Assiut Vet. Med. J. Vol 59 No. 136 January 2013

EFFECT OF OZONE ON PRESERVATION OF CHILLED CHICKEN

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ABSTRACT

Received at: 10/12/2012

Accepted: 14/1/2013

The effects of gaseous ozone treatment on microbial counts and shelf life of chilled boneless chicken breasts as well as the influence of ozone on chicken quality properties such as color, odor, and texture were studied. Treatment of chicken breasts with 40, 60, and 70 ppm of gaseous ozone for 20 minutes efficiently reduced the populations of Total aerobic bacterial count, Coliforms, and Total mould counts and prolonged the shelf life of the chicken breasts more than 9 days. Immediately after ozone treatment panelists were unable to detect any color, odor or texture differences between the ozonated and control groups but with storage time ozonated groups seemed to had better quality as compared with non-ozonated group. Thus, at the ozone concentrations and exposure times used in this study, ozone effectively reduced the population of spoilage bacteria contaminating the chicken breasts yet had no adverse effects on their quality characteristics.

Key words: *Ozone, chilled chicken, bacterial count*

INTRODUCTION

Chicken meat have been widely consumed especially in the recent years due to its low fat content, fast preparation, and being more economical than red meat. Chicken meat is being sold as whole or as pieced depending on the demands of the consumers (Cevger *et al.*, 2002). There is an increase on the pieced chicken demand especially in large cities (Şengör, 2002).

Microorganisms that are present in chicken's interior organs, skin surface and feather, can easily contaminate the meat during poultry processing steps. Contamination is mostly seen at steps of scalding, plucking, and evisceration. In addition cross contamination in the carcasses, dirtiness of the processing water and equipments increase the contamination level in the processing steps (Tosun and Tamer 2000; Anonymous, 2002).

In order to prevent the microbial contamination of the chicken meat, methods like cooling, vapor-vacuum system, vapor pasteurization are being used (Allen *et al.*, 2000). Along with this, chemicals like chlorine and chlorine compounds (Erickson, 1999), ozone (Chang and Sheldon, 1989; Whistler and Sheldon, 1989), organic acids (Anonymous, 2002), trisodium phosphate (Rio *et al.*, 2006) are being widely used for decontamination purposes.

Food researchers are trying to discover an alternative cleaning and sanitizing agents effective against food spoilage and pathogenic bacteria, harmless to humans and environment. Ozone (O3) is effective against the majority of microorganisms tested by numerous research groups. Relatively low concentrations of ozone and short contact time are sufficient to inactivate Gram positive and Gram negative bacteria, fungi and fungal spores, parasites and viruses (Guzel- Seydim *et al.*, 2004), even though it does not leave any harmful residues due to quick decomposition to a non toxic product (O2).

Ozone is produced by passing gaseous oxygen through a high voltage electrical field at ambient or refrigerated temperatures (Graham 1997; Horvath *et al.*, 1985). The resulting gas is a more effective sanitizer than chlorine. Ozone has been used for decades in many countries, the USDA 1997 granted ozone, generally recognized as safe (GRAS)and in 2001 the FDA officially approved media containing ozone for use in the food industry, also for direct contact with food products, including fish, meat and poultry (Mielcke and Ried, 2004; Vaz-Velho *et al.*, 2006 and Zentox, 2007).

Ozone can be used in its gaseous or aqueous state; this flexibility makes it a viable option for application on easy to damage products (Perry and Yousef, 2011).

It has been proposed that ozone destroys microorganism by the progressive oxidation of vital cellular components. The bacterial cell surface has been suggested as the primary target of ozonation. Two major mechanisms have been identified in ozone inhibition of microorganisms, the first; is that

ozone attacking protein or lipids of bacterial cell walls or membranes, oxidizing sulfhydryl groups of bacterial enzymes (Victorin, 1992), or by modification of the purine and pyrimidine bases of nucleic acids (Greene *et al.,* 1993).

Ozone applications in food industry are mostly related to decontamination of environments and water treatment. Moreover, ozone has been used with success to inactivate contaminant microflora on meat, poultry, eggs, fish, fruits, vegetables and dry foods. The gas also is useful in detoxification and elimination of mycotoxins and pesticide residues from some agricultural products (Yousef *et al.,* 1999).

The current research aimed to study the effect of gaseous ozone in preservation of chilled poultry and its effect on the quality of chicken meat.

MATERIALS and METHODS

1- Sampling:
A total of 24 fresh boneless chicken breasts were purchased from poultry processing plant in Port- Said city, Egypt. The samples were transferred to the lab without delay on ice and each sample was backed into a separate polyethylene bag.

2- Ozonation:
The samples were divided into 4 groups, the first non-treated group was control; the 2nd, 3rd, and 4th groups were treated with ozone gas at 40, 60, and 70 ppm for 20 min. Ozone gas was generated from a Cold plasma ozone generator (MA 5001 Model), Germany, using oxygen, with a working voltage of 220 volt, work at ambient temperature, located in Dr. Adel- Abd- Elrahman Clinic, Helioplis, Egypt. Ozone gas treatment was carried out in a glass box where the chicken breasts were placed in

3- Storage Condition:
After ozone treatment, the non-ozonated and ozonated chicken breasts were transported to the laboratory in packed ice via insulated polystyrene boxes. Samples were subsequently stored in refrigerator maintained at 4 ±1°C.

4- Microbiological analysis:
Treated and non- treated samples were examined microbiologically for Total bacterial count (FDA, 2001a), Total mould count (FDA, 2001b), and Total Coliforms (FDA, 2002) immediately after treatment and then after 1, 3, 5, 7, and 9 days of storage at refrigerators.

5- Organoleptic examination
Chicken breasts were examined by the panelists for any changes in the color, odor and /or texture due to treatment with ozone by the 5 points hedonic scale: 1, very poor; 2, poor; 3 common; 4, good; 5, very good (Szczesniak, 1987).

6- Statistical analysis:
The experiment was repeated twice and data were submitted to calculation of means, standard deviations, and the least significant difference test $p \leq 0.05$ (Draper and Smith, 1998). All statistical procedures were computed using the Microsoft Excel 2007 in order to compare the mean values of the investigated parameters.

RESULTS

Table 1: Microbiological evaluation of ozonated and non- ozonated chicken breasts during chilling storage (4±1°c) period.

Storage days	Total Bacterial Count (cfu/g)				Total Coliforms Count (cfu/g)				Total Mould Count (cfu/g)			
	Control	Ozone treatment (ppm)			Control	Ozone treatment (ppm)			Control	Ozone treatment (ppm)		
	0	40	60	70	0	40	60	70	0	40	60	70
0	10^{a}	$<10^{b}$	$<10^{b}$	$<10^{b}$	$<10^{a}$	$<10^{b}$	$<10^{b}$	$<10^{b}$	$<10^{a}$	$<10^{b}$	$<10^{b}$	$<10^{b}$
1	$3.9x10^{1a}$	$<10^{b}$	$<10^{b}$	$<10^{b}$	$3x10^{1a}$	$<10^{b}$	$<10^{b}$	$<10^{b}$	$1.1x10^{1a}$	$<10^{b}$	$<10^{b}$	$<10^{b}$
3	$4.1x10^{2a}$	$2.1x10^{1b}$	$1.4x10^{1b}$	$<10^{c}$	$9.6x10^{1a}$	$3.9x10^{1b}$	$1.9x10^{1c}$	10^{d}	$5x10^{1a}$	$3.1x10^{1b}$	$2.9x10^{1b}$	$1.4x10^{1c}$
5	$2.8x10^{4a}$	$2.2x10^{2b}$	$1.9x10^{2c}$	$9x10^{1d}$	$6.2x10^{2a}$	$2.3x10^{2b}$	$1.4x10^{2c}$	$2.8x10^{1d}$	$2.7x10^{2a}$	$9.7x10^{1b}$	$7.6x10^{1c}$	$5.8x10^{1d}$
7	$7.8x10^{5a}$	$7.4x10^{3b}$	$2.9x10^{3c}$	$3.4x10^{2d}$	$5.5x10^{3a}$	$9.1x10^{2b}$	$8.4x10^{2c}$	$6.5x10^{2d}$	$9.6x10^{4a}$	$6.3x10^{2b}$	$5.4x10^{2c}$	$1.9x10^{2d}$
9	R	$8.8x10^{4a}$	$6.2x10^{4b}$	$2.4x10^{4c}$	R	$3.5x10^{3a}$	$1.1x10^{3b}$	10^{3c}	R	$4.2x10^{3a}$	$2.6x10^{3b}$	$1.4x10^{3c}$

ND: Not Detected R: Rejected (according to EOS- 1090/2005)
Different litters within the same row in the same feature are significantly different($P \leq 0.05$)

Table 2: Organoleptic evaluation of ozonated and non- ozonated chicken breasts during chilling storage (4±1°c) period.

Storage days	Color				Odor				Texture			
	Control	Ozone treatment (ppm)			Control	Ozone treatment (ppm)			Control	Ozone treatment (ppm)		
	0	40	60	70	0	40	60	70	0	40	60	70
0	4.9±0.02^{a}	4.84±0.01^{a}	4.81±0.10^{a}	4.85±0.11^{a}	4.5±0.11^{b}	4.88±0.12^{b}	4.72±0.02^{b}	4.74±0.13^{b}	4.89±0.01^{c}	4.8±0.11^{c}	4.9±0.02^{c}	4.85±0.10^{c}
1	4.91±0.14^{a}	4.82±0.03^{a}	4.9±0.12^{a}	4.88±0.2^{a}	4.6±0.01^{b}	4.76±0.13^{b}	4.77±0.10^{b}	4.68±0.12^{b}	4.79±0.03^{c}	4.6±0.32^{c}	4.8±0.04^{c}	4.8±0.13^{c}
3	4.2±0.31*	4.74±0.12^{a}	4.71±0.1^{a}	4.7±0.24a	4.5±0.23^{b}	4.64±0.20^{b}	4.6±0.01b	4.61±0.04^{b}	4.3±0.60***	4.5±0.01^{c}	4.5±0.14^{c}	4.6±0.03^{c}
5	4±0.5*	4.61±0.04^{a}	4.63±0.2^{a}	4.64±0.11^{a}	2.6±0.25**	4.3±0.6^{b}	4.4±0.03^{b}	4.4±0.01^{b}	3.5±0.111***	4.4±0.31^{c}	4.3±0.23^{c}	4.4±0.12^{c}
7	3.1±0.15*	4.3±0.07^{a}	4.2±0.30^{a}	4.5±0.11^{a}	1.7±0.30**	3.5±0.02^{b}	3.6±0.14^{b}	3.8±0.54^{b}	1.8±0.22***	3.4±0.31^{c}	3.2±0.14^{c}	3.2±0.16^{c}
9	2.1±0.17*	3.2±0.01^{a}	3.4±0.5^{a}	3.5±0.26^{a}	0.98±0.45**	3.1±.61^{b}	3.2±0.42^{b}	3.17±0.35^{b}	1.2±0.13***	2.9±0.34^{c}	2.6±0.45^{c}	2.8±0.25^{c}

Different superscription within the same raw and the same feature are significantly different $p \leq 0.05$.

DISCUSSION

The data presented in (Table 1) clearly showed the efficacy of gaseous ozone to reduce the counts of microorganism of chicken breast samples. Immediately after treatment, Microbial populations it is $<10^{-1}$ by the used methods in the ozonated chicken breasts. After storage of the samples at 4°c for one day there were slight increase in the microbial populations of treated groups (but still less than 10 cfu/g) and non- treated one. At first (0 and 1st day of storage) there were not significant differences($p \leq 0.05$) in the cfu/g of TBC, TCC, and TMC between the treated groups but from the 3rd day of storage until the end of the storage period there were indirect proportions between the dose of ozone and the microbial count (i.e. increased ozone dose decreased the microbial populations). The microbial populations increased gradually during the storage period. At the 7th day of storage the control (non-treated) group was rejected because the microbial populations (TBC, TCC, and TMC) reached $7.8x10^{5}$, $5.5x10^{3}$ and $9.6x10^{4}$respectively; while the treated groups were still within the permissible limits approved by the (EOS-1090/2005) after 9 days of storage. These results indicated that treatment with 40, 60, and 70 ppm of ozone for 20 minutes increased the shelf-life of the chicken breasts. The obtained results come in parallel with Nieto *et al.* (1984) who observed that ozone has a pronounced effect on the flora causing deterioration and had prolonged the useful- life of poultry in refrigerated storage and Sharma and Hudson (2008) who concluded that ozone at 25 ppm reduced the population of 15 bacterial spp. including Gram positive and Gram negative bacteria by more than 3 log cfu/ml. Also Yang and Chen (2007) stated that ozone treated broiler parts had consistently lower microbial counts than the control parts during the entire refrigerated period. They added that the broiler parts treated with ozone had extended shelf- life for 2.4 days. Jindal *et al.* (1995) studied the effect of ozone on drumstick and they observed that ozone reduced the levels of aerobic plate count, coliforms, and *E. coli* by more than one log and extended the shelf-life for as much as two days. Graham (2000) also concluded that ozonation of poultry carcasses is a suitable treatment process for reducing spoilage and pathogenic microorganisms. In a study conducted by Sheldon and Brown (1986) the microbiological load of the chicken carcasses bathed in ozonated water was two logarithmically times lower as compared with non treated one.

In addition, Data of the sensory analysis in (Table 2) showed that ozone treatment had no negative effects on the quality of the chicken breasts including color, odor, and texture but also prolonged the acceptable features by more than 9 days. As off odors and slime caused by microorganisms when populations reach approximately 10^{7} to 10^{8} cfu/g (James 2004). The obtained results are in agreement with several studies done to study the effect of ozone treatment on the quality characteristics of poultry, meat, and fish by Sheldon and Brown (1986); Graham (1997); Graham (2000); Leusink and Karf (2000); Maris *et al.* (2000); Al- Haddad *et al.* (2005); Perry and Yousef (2011).

CONCLUSIONS

All data as summarized in this paper have shown the effectiveness of gaseous ozone like a promising broad spectrum antimicrobial agent (significant potential gains in shelf life and quality production) that should be considered as part of the any poultry processing sanitation protocol.

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تأثير استخدام الأوزون في حفظ الدواجن المبردة

حنان أمين مصطفى الدهشان ، تغريد احمد السيد حافظ ، حنان عباس الغياتى

تم دراسة تأثير استخدام غاز الأوزون فى معالجة صدور الدجاج المخلية على أعداد الميكروبات وذلك لمعرفة تأثيرة على حفظ الدجاج المبرد وكذلك تأثيرة على الخواص الحسية لهذا المنتج. وقد لوحظ انخفاض كبير فى العدد الكلى للبكتريا والعصيات المعوية وكذلك الفطريات فى العينات التى تم تعريضها لجرعات 40,60، 70 جزء من مليون من غاز الأوزون لمدة 20 دقيقة. كما لوحظ زيادة فى فترة صلاحية المنتج للاستهلاك الآدمي عن 9 أيام عند حفظة بالثلاجة عند درجة 4 مئوية. ولم تسجل اى فروق معنوية سلبية من حيث اللون أو الرائحة أو الملمس فى العينات المعالجة بغاز الأوزون بل وتحسنت حالة المنتج بالمقارنة بالمجموعة الضابطة بعد الحفظ بالثلاجة لعدة ايام .