogens.After collecting data, the plasma jet was applied to raw milk samples for 3 minutes, and then sampleswereanalyzedagain.The power rate of theplasma jetwas 22 kHZ.The experiment was performed in laboratory condition.A schematic diagram of the experimental setup used forsterilization raw milk by the cold plasma jet is shown in figure 2.

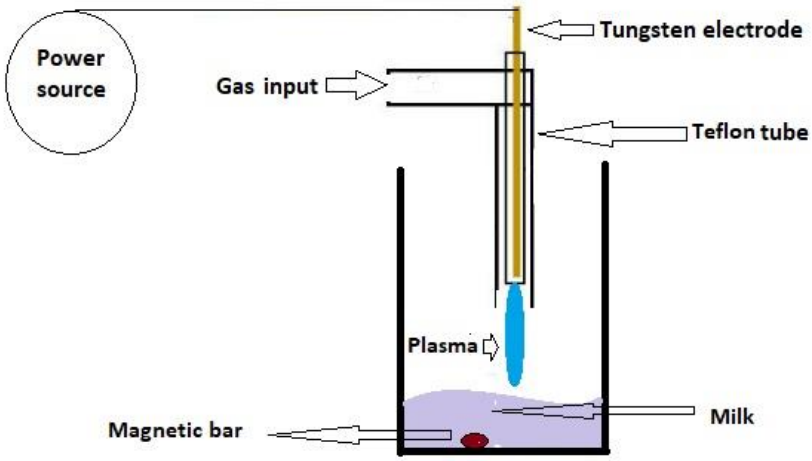

Fig2. A schematic diagram of the experimental setup

The magnetic bar inside milk was causedmilk to be uniformly exposed to the cold plasma jet radiation.

3. Result and Discussion

This study isinvestigated a total of 50raw milk and 50 milkafter plasma application to assess microbiological quality. Also effects of the plasma jet on the qualityproperties of raw milk during treatmentare analyzed.The lab analysis

recognizes presence bacteria like coliform and other in milk samples. Theaverage count of analyzed raw milk and milk which was treated bytheplasma jet is presented in Table 1.

Table 1. Total average bacterial counts (cfu/ml) and coliform counts (cfu/ml) in raw milk and milk which was treated bythe plasma jet.

Raw milk (n = 50)		**Milk treated bythe plasma (n = 50)**	
Average TVBC (cfu/ml)	**Average TCC (cfu/ml)**	**Average TVBC (cfu/ml)**	**Average TCC (cfu/ml)**
3.7×10^4	2.6×10^1	2.6×10^2	0

Raw milk samples were infected with several pathogenic bacteria such as Salmonella species, Escherichia coli, Vibrio species and Shigella species whichthe presence of these species indicates low quality milk samples.Presence of pathogenic bacteria in different milk (raw milk and milk which was treated by the plasma jet) samples are present in table 2.

Table2. Summary of the results of pathogenic bacteria analysesof raw and milk that was treated by the cold plasma samples.

Number of samples infected with pathogenic bacteria		
Bacteria	**Raw milk (n=50)**	**Milk treated by the plasma jet (n=50)**
Salmonella	3	0
E. coli	26	3
Vibrio spp.	1	0
Shigella	5	2

As we can see in table 1 and table 2, the atmospheric cold plasma jet can be a good candidate for bacterial decontamination and sterilization of raw milk.
Duringapplying the plasma jet on raw milk, milk might be placed in strong electricfield and numerous reactive gas species that could an adverseeffect on organoleptic and nutrient factorsquality.A summary of effects of the plasma jet on raw milknutrient factorsis presented in Table3.

Table3. Effects of theplasma jet on raw milk nutrient factors.

Nutrient Factors	**Raw Milk**	**Milk was treated bythe plasma jet**
B-Complex Vitamins	100% Active	41% Reduction
Vitamin E	100% Active	16% Reduction
Vitamin C	100% Active	38% Reduction
Vitamin A	100% Active	29% Reduction
Calcium	100% Active	24% Reduction
Iron	100% Active	62% Reduction
Zinc	100% Active	64% Reduction

As we can see in Table 3, the nutrients in milk are significantly reduced after the plasmajet application.

4. Conclusion

The plasma jet device was designed to investigate theeffects of nutrient factors andthe efficacy of sterilization process on raw milk. Results indicatethat the plasma jet can be a good candidate for killing bacteriaand sterilizing

milk process.Also the nutrients in milk are sufficiently reduced after the plasma jet application.Most of the experimental research is widely focused on killing bacteria with limited importance on food quality. It is important that understanding of the effects of cold plasma technology on the qualitypropertiesand nutrient factors of food.

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