THE USE OF ARGON COLD PLASMA FOR SURFACE MEAT DECONTAMINATION

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Abstract - Applications of cold plasmas seem to be a promising treatment for inactivation of bacteria on meat surface. Argon plasma produced under reduced pressure was used to investigate effects of a plasma on bacteria on surfaces of fresh meat and its influence on color and pH of meat. Psychrotrophs were reduced by one log unit. Reductions at the same level in meat exposed to argon plasma were obtained for a total viable counts and yeast and mould. Changes in color parameters of meat after plasma treatment were not statistically significant. The pH of meat was reduced as the result of plasma action.

Key Words – bactericidal effect, beef, cold plasma meat color, meat pH

I. INTRODUCTION

Low-temperature plasma, also known as cold plasma is a form of matter resembling partially ionized gas, which contains electrons, positive and negative ions, radicals, atoms or photons. Plasmas can be classified as low or high pressure. Low-pressure plasma is formed at or below atmospheric pressure [1].

There are several methods for generating plasma including thermal or photon ionization, or exposure to alpha, beta or gamma radiation. However, the most common method for plasma production is by use of electrical discharges [2]. It is possible to control parameters such as the working gas pressure and composition, structure of the electromagnetic field, discharge geometry and parameters of power supply [3]. Plasma techniques have various advantages for industry. They are environmentally friendly, work at low temperatures, are clean and safe for operators and allow treatment of a wide range of materials with different properties [4].

Plasma is used for decontamination of product surfaces. Application of this method is effective in the case of thermolabile substances and may be an alternative to conventional sterilization methods which require high temperature or chemical substances [5]. Mechanisms of plasma sterilization are due to the presence of reactive molecules in the plasma such as UV photons and radicals that lead to destroying the genetic material of microorganisms. Another mechanism of inactivation is the "erosion" of the microorganism atom by atom because of inside desorption caused by UV radiation. UV exposure leads to the rupture of bonds in the molecules that build the cell, with formation of low molecular weight volatile compounds such as CO and CHX. The other "erosion" mechanism is due to etching of the microorganisms. Free radicals oxidize cell during this process, which looks like a combustion reaction, whose products are carbon dioxide and water [5]. Plasma technologies are used in many fields such as metallurgy and materials science, medicine, and ecotechnique. Inactivation of gram-negative and gram-positive bacteria, yeast, fungi, biofilm formers, and endospores was proved by Moreau [2]. Recently, the possibility of using plasma has been investigated for inactivation of contaminated food products such as almonds [6], pericarps of mangos, melons [7] and surfaces of fresh cut fruit [8]. The possibilities for use of this technique have not been fully understood, and further study is required.

The objective was to check the possibility of meat surface decontamination by plasma of argon gas.

II. MATERIALS AND METHODS

The longissimus dorsi muscle (*musculus longissimus thoracis*) was collected from Meat Industry ‘‘Dworeccy’’ (Golejewo, Poland) plant.

The study was conducted with samples not exposed to the cold plasma and samples treated with cold plasma using a laboratory pulsed plasma reactor (Ertec, Wroclaw, Poland), where the plasma state is maintained by high-energy pulses of electric fields in a glass cupola with a capacity of 30 dcm^3 with the vacuum ≤ 1 mbar. Plasma is generated in the space between the electrodes of the discharge condenser located on a high voltage table, where the meat sample is placed. Electrical impulses were generated using a pulse generator operating at frequencies around 70 kHz and 1.2 kVA power, adjustable in the range 0.5 to 20 kV AC, with a minimum pulse repetition time of 0.5 s. Samples of meat were exposed to argon plasma treatment for 3 or 6 minutes at the final vacuum 0.9 MPa and gas pressure 0.6 MPa.

The microbial conditions of fresh meat and meat treated with cold plasma were determined. Psychrotrophs were counted after 10 days of incubation at 6 ^{o}C (ISO 17410:2001). Meat was minced and homogenized in sterile bags using a Stomacher. Samples were serially diluted and plated on agar with hydrolyzed casein, yeast extract and glucose. Total number of bacteria was determined by plate count at 30 ^{o}C (PN-A-82055-6). Series of dilutions were prepared and inoculated using a pour technique to a medium containing: tryptone, yeast extract, glucose and agar. After 72 h of incubation, bacterial colonies were counted. Sample preparation to determine number of yeast and mould was the same like for total number of bacteria. Test conditions were 25 ^{o}C of temperature for 72, 96 and 120 hours (PN-A-82055-16). Pour technique was used for inoculation in selective medium with yeast extract, α-D-glucose, agar, oxytetracycline and gentamicin. The results are presented as log cfu/g.

Instrumental evaluation of color parameters L* a* b* was performed by colorimeter MINOLTA CR-400. Parameters of color L*, a*, b * were measured, where L* indicates lightness, a* and b* are the chromaticity coordinates. The a* and b* indicate color directions: +a* is the red direction, -a* is the green direction, +b* is the yellow direction, and –b* is the blue direction. Colorimeter was calibrated to white master (Y = 93.8, x = 0.3158, y = 0.3323), before every measurement.

pH values were determined using pH-meter.

Statistical analysis of results was performed using STATISTICA 9. Multi-factorial analysis of variance (ANOVA) was used to test significant differences defined at p≤ 0.05 in Duncan's test.

III. RESULTS AND DISCUSSION

Survival curve of psychrotrophs, total number of bacteria and yeast and mould as a function of time of plasma treatment are illustrated in Fig. 1.

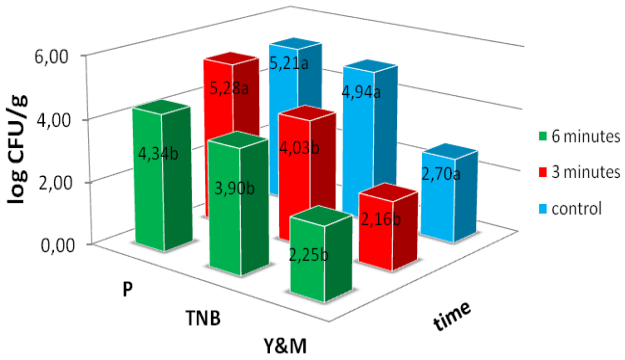
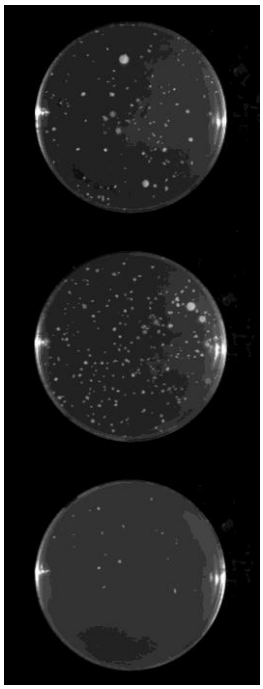


Figure 1. Reduction of psychrotrophs (P), total number of bacteria (TNB) and yeast and mould (Y&M)

All plasma treatments result in significant reduction of psychrotrophs, total bacteria, and yeast and mould. Psychrotrophs were little affected by active plasma after 3 minutes. After 6 minutes of plasma action the numbers of psychrotrophs hard decreased almost by 1 log cfu/g(Fig. 2). Total numbers of bacteria were reduced about 1 log cfu. A longer time of exposure caused greater inactivation of microbes on meat surfaces. Kim found that increasing power and longer time of plasma treatment can reduce pathogens on bacon surfaces [9]. Increasing reductions of *Listeria* were also obtained by increasing these two conditions of plasma treatment in sliced cheese and ham [10]. The significant effect of cold plasma on yeasts and moulds in meat was noted, but the reduction was not as great as reductions of bacteria. It should be possible to obtain better reductions with longer time of exposure or with other gases.



control

after 3 minutes of plasma treatment

after 5 minutes of plasma treatment

Figure 2. Plate counts of psychrotophs after various time of argon plasma treatment

Table 1 presents parameters, such as L*, a*, b* and pH, which were measured after cold plasma treatment. There were no significant differences between all color parameters, which means that argon plasma has not changed the color of meat. Rod obtained similar results, for changes in the quality of ready to eat meat after cold atmospheric pressure plasma treatment (2012). However, changes in pH value of meat during plasma exposure from 5.64 to 5.59 were noted. The differences were small, but statistically significant.

Table 1 Changes in color and pH parameters

Time	Parameters			
	L*	a*	b*	pH
Control	40.62[a]	6.28[a]	1.47[a]	5.64[a]
3 minutes	39.17[a]	6.15[a]	1.55[a]	5.59[b]
6 minutes	41.01[a]	6.05[a]	1.62[a]	5.59[b]

IV. CONCLUSION

It is possible to use argon as a gas in cold plasma generation, for effective reduction of surface contaminants of meat, without any changes in color parameters of product.

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