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Assessment of the Effect of Aqueous Ozone Treatment on the Sensory Attributes of Retail Meat in the Iraqi Wasit Governorate

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ABSTRACT

Meat is highly vulnerable to pathogens as well as it is very sensitive to contamination during handling. Therefore, in order to provide a safe product to the consumer, these meats must be sterilized. This study aimed to investigate the effect of ozone treatment (0.5 ppm/ 20 minutes) at 4 °C on the sensory attributes of untreated and treated retail meat samples. A total of 50 samples of retail meat encompassing [chicken quarters (n=30) and cattle meat (n= 20)],were obtained at random from different markets of Wasit governorate. An ozone generator (A_2Z/AQUA-6, USA) was used to produce ozone, CHE-Mets®-Kit, USA, was used to assess its concentration (ppm) in water. Ozone treated samples revealed an enhancement in the meat quality characteristics including surface color, odor and consumer acceptability as compared to control. Our results suggested that ozone treatment could be used as the foundation for a new and healthy method of sanitizing meat and meat products at slaughterhouses, as well as before cooking in homes and restaurants.

Keywords: Aqueous ozone, consumer acceptability, retail meat, sensory attributes.

INTRODUCTION

Meat ranks among one of the most significant, nutritious and energy-rich natural food product, utilized by the humans to fulfill their regular body requirements (Pereira and Vicente, 2013). Despite high nutritional value of meat, it ranks among the high perishable food material, as it contain around more than 70% of moisture in it. Apart from reduction in shelf life, its presence imparts a strong impact on the color, texture and flavor of muscle tissues of meat (Ahmad *et al*., 2018). In addition to the high perishability of meat, these products have a high susceptibility to contamination with various contaminants, some of which are classified as superbug foodborne pathogens (Ghaffoori, 2017; Kanaan and

Khashan, 2018; Kanaan, 2018; Kanaan and Al-Isawi, 2019; Kanaan and Abdulwahid, 2019; Kanaan and Abdullah,2019; Kanaan and Mohammed, 2020; Kanaan *et al*., 2020; Kanaan, 2021). So in order to eliminate/reduce contamination with extend the shelf life of meat and meat products, various processing techniques as well as storage treatments have been developed (Kim and Day, 2007). Chlorine and its compounds are considered one of the most effective sterilizers used in poultry processing factories, and due to the dangers of chlorine residues in poultry meat, food industry researchers have worked to develop alternative sterilization methods that are more efficient, safer for consumers and the environment, and do not threaten the meat's organoleptic qualities (Kanaan,2018). Ozone (O_3) is used to extend the shelf life of foods to ensure food protection, as well as for water disinfection, waste disposal, and pesticide residue destruction (Guzel-Sydin *et al*., 2004). Ozone is listed as a secondary direct food additive/processing aid permissible for all meat and poultry products, according to FDA guidelines on additives and sources of radiation used to reduce microorganisms on carcasses, ground beef, and beef trimmings (FDA 2001). Because of ozone's high reactivity, predicting its reaction in the presence of organic matter is difficult. According to other researchers, ozone can oxidize or ionize a substrate or spontaneously decompose into oxygen and free radicals (Manousaridis *et al*., 2005). Given the insufficiency of information on the application of ozone to meat products in the literature, the aim of this study was to explore how ozone treatments (0.5 ppm) at 4°C affected the quality characteristics of treated retail meat, as measured by sensory attributes and acceptability degree.

MATERIALS AND METHODS

Ethical Approval

There was no requirement for such approval because the meat samples were collected from the marketplaces.

Samples collection

Fifty retail meat samples encompassing [chicken quarters (n=30) and cattle meat (n= 20)], with average weight 300 gm /sample were collected randomly from different markets of Wasit province. The Samples were packed separately in sterile polyethylene bag and kept in ice box and transferred within 2-3 hrs to the laboratory and kept in a deep freezer at -18 °C for further analysis.

Calculate the amount of O^3 generated (ppm/in water)

Using the O_3 CHE-Mets®-Kit and a technique developed by Kanaan and Abdullah, the O_3 concentration (ppm) in water provided by the O_3 generator (A2Z/AQUA-6 Specifications) was measured (Kanaan and Abdullah, 2021). In brief, a plastic tub was filled with 1.5 liters of tap water and sealed with its lid. Through a hole in the cover, the aeration stone was injected into the bottle. Five touch times (exposure times) were selected (5, 10, 15, 20, and 30 min). The tap water was changed after each exposure period, and the container was flushed with fresh tap water, and the process was repeated. The aqueous ozone was filled to the 25 ml mark in the empty sample cup, the CHEMet ampoule tip was placed into the cup, and the tip of the ampoule was broken and occupied by the aqueous ozone, then it has been reversed several times and waited a minute for the color to change. The ampoule was positioned between the color standards before a wide range comparator could fit the best color (Kanaan and Abdullah, 2021). The maximum concentration was obtained at 15, 20, and 30 min, which was 0.5 ppm/in water, out of the five times used.

Processing of meat samples

The samples were thawed in a refrigerator at 4°C overnight, each sample was divided in to two halves the 1st half was treated with O_3 (0.5 ppm /20 min) at 4°C, while left the 2nd half as a control. Both halves (treated and control) were placed into uncovered roasting bag, then cooked separately with slightly salt with no spices into a microwave oven at temperature of 175 °C for 30 min, and left to cool for 30 minutes before subjected to panel test. The panel test comprised five experienced tasters who determined the overall sensory attributes (surface color, odor and acceptability percentage) before and after cooking. Then cooked samples (treated and control) were kept in a refrigerator overnight at 4 °C. Taste panel after cooking (flavor) was done to evaluate the acceptability degree of cooked meat. Control and handled samples were classified as acceptable (+), preferred (++) or highly preferred (+++) by five panelists, as defined previously by Graham *et al*., 2002; with some modification by the authors.

Statistics

MedCalc Software bvba version 18 (BE, USA) was used to analyze the data. The proportion was utilized as a descriptive statistic. To compare significance between

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percentages before and after treatment with aqueous ozone, two samples Chi square between percents were employed (https:// www.medcalc.org/).

RESULTS

The effect O_3 treatment on the quality characteristics (surface color) of retail meat was presented in Table 1. Our results showed that , of the 150, and 100 observations for chicken and cattle meat, respectively 18/120 (15%) and 11/100 (11%) observed that there was a change in the surface color to bright white. Whereas 132/150 (88%) and 89/ 100 (89%) observed no changes in the surface color (light brown) after handling with O_3 (0.5 ppm /20 minutes) at 4°C compared to 0% observed no changes in the surface color (light brown) for control samples before treatment.

Statistically, there is a high significant effect ($p< 0.005$) of O_3 treatment on the quality characteristics in terms of changing the surface color of the treated chicken and cattle meat, respectively to a bright white (χ^2 = 19.085, p<0.0001; χ^2 = 11.582, p=0.0007).

Moreover, the results also revealed that 27/60 (45%) and 25/100 (25%) of the treated chicken and cattle meat, respectively observed that there was a change in the odor (no rancidity). Whereas 123/150 (82%) and 75/100 (75%) of the treated chicken and cattle meat, respectively observed that there was no change in the odor (rancid) after treatment compared to 7/60 (11.7%) and 26/100 (26%) of chicken and cattle meat, respectively observed that there was a change in odor (no rancidity) and 143/150 (95.3%) and 74/100 (74%) observed no change in the odor (rancid) before treatment with ozonated water (Table 2). Statistically, there is a high significant effect ($p< 0.005$) of O_3 treatment on the qualitative characteristics in terms of changing the odor of treated chicken meat (no rancidity), (χ^2 = 13.141, p=0.0003). On the other hand, there is no significant effect ($p> 0.05$) of treatment on the changing of the odor of treated cattle meat (χ^2 = 0.26, p=0.8714).

Acceptability degree of control and treated meat samples with O_3 (0.5 ppm/ 20 min) at 4 °C then cooked for 30 minuts in microwave oven at 175°C for 30 min were furthure evaluated and the results were presented in Table 3. The overall acceptability degree (%) of the meat samples were scaled as acceptable (+) , preferred (++) and highly preferred (+++). The results showed that of the 150 and 100 observations for chicken and cattle meat, respectively the acceptability degree (%) were (86.7%, 98%) highly preferred, and (33.3%, 5%) preferred after

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treatment with O_3 compared to (92%) preferred and (20%, 13.3%) acceptable for control chicken and cattle meat, respectively (Table 3). Statistically, there is a high significant effect of O_3 treatment on the degree of acceptance of the treated chicken and cattle meat, respectively in terms of an improvement in the degree of preference from preferred to highly preferred ($\chi^2 = 78.866$, $p<0.0001$; $\chi^2 = 97.326$, $p<0.0001$).

DISCUSSION

Sensory analysis is one of the oldest means of quality control, but in principle is an essential part of the mandatory assessment of food quality allowing manufacturers to identify, understand and respond to consumer preferences more effectively. For buyers, colour, texture, smell, overall outlook are the initial preference criteria when purchasing a raw chicken product (Liu *et al*., 2004; Fanatic *et al*., 2007; Castellini *et al*., 2008 ; Saha *et al*., 2009 ; Adeyemo and Sani , 2013).

In this study the changes in surface color (Table 1), might be attributed to oxidation of the pigments by O_3, O_3 reacts with molecules responsible for pigmentation breaks the functional groups which causes the discoloration of color to bright white (Bekhit *et al*., 2013). Ozone is widely used for treatment of drinking water to improve taste, odor and color as disinfection and biodegradability of impurities (Kim *et al* ., 1999). In this study improvement of odor and taste could be attributed to oxidizing power of O_3. Ozone has the ability to quickly react with aromatic compounds and oxidize low-molecular structures, such as soluble microbial products (SMPs) and other aromatic proteins (APs), improving odor and taste (Wang and Chen, 2014).

Generally speaking, the results of this study were in agreement with the results obtained by Trindade *et al.*(2012) who investigated the effects of two treatments (chlorine and O_3) in chicken immersion chilling water as 1.5 ppm at 4°C for 45 min on the sensory characteristics of carcasses, and they discovered that samples from both treatments had similar acceptance scores for odor and overall appearance, but that O_3 had a significantly higher acceptance score for color than the chlorine treatment. As well as, Muhlisin *et al.*(2016) conducted another study to assess the effects of gaseous O_3 (214 ppm O_3/ m3) at 4°C for 4 days on the surface color of chicken and duck breasts., and they found that over storage time, O_3 exposure substantially decreased the Commission Internationale de l'

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Eclairage a* (CIE a*) value (redness) of duck and chicken breast, while the CIE L* (lightness) and CIE b* (yellowness) values fluctuated, and attributed the decrease in CIE a* value to the ozone-induced oxidation of myoglobin and oxymyoglobin to metmyoglobin, which resulted in meat discoloration and lower redness (Mancini and Hunt, 2005). In addition, the major decrease in CIE a* observed was not caused by the gaseous O_3 dose, but was affected by storage time. The results of this study were also agreed with EL Dahshan *et al*. (2013) who studied the effects of gaseous O_3 as 40, 60, and 70 ppm for 20 min on chicken quality properties such as color, odor, and texture , they found that immediately after O_3 treatment panelists were unable to detect any color, odor or texture differences between the ozonated and control groups. They also found that at the O_3 concentrations and exposure periods used, O_3 had no negative effects on the color, odor, or texture of the chicken breasts, and that it also extended the appropriate features by more than nine days.

Our results revealed an improvement in the degree of acceptance of ozonated meat by the consumer after cooking with microwave oven at 175˚C for 30 min in terms of improving the degree of preference from preferred to highly preferred (Table 3). These findings matched those of Graham *et al*. (2002), who compared the flavor of roasted treated birds from the pilot chiller water maintained at 4°C with flavor of roasted control birds from the plant chiller after roasting at 350° F for 1 hour and cooling in refrigerator overnight before tasting. They discovered that ozonated chickens were identical to commercial chickens from the same line treated with chlorine in sensory evaluations by expert panels and at-home food service. Gertzou *et al*. (2016) conducted another study to determine the effect of different O_3 doses (2, 5, and 10 ppm for 1 h) on the shelf life and sensory properties of fresh chicken legs packed in polyamide/polyethylene (PA/PE) bags and stored at 4°C for a duration of 12 days, and discovered that after microwave cooking at high power (700 W) for 4 min, the acceptability (odor, texture, appearance, and taste) of cooked chicken meat was maintained at a higher score than three for 10 days in samples treated with 10 ppm of ozone (acceptability score ranging from five to zero , with five corresponding to a most liked sample), although samples treated with 2 - 5 ppm of O_3 maintained an adequate score of three for eight days. Furthermore, they concluded that a 10 ppm O_3 treatment for 1 hr was adequate for preserving the freshness and consistency of chicken legs packed in PA/PE plastic containers under refrigeration, since they retained the original characteristic features of fresh chicken legs‘’ fresh score’’ for 10 days .

CONCLUSION

Our data concluded that treated meat with aqueous O_3 (0.5ppm) for 20 min at 4 °C were exhibited enhancement in the cooked meat quality including surface color, odor and consumer preference as compared to control. So, our data recommended that aqueous O_3 can be used as an antimicrobial agent either at slaughter houses or before domestic cooking (home and restaurants) without adversely affecting the organoleptic characteristic of the meat (color, taste, and aroma), as well as reducing the off-flavor (rancidity).

Authors’ Contributions

MHGK completed the laboratory work for this study, as well as organizing, writing, and reviewing the manuscript. AMT and FAM were in charge of data analysis and interpretation of the outcomes. The final version of the manuscript has been read and approved by all of the researchers.

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Conflict of Interest

The authors declares that they have no conflict of interest.

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Table 1: Sensory attributes (surface color) before microwave oven cooking of control and treated meat with aqueous ozone (0.5 ppm/20 min)

Sample type	Set number	Control		Treated	
		Colour			
		C (%)	NC (%)	C (%)	NC (%)
Chicken meat	1	-	30/30 (100)	3/30 (10)	27/30 (90)
	2	-	30/30(100)	2/30 (6.7)	28/30 (93.3)

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	3	-	30/30(100)	-	30/30 (100)
	4	-	30/30(100)	6/30 (20)	24/30 (80)
	5	-	30/30(100)	7/30 (23.3)	23/30 (76.7)
Total		(0)	150/150(100)	18/120 (15)	132/150 (88)
Sample type	Set number	C (%)	NC (%)	C (%)	NC (%)
Cattle meat	1	-	20/20(100)	3/20 (15)	17/20 (85)
	2	-	20/20(100)	4/20 (20)	16/20 (80)
	3	-	20/20(100)	1/20 (5)	19/20 (95)
	4	-	20/20(100)	2/20 (10)	18/20 (90)
	5	-	20/20(100)	1/20 (5)	19/20 (95)
Total			100/100(100)	11/100 (11)	89/100 (89)
C= change; NC= no change					

Table 2: Sensory attributes (odor) before and after microwave oven cooking 175 °C/30 min of control and treated meat with aqueous ozone (0.5 ppm/20 min)

Sample type	Set number	Control		Treated	
		Odor			
		C (%)	NC (%)	C (%)	NC (%)
Chicken meat	1	-	30/30 (100)	12/30 (40)	18/30 (60)
	2	-	30/30 (100)	-	30/30 (100)
	3	-	30/30 (100)	6/30 (20)	24/30 (80)
	4	5/30 (16.7)	25/30 (83.3)	9/30 (30)	21/30 (70)
	5	2/30 (6.7)	28/30 (93.3)	-	30/30 (100)
Total (%)		7/60 (11.7)	143/150 (95.3)	27/60 (45)	123/150 (82)
Sample type	Set number	C (%)	NC (%)	C (%)	NC (%)
Cattle meat	1	5/20 (25)	15/20 (75)	3/20 (15)	17/20 (85)
	2	9/20 (45)	11/20 (55)	7/20 (35)	13/20 (65)
	3	3/20 (15)	17/20 (85)	5/20 (25)	15/20 (75)
	4	4/20 (20)	16/20 (80)	2/20 (10)	18/20 (90)
	5	5/20 (25)	15/20 (75)	8/20 (40)	12/20 (60)
Total (%)		26/100 (26)	74/100 (74)	25/100 (25)	75/100 (75)
C= change; NC= no change					

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Table 3. Tester's acceptability (%) of control and treated meat with aqueous ozone (0.5 ppm/20 min) after microwave oven cooking 175 °C/30 min and kept in refrigerator overnight.

Sample type		Acceptability degree (%)					
	Set number	Control (%)			Treated (%)		
		+(%)	++(%)	+++(%)	+(%)	++(%)	+++(%)
Chicken meat	1	-	30/30 (100)			-	30/30(100)
	2	-	30/30 (100)			-	30/30 (100)
	3	-	30/30 (100)			-	30/30 (100)
	4	5/30 (16.7)	25/30 (83.3)			11/30 (36.7)	19/30 (63.3)
	5	7/30 (23.3)	23/30 (76.7)			9/30 (30)	21/30 (70)
Total (%)		12/60 (20)	138/150 (92)			20/60 (33.3)	130/150 (86.7)
Sample type	Set number	+ (%)	++(%)	+++(%)	+(%)	++(%)	(%)+++
Cattle meat	1	3/20 (15)	17/20 (85)			1/20 (5)	19/20 (95)
	2	2/20 (10)	18/20 (90)			-	20/20 (100)
	3	3/20 (15)	17/20 (85)			1/20 (5)	19/20 (95)
	4	-	20/20 (100)			-	20/20 (100)
	5	-	20/20 (100)			-	20/20 (100)
Total (%)		8/60 (13.3)	92/100 (92)			2/40 (5)	98/100 (98)

+= acceptable

++= preferred

++ += highly preferred