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COMBINED EFFECT OF FLASH PASTEURIZATION, LACTIC ACID BUFFERED SYSTEM AND MODIFIED ATMOSPHERE PACKAGING ON THE SHELF LIFE OF FRESH POULTRY

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ABSTRACT: *Fresh chicken legs were subjected to different treatments; flash pasteurization (FP) for 15 seconds; 10% lactic acid buffered system pH3 (LABS); Modified Atmosphere Packaging (MAP); combination of FP+LABS; FP+MAP; LABS+MAP and finally FP+LABS+MAP to study the effect of these treatments on chicken quality during storage at 5°C. Results revealed that the total viable bacteria, Enterobacteriaceae, H_2S-producing bacteria, lactic acid bacteria and yeast were inhibited by all treatments used as compared with the untreated sample. The highest inhibition was observed with FP+ LABS + MAP treatment followed by LABS+MAP. The buffering capacity of the buffer systems seems to be sufficient to maintain a low pH of the skin during storage. Sensory evaluation revealed that FP treatment improved the colour of the fresh chicken legs and showed no cooking effect .Microbiological changes supported the sensory results. Chicken legs treated with FP, LABS and MAP; gave shelf life of 7, 11 and 12 days when stored at 5°C, respectively. Meanwhile combination of FP+LABS; FP+MAP; LABS+MAP and FP+ LABS+ MAP gave 12, 14, 16 and 18 days, respectively. However, the untreated chicken had 5 days.*

Key words: *Poultry; Quality; Flash pasteurization; Lactic acid buffer system; Modified atmosphere packaging.*

INTRODUCTION:

The microbiological quality of commercially processed poultry products are major areas of concern for producers, consumers, and public health officials worldwide (Abu-Ruwaida *et al.*, 1994; Russell *et al.*, 1997). Products excessively contaminated with microorganisms are undesirable from the standpoint of public health, storage quality, and general aesthetics (Mead, 1989; Abu-Ruwaida *et al.*, 1994; Zeitoun *et al.*, 1994; Mulder, 1997). Psychrotrophic bacteria are the major group of microorganisms responsible for spoilage of fresh poultry (Goksoy *et al.*, 2001; Bailey *et al.*, 2004).The shelf life of poultry meat thus depends on the level of its microbial contamination (Mead, 1989; Zeitoun *et al.*, 1994; Mulder, 1995).Therefore enhancing the keeping quality, reducing or killing spoilage causing microorganisms of chicken carcasses are very important objectives of food technologists and microbiologists (Mead, 1989; Zeitoun *et al.*, 1994; Mulder,1995) One way to reduce the level of microorganisms of chicken carcasses is through pasteurization. Microbial reduction by flash pasteurization has been studied in a large number of foods including: Poultry (Goksoy *et al.*, 2001; Avens *et al.*, 2002; Purnell *et al.*, 2004); fish and shell fish (Rosenberg and Werner, 1997).

Moreover, lactic acid has also been used successfully in extending the shelf life of fresh meat and poultry (Van der Marel *et al.*, 1988; Zeitoun *et al.*, 1994; Smulders, 2003).

Modified Atmosphere packaging (MAP) and refrigerated poultry products have increasing need for quality improvement and extending the shelf life (Jimenez *et al.*, 1999; Bjorn *et al.*, 2006), to meet consumer demands for fresh, refrigerated foods with extended shelf life. Developments in packaging materials and techniques over the last 20 years have made the use of modified atmospheres at the retail level possible (Jimenez *et al.*, 1999; Sivertsvik *et al.*, 2002; Eilert, 2005; Bjorn *et al.*, 2006).

At present there is no literature data available documenting the effect of combined application of flash pasteurization, lactic acid buffered system and modified atmosphere packaging on poultry. Therefore, the objective of this study was to investigate such effects with fresh poultry.

MATERIALS AND METHODS

Materials:

Fresh chicken legs were obtained directly from a local commercial poultry processing plant (In Alexandria).They were transported under refrigeration to the laboratory of Faculty of Agric. Saba Bacha, within two hours. Legs were used for practical reasons, instead of whole carcasses.

Flash pasteurization: Fresh chicken legs were pasteurized by immersion in boiling water (1:2 w/v) at 95°C for 15 seconds. The immersion time of chicken legs in the boiling water (15 seconds) was chosen as a result of preliminary trials which showed that this time had no cooking effect on the chicken skin, chicken legs were allowed to cool and drain at 5°C for two hrs, then packed in Sidamil plastic bags (permeability. 6ccO_2 /m^2 /24h, 15cc CO_2 /m^2/ 24h, 2ccN_2 /m^2 /24h, at 25 °C and 100% RH) and stored at 5°C and 96% RH. Non-treated controls were also stored in the Sidamil plastic bags.

Lactic acid buffered system treatment: Chicken legs were decontaminated by spraying with lactic acid /sodium lactate buffered system pH3 according to Zeitoun and Debever (1990) .Spraying was performed uniformly over the surface on both sides of the legs by using spray gun. After this treatment, the chicken legs were allowed to drain at 5°Cfor two hrs, packed separately in Sidamil plastic bags and stored at 5°C. Samples of flash pasteurization chicken legs were also treated with lactic acid buffered system and stored at 5°C.

Gas packaging: Samples of flash pasteurized, flash pasteurized and decontaminated with 10% lactic acid buffered system; decontaminated with 10% lactic acid buffered and untreated samples were packed in Sidamil plastic bags. All bags were totally evacuated from air and completely flushed with gas mixture of 90% CO_2 and 10% O_2 (International Co. for Air and Gases Products, El-Sadat city) and then heat sealed. The bags were stored at 5°C.

Microbiological analysis: At each sampling time, three legs were sampled aseptically taken by means of excision of surface areas of 15 cm^2 of skin. A sterile filter paper (6×2.5 cm) was used to outline the area. Filter paper and skin were homogenized for 2 min in 150 ml sterile physiological saline supplemented by 0.1% peptone, using a stomacher (Lab Blender 400, Seward Medical, London). From this homogenate, decimal dilutions were prepared in physiological saline containing 0.1% peptone and were plated. Total viable bacteria were determined by the pour-plated method in plate count agar (PCA; Oxoid CM 325), incubated at 25°C for 72 h (Jimenez *et al.*, 1999; Panagiotis and George, 2002). Lactic acid bacteria were assessed as colony forming units on MRS agar (Oxoid CM 361) with an overlay of the same agar incubated for 3 days at 30°C (Jimenez et al., 1999; Panagiotis and George, 2002). H_2S-producing colony forming units were determined on iron agar as described by Jensen and Schulz (1980), supplemented with 0.04%L-cysteine (w/v) (Gram *et al.*, 1987; Zeitoun and Debevere, 1990) covered with an overlay of the same agar, and incubated for 3 days at 25°C. *Enterobacteriaceae* were determined as colony forming units on Violet Red Bile Glucose Agar (VRBG) (Oxoid CM 485), overlaid with the same medium and incubated at 37°C for 24 h. (Zeitoun *et al.*, 1994; Panagiotis and George, 2002). Yeast colony forming units were determined on Rose Bengal Chloramphenicol agar (RBC) (Oxoid CM 549) with supplement (Chloramphenicol antibiotic supplement Oxoid SR 78), incubated up to 5 days at 30°C (Zeitoun and Debevere, 1992).

Sensory analysis: Sensory evaluation was carried out using five trained panelists. Samples were judged for odour, colour and texture. A hedonic scale was used between 9 (extremely good) and 1 (extremely poor) (Jimenez *et al.*, 1999). The score of each parameter was calculated in terms of average score points given by panel of judges to each sample. A score of 5 was taken as the average score for minimum acceptability.

Triangle test was performed on flash pasteurized samples compared with blank (untreated chicken legs) at day zero to examine weather the flash pasteurization has a cooking effect.

The pH measurement: After sampling for microbiological analysis, the rest of the skin was removed, macerated (skin only) in a blender for 10s

(Zeitoun and Debevere, 1990) and the pH was measured using a digital pH meter (Thermo Orion, model 260A) (USA).

Statistical analysis: Obtained data were analyzed using analysis of variance two ways (ANOVA) and subjected least significant difference (LSD) at 0.05% level of significance was used to compare the treatment means (Waller and Duncan, 1969). Computations were done using SAS (1996).

RESULTS AND DISCUSSION:

Foods should be regarded as unwholesome when they have a large population of microorganisms. High counts in foods indicate contaminated raw materials and /or unsatisfactory processing and /or cross contamination after processing from a sanitary point of view (ICMSF, 1988). Immersion in hot water is one of many potential methods for reducing levels of spoilage and pathogenic bacteria on raw poultry (Whyte *et al.,* 2003; Purnell *et al.*, 2004). Results of the effect of treatment with flash pasteurization (FP), 10% lactic acid buffer system (LABS) and Modified Atmosphere Packaging (MAP) on the growth of total viable bacteria on chicken legs stored at 5 °C is shown in Table 1. The initial number of total viable bacteria was 4.98 $\log_{10}$ CFU/cm^2 on fresh chicken legs. A reductions of 1.03 and 1.86 $\log_{10}$ units were obtained by the treatments with flash pasteurization (FP); and flash pasteurization (FP) combined with 10% lactic acid buffer system pH3 (LABS), respectively. Several 0utbreaks of highly pathogenic avian influenza (HPAI) in poultry are caused by influenza H5N1 virus (WHO, 2005). Lipatov *et al.*, (2004), reported that avian influenza H5N1 virus was killed at 62.2 °C. This meant that safety of chicken legs against pathogenic avian influenza H5N1 virus can be improved by flash pasteurization treatment (FP). On day 3 and 5 there were significant differences ($P<0.05$) for the number of total viable bacteria between legs treated with FP; LABS; MAP; FP+ LABS; FP+MAP; LABS+MAP; and FP+ LABS+ MAP as compared with blank. After 14 days of storage at 5 °C, the number of total viable bacteria on chicken legs treated with FP+LABS+MAP was still lower than the initial number (day zero). Chicken legs treated with flash pasteurization (FP) combined with 10% lactic acid buffer system pH3 (LABS) have a shelf life equal to samples packed in modified atmosphere packaging (12 days). Chicken legs treated with flash pasteurization (FP); 10% lactic acid buffer system (LABS); Modified Atmosphere Packaging (MAP); FP+LABS; FP+MAP; LABS+MAP And FP+LABS+MAP showed shelf life of 7, 11, 12, 12, 14, 16 and 18 days of storage at 5 °C, respectively. This signifies a prolongation of shelf life at 5°C of 2, 6, 7, 7, 9, 11 and 13 days, respectively as compared with blank samples. The increased shelf life obtained by those treatments could be explained by inhibition of H_2S-producing bacteria resulting in lower levels of hydrogen sulphide and other sulphur containing spoilage compounds (Bailey *et al.*, 2004; Zeitoun and Debevere, 1992). Results obtained for H_2S-producing bacteria (Table 2) gave similar trends. Data in Table (3) represent the effect of flash pasteurization (FP), 10% lactic acid buffer system (LABS) and Modified Atmosphere packaging (MAP) on pH of chicken legs stored at 5 °C. Initial pH value for the skin of chicken legs used in this study was 6.60. A reduction of 1.85 pH was obtained by using 10% lactic acid buffer system (LABS). The buffering capacity of the buffer system seemed to be sufficient to maintain a pH of chicken legs which was lower than the initial pH for 11 days of storage at 5 °C. Samples packed in modified atmosphere packaging (MAP) showed significant decrease in pH ($p < 0.05$) as compared with the initial pH. This decrease in the pH mainly due to CO_2 absorbed by the chicken (Bjorn *et al.*, 2006).The pH of fresh chicken increased as the microbial population increased (Genigeorgis, 1985; Bjorn *et al.*, 2006). These results are contradictory to those obtained for pH (Table 3) and total viable bacteria (Table 1).

When chilled meat is packaged in modified atmosphere packaging with an elevated level of carbon dioxide, its microflora is dominated by lactic acid bacteria (Genigeorgis, 1985; Panagiotis and George, 2002; Bjorn *et al.*, 2006). Such new packaging technologies present opportunities for microbial control that may not only extend shelf life, but also enhance the microbiological safety of meats (Genigeorgis, 1985; Bjorn *et al.,* 2006). Bacteriocins are antimicrobial proteins produced by lactic acid bacteria; act on target cells by various mechanisms, most of which are, as yet, unclear (Stiles and Hasting, 2003). Changes in lactic acid bacteria are presented in Table (4). The initial number of lactic acid bacteria was 4.12 $\log_{10}$ CFU/cm^2 on blank samples. The numbers of lactic acid bacteria were reduced by 0.85 log10 unit for FP and 1.44 for LABS.

The initial number on untreated sample (4.12 $\log_{10}$ CFU/cm^2), increased to 5.37 after 5 days of storage. However, the rates of increases for sample treated with FP and sample treated with LABS were slower than that on untreated sample. Chicken legs treated with MAP; FP+MAP; LABS+MAP; and FP+LABS+MAP showed a lag period of 3, 5, 5 and 7 days of storage at 5°C, respectively. After these periods the number of lactic acid on these samples starts to increase at slower rate as compared with untreated samples. On the day of spoilage on all samples packed in modified atmospheres irrespective of the treatment received, lactic acid bacteria were found to be the predominating flora. Similar results were obtained by other investigators (Genigeorgis, 1985; Panagiotis and George, 2002; Bjorn *et al.*, 2006), who demonstrated that lactic acid bacteria are less inhibited by CO_2 than Gram-negative bacteria.

Table (1). Effect of treatment with flash pasteurization, lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging on total viable count of chicken legs stored at 5°C.

Treatments	Log CFU of total viable count at n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	4.98^{Aa}	5.70^{Ba}	6.92^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization (FP)	3.95^{Ab}	4.57^{Bb}	5.43^{Cb}	6.78^{Da}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	3.43^{Ac}	3.64^{Ac}	4.32^{Bd}	5.38^{Cb}	5.93^{Da}	6.84^{Ea}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	4.98^{Aa}	4.47^{Bb}	4.90^{Ac}	5.23^{Cc}	5.50^{Db}	6.22^{Eb}	6.93^{Fa}	n.d.	n.d.	n.d.
FP + LABS	3.12^{Ad}	3.25^{Ad}	3.98^{Be}	4.52^{Cd}	5.14^{Dc}	6.17^{Eb}	6.82^{Fa}	n.d.	n.d.	n.d.
FP+ MAP	3.95^{Ab}	3.72^{Bc}	3.83^{Bf}	4.14^{Ce}	4.52^{Dd}	5.14^{Ec}	5.73^{Fb}	6.87^{Ga}	n.d.	n.d.
LABS + MAP	3.43^{Ac}	3.20^{Bd}	3.36^{Ag}	3.50^{Af}	3.83^{Be}	4.10^{Cd}	4.62^{Dc}	5.58^{Eb}	6.80^{Fa}	n.d.
FP + LABS + MAP	3.12^{Ad}	2.64^{Be}	2.58^{Bh}	2.69^{Bg}	2.94^{Cf}	3.22^{De}	3.48^{Ed}	4.47^{Fc}	5.64^{Gb}	6.76^{H}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO_2 + 10% O_2.

Table (2). Effect of treatment with flash pasteurization, lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging on the growth of H_2S-producing bacteria on chicken legs stored at 5°C.

Treatments	Log CFU of H_2S-producing bacteria at n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	1.78^{Aa}	3.62^{Ba}	6.64^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization (FP)	1.02^{Ab}	2.78^{Bb}	3.95^{Cb}	6.13^{Da}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	0.74^{Ac}	0.82^{Ad}	1.24^{Bd}	2.35^{Cc}	3.64^{Da}	5.27^{Ea}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	1.78^{Aa}	1.44^{Bc}	1.86^{Ac}	2.72^{Cb}	3.53^{Da}	4.06^{Eb}	4.75^{Fb}	n.d.	n.d.	n.d.
FP + LABS	0.50^{Ad}	0.84^{Bd}	1.15^{Cde}	1.94^{Df}	2.83^{Fd}	4.13^{Gb}	4.92^{Ha}	n.d.	n.d.	n.d.
FP+ MAP	1.02^{Ab}	0.80^{Bd}	1.07^{Ae}	2.10^{Cd}	3.08^{Dc}	3.72^{Ec}	4.03^{Fc}	4.62^{Ga}	n.d.	n.d.
LABS + MAP	0.74^{Ac}	0.67^{Ae}	0.92^{Af}	1.25^{Bg}	1.79^{Cf}	2.35^{Dd}	2.86^{Ed}	3.36^{Fb}	4.35^{Ga}	n.d.
FP + LABS + MAP	0.50^{Ad}	0.65^{Ae}	0.84^{Af}	0.75^{Ah}	1.12^{Bg}	1.64^{Ce}	1.98^{De}	2.42^{Fc}	3.05^{Gb}	3.82^{H}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO_2 + 10% O_2.

Table (3). Effect of treatment with flash pasteurization, lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging on pH of chicken legs stored at 5°C.

Treatments	pH of the skin after n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	6.60^{Aa}	6.75^{Ba}	6.94^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization (FP)	6.58^{Aa}	$6.63A^{Bb}$	6.68^{Bb}	6.82^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	4.75^{Ab}	4.78^{Ad}	4.90^{Bd}	5.15^{Cc}	5.35^{Db}	5.84^{Eb}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	6.60^{Aa}	6.38^{BCc}	6.35^{BCc}	6.32^{Cb}	6.40^{Ba}	6.37^{BCa}	6.42^{Ba}	n.d.	n.d.	n.d.
FP + LABS	4.72^{Ab}	4.75^{Ad}	4.82^{Bd}	4.95^{Cd}	5.08^{Dc}	5.32^{Ed}	5.78^{Fc}	n.d.	n.d.	n.d.
FP+ MAP	6.58^{Aa}	6.36^{Bc}	6.30^{Cc}	6.35^{BCb}	6.37^{Ba}	6.34^{BCa}	6.28^{Cb}	6.39^{Ba}	n.d.	n.d.
LABS + MAP	4.75^{Ab}	4.60^{Be}	4.62^{Be}	4.65^{Be}	5.04^{Cc}	5.42^{Dc}	5.81^{Ec}	5.92^{Fb}	6.05^{Ga}	n.d.
FP + LABS + MAP	4.72^{Ab}	4.55^{Be}	4.57^{Be}	4.61^{Be}	4.98^{Cd}	5.07^{De}	5.16^{Fd}	5.38^{Gc}	5.54^{Hb}	5.77^{I}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

Results of the effect of treatment with flash pasteurization (FP), 10% lactic acid buffer system (LABS) and Modified Atmosphere packaging (MAP) on the growth of *Enterobacteriaceae* on chicken legs stored at 5°C are illustrated in Table 5. The ANOVA indicates that storage time and treatment effects were significant ($P< 0.05$) in *Enterobacteriaceae* counts. The initial number of *Enterobacteriaceae* on the chicken was 3.05 log_{10} CFU/cm^2. A reduction of 1.47, 1.73 and 2.18 log_{10} CFU/cm^2 was obtained for treatment with FP, LABS and FP+LABS, respectively as compared with blank. Such reduction would improve the safety of the chicken legs. The number of *Enterobacteriaceae* increased rapidly on untreated samples (control). After 5 days of storage at 5°C, reduction of 4.94, 4.82, 4.62, 4.47, 4.20, 2.97, and 2.04 log_{10} CFU/cm^2 were obtained for FP+LABS+MAP; LABS+MAP; FP+MAP; FP+LABS; LABS; MAP and FP respectively as compared with blank. A similar trends for H_2S-producing bacteria (Table 2) were obtained resulting in reductions of 5.8, 5.72, 5.57, 5.49, 5.40, 4.78, 2.69 log_{10} CFU/cm^2 respectively.

Effect of FP and LABS on growth of yeast (Table 6) was slightly lesser than those obtained for *Enterobacteriaceae* (Table 5) and H_2S-producing bacteria (Table 2). Growth of yeast on all chicken legs packed in modified atmospheres irrespective of the treatment received, were strongly inhibited. It seemed that 90% O_2 was sufficient to control the growth of yeast. On the other hand, the initial number of lactic acid bacteria on untreated samples (2.94 log_{10} CFU/cm^2), increased to 4.97 log_{10} CFU/cm^2 , after 5 days of storage at 5°C.

Table (4). The growth of lactic acid bacteria on chicken legs treated with flash pasteurization, lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging and stored at 5°C.

Treatments	Log CFU of lactic acid bacteria at n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	4.12^{Aa}	4.65^{Ba}	5.37^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization (FP)	3.27^{Ab}	3.56^{Bc}	4.25^{Cc}	5.18^{Da}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	2.68^{Ac}	2.82^{Be}	3.39^{Cd}	3.82^{Dc}	4.65^{Eb}	5.14^{Fb}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	4.12^{Aa}	4.15^{Ab}	4.46^{Bb}	4.83^{Cb}	5.02^{Da}	5.61^{Ea}	6.43^{Fa}	n.d.	n.d.	n.d.
FP + LABS	2.15^{Ad}	2.33^{Bf}	2.76^{Ce}	3.04^{Dd}	3.76^{Fd}	4.54^{Gd}	5.08^{H}c	n.d.	n.d.	n.d.
FP+ MAP	3.27Ab	3.34^{Ad}	3.30^{Ad}	3.78^{Bc}	4.18^{Cc}	4.88^{Dc}	5.32^{Eb}	6.24^{Fa}	n.d.	n.d.
LABS + MAP	2.68^{Ac}	2.51^{Bg}	2.65^{Af}	2.83^{Ce}	3.42^{De}	3.88^{Ee}	4.55^{Fd}	5.49^{Gb}	6.32^{Ha}	n.d.
FP + LABS + MAP	2.15^{Ad}	2.01^{Bh}	2.22^{Ag}	2.16^{Af}	2.55^{Cf}	2.76^{Df}	3.63^{Ee}	4.32^{Fc}	5.43^{Gb}	6.35^{H}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

Table (5). Effect of treatment with flash pasteurization, lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging on the growth of *Enterobacteriaceae* on chicken legs stored at 5°C.

Treatments	Log CFU of *Enterobacteriaceae* at n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	3.05^{Aa}	3.92^{Ba}	6.12^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization (FP)	1.58^{Ab}	2.67^{Bc}	4.08^{Cb}	5.86^{Da}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	1.32^{Ac}	1.38^{Ad}	1.92^{Bd}	3.14^{Cc}	4.15^{Da}	5.32^{Ea}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	3.05^{Aa}	2.87^{Bb}	3.15^{Ac}	3.70^{Cb}	4.10^{Da}	4.63^{Eb}	5.19^{Fa}	n.d.	n.d.	n.d.
FP + LABS	0.87^{Ad}	0.85^{Af}	1.65^{Be}	2.76^{Cd}	3.58^{Db}	4.30^{Ec}	5.28^{Fa}	n.d.	n.d.	n.d.
FP+ MAP	1.58^{Ab}	1.32^{Bd}	1.54^{Af}	2.10^{Cf}	2.94^{Dc}	3.72^{Ed}	4.13^{Fb}	4.92^{Ga}	n.d.	n.d.
LABS + MAP	1.32^{Ac}	1.12^{Be}	1.30^{Ag}	1.76^{Cg}	2.14^{Dd}	2.66^{Ee}	2.85^{Fc}	3.02^{Gb}	3.64^{Ha}	n.d.
FP + LABS + MAP	0.87^{Ad}	0.85^{Af}	1.18^{Bh}	1.15^{Bh}	1.36^{Ce}	1.74^{Df}	1.95^{Fd}	2.16^{Gc}	2.45^{Hb}	2.82^{I}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

Table (6). Effect of treatment with flash pasteurization, lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging on the growth of yeasts on chicken legs stored at 5°C.

Treatments	Log CFU of yeasts at n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	2.94^{Aa}	3.63^{Ba}	4.97^{Ca}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization (FP)	2.63^{Ab}	3.15^{Bb}	3.58^{Cb}	4.82^{Da}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	2.38^{Ec}	$2.54^{E}d$	2.96^{Dc}	3.47^{Cb}	3.89^{Ba}	4.75^{Aa}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	2.94^{Aa}	2.82^{Ac}	2.65^{Bd}	2.46^{Cd}	2.85^{Ac}	2.87^{Ac}	2.79^{ABb}	n.d.	n.d.	n.d.
FP + LABS	2.55^{Fb}	2.38^{Fe}	2.75^{Dd}	3.08^{Cc}	3.17^{Cb}	3.93^{Bb}	4.68^{Aa}	n.d.	n.d.	n.d.
FP+ MAP	2.63^{Ab}	2.46^{Abe}	2.52^{Ae}	2.38^{Bde}	2.33^{Bd}	2.12^{Cd}	2.54^{Ac}	2.47^{ABa}	n.d.	n.d.
LABS + MAP	2.38^{Ac}	2.17^{Cf}	2.15^{Cf}	2.33^{ABef}	2.42^{Ad}	2.22^{BCd}	2.40^{Ad}	2.17^{Cb}	2.25^{BCa}	n.d.
FP + LABS + MAP	2.55^{Ab}	2.00^{Eg}	2.10^{DEf}	2.25^{Cf}	2.39^{Bd}	2.17^{CDd}	2.27^{Ce}	2.08^{DEb}	2.12^{Da}	2.18^{CD}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

The evaluation of the organoleptic quality of chicken legs treated with flash pasteurization (FP), lactic acid buffer system pH3 (LABS) and modified atmosphere packaging (LABS) and stored at 5°C (Table. 7) showed that colour and odour of chicken legs were enhanced by flash pasteurization (FP). According to triangle test (at day zero) flash pasteurization showed no cooking effect on flesh of the chicken legs. Likewise, the treatment with 10% lactic acid buffer system (LABS) had no influence on the sensory quality (Zeitoun and Debevere, 1990). The changes in odour followed closely the changes in bacterial counts. The odour of all treated chicken legs showed significantly improvement ($p<0.05$) as compared with untreated sample after 3 and 5 days of storage at 5°C. Untreated chicken was spoiled with persistent putrid odour after 5 days of storage at 5°C.

The critical spoilage level of $\log_{10}$ CFU/cm^2 7-8 of total viable bacteria followed by typical off odour on the next day (Van der Marel *et al.*, 1988; Zeitoun *et al.*, 1994). All samples at the end of storage periods were below the critical marginal quality, followed by off odour next day. According to that limit and sensory quality, samples treated with flash pasteurization (FP); 10% lactic acid buffer system pH3 (LABS); Modified Atmosphere packaging (MAP); FP+ LABS; FP+ MAP; LABS+ MAP and FP+ LABS+ MAP have a shelf life at 5°C of 7,11, 12, 12, 14, 16 and 18 days respectively. This signifies a prolongation of shelf life at 5 °C of 2, 6, 7, 7, 9, 11 and 13 days respectively, as compared with untreated chicken. This could be explained by synergistic effect between FP and LABS; FP and MAP; MAP and LABS. Decontamination of poultry legs with flash pasteurization is particularly suitable in combination with LABS and MAP. Several considerations have led to the use of lactic acid as a decontamination agent because of the excellent bactericidal properties (Van der Marel *et al.*, 1988; Smulders, 2003).The use of MAP has good intrinsic preservation qualities (Genigeorgis, 1985; Panagiotis and George, 2002; Bjorn *et al.*, 2006) and prevents cross contamination during further handling and storage of the product.

In conclusion, the most marked result was noted in the treatment with flash pasteurization (FP) combined with lactic acid buffer system (LABS) and MAP (90% CO_2 + 10% O_2), which prolongs shelf life and improves safety, while still ensuring an acceptable organoleptic quality.

Table (7). Evaluation of sensory quality of poultry treated with flash pasteurization, Lactic acid buffer system (LABS) (pH3) and Modified Atmosphere Packaging and stored at 5°C (A= odour, B= colour, C= texture).

A: Odour

Treatments	n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	8.35^{Ab}	7.12^{Bd}	5.38^{Cg}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization(FP)	8.92^{Aa}	8.17^{Bc}	7.06^{Cf}	5.63^{De}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	8.46^{Ab}	8.30^{Bb}	7.97^{Ce}	7.35^{Dd}	6.62^{Ee}	5.49^{Ff}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	8.35^{Ab}	8.38^{Ab}	8.12^{Bd}	7.91^{Cc}	7.15^{Dd}	6.02^{Ee}	5.48^{Fe}	n.d.	n.d.	n.d.
FP + LABS	8.84^{Aa}	8.77^{Aa}	8.26^{Bc}	7.97^{Cc}	7.64^{Dc}	6.81^{Ed}	5.72^{Fd}	n.d.	n.d.	n.d.
FP+ MAP	8.92^{Aa}	8.86^{Aa}	8.57^{B}b	8.24^{Cb}	8.03^{Db}	7.64^{Ec}	6.92^{Fc}	5.7^{Ga}	n.d.	n.d.
LABS + MAP	8.46^{Ab}	8.39^{Ab}	8.28^{Bc}	8.27^{Bb}	8.05^{Cb}	7.90^{Db}	7.35^{Eb}	6.78^{Fb}	5.64^{Ga}	n.d.
FP + LABS + MAP	8.84^{Aa}	8.78^{ABa}	8.72^{Ba}	8.64^{Ca}	8.51^{Da}	8.32^{Ea}	7.97^{Fa}	7.45^{Gc}	6.93^{Hb}	5.97^{I}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

B : Colour

Treatments	n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	8.41^{Ab}	7.12^{Bd}	5.28^{Ce}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization(FP)	8.87^{Aa}	8.71^{Bb}	8.14^{Cc}	6.74^{Dd}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	8.41^{Ab}	8.28^{Bc}	8.17^{Cc}	7.91^{Dc}	7.02^{Ee}	5.42^{Ff}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	8.41^{Ab}	8.36^{Ac}	8.09^{Bcd}	7.94^{Cc}	7.56^{Dd}	6.45^{Ee}	5.38^{Fd}	n.d.	n.d.	n.d.
FP + LABS	8.87^{Aa}	8.82^{Aa}	8.5^{Bb}	8.32^{Cb}	7.95^{Dc}	6.72^{Ed}	5.6^{Fc}	n.d.	n.d.	n.d.
FP+ MAP	8.87^{Aa}	8.89^{Aa}	8.74^{Ba}	8.61Ca	8.12^{Db}	7.66^{Eb}	6.92^{Fb}	5.78^{Gc}	n.d.	n.d.
LABS + MAP	8.41^{Ab}	8.26^{Bc}	8.02^{Cd}	7.89^{Dc}	7.62^{Ed}	7.24^{Fc}	6.98^{Gb}	6.27^{Hb}	5.30^{Ib}	n.d.
FP + LABS + MAP	8.87^{Aa}	8.84^{Aa}	8.73^{Ba}	8.66^{Ba}	8.45^{Ca}	8.05^{Da}	7.76^{Ea}	6.82^{Fa}	6.27^{Ga}	5.52^{H}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

C : Texture

Treatments	n days of storage at 5°C									
	0	3	5	7	9	11	12	14	16	18
Blank	8.62^{Aa}	6.89^{Be}	5.55^{Cf}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Flash pasteurization(FP)	3.62^{Aa}	7.93^{Bd}	7.12^{Ce}	5.64^{Dg}	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
10% LABS (pH3)	8 62^{Aa}	8.24^{Bc}	7.56^{Cd}	6.89^{Df}	6.15^{Ef}	5.50^{Fg}	n.d.	n.d.	n.d.	n.d.
MAP (90% CO_2 + 10% O_2)	8.62^{Aa}	8.37^{Bb}	7.90^{Cc}	7.53^{De}	6.98^{Ee}	6.08^{Ff}	5.32^{Ge}	n.d.	n.d.	n.d.
FP + LABS	8.62^{Aa}	8.41^{Bab}	8.12^{Cb}	7.84^{Dd}	7.05^{Ed}	6.35^{Fd}	5.64^{Gd}	n.d.	n.d.	n.d.
FP+ MAP	8.62$^{'a}$	8.36^{Bb}	8.13^{Cb}	7.92^{Dc}	7.56^{Ec}	6.98^{Fc}	6.35^{Gc}	5.34^{Hc}	n.d.	n.d.
LABS + MAP	8.62^{Aa}	8.52^{Ba}	8.40^{Ca}	8.10^{Db}	7.91^{Eb}	7.38^{Fb}	7.05^{Gb}	6.48^{Hb}	5.67^{Ib}	n.d.
FP + LABS + MAP	8.62^{Aa}	8.55^{Aa}	8.41^{Ba}	8.25^{Ca}	8.05^{Da}	7.72^{Ea}	7.44^{Fa}	7.08^{Ga}	6.40^{H}	5.48^{I}

1. Values with the same superscripts in the same horizontal row (A-G) or vertical column (a-h) are not significantly different ($p \geq 0.05$).
2. n.d. = not determined because of spoilage.
3. FP= Flash pasteurization.
4. LABS= 10% Lactic acid buffer system pH3.
5. MAP = 90% CO2 + 10% O2.

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التأثير المشترك لكل من البسترة السريعة وحامض اللاكتيك والتعبئة في جو غازي معدل علي فترة صلاحية الدجاج الطازج

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تم إجراء المعاملات المنفردة المختلفة التالية علي أفخاد الدجاج الطازج :

البسترة السريعة لمدة ١٥ ثانية علي درجة حرارة ٩٥ °م أو الرش بمحلول حامض اللاكتيك المنظم ١٠% أو التعبئة في جو غازي معدل مكون من خليط ٩٠% ثاني أكسيد كربون و ١٠% أكسيجين .

وتم إجراء مختلف المعاملات المشتركة الآتية:

البسترة السريعة + الرش بمحلول حامض اللاكتيك المنظم ١٠% كمعاملة واحدة,, البسترة السريعة + التعبئة في جو غازي معدل كمعاملة مستقلة , ثم الرش بمحلول حامض اللاكتيك المنظم ١٠% + التعبئة في جو غاري معدل, وأخيراً تم عمل البسترة السريعة + الرش بمحلول حامض اللاكتيك المنظم ١٠% + التعبئة في جو غازي معدل معاً كمعاملة واحدة بالإضافة للعينة الكنترول(بدون أي معاملة) وذلك لدراسة تأثير هذه المعاملات علي جودة أفخاد الدجاج الطازج والمخزن علي٥ °م. وقد أظهرت النتائج أن المعاملات جميعها أحدثت تثبيط لكل من المجموع الكلي للبكتيريا و بكتريا ***Enterobacteriaceae*** والبكتريا المنتجة لغاز ثاني أكسيد الكبريت وبكتريا حامض اللاكتيك والخمائر إذا ما قورنت بالعينة الغير معاملة.

وقد لوحظ أن أعلي تثبيط تم في المعاملة التي طبق فيها البسترة السريعة + الرش بمحلول حامض اللاكتيك المنظم ١٠% + التعبئة في جو غازي معدل، يليها المعاملة التي طبق فيها الرش بمحلول حامض اللاكتيك المنظم ١٠% + التعبئة في جو غاري معدل. كما أوضحت

النتائج أن السعة التنظيمية لمحلول الحامض كافية لإبقاء رقم الحموضة منخفض علـــي الجلـــد أثناء التخزين .

وقد أكدت نتائج التقييم الحسي أن البسترة السريعة أدت إلى تحسين لون الجلد لأفخاد الدجاج المعامل بالبسترة ولم يظهر أي أثر طبخ علي الجلد أو اللحم. أيضاً كان هناك تطــابق بين نتائج التقييم الحسي والتغير في المحتوي الميكروبي أثناء فترات التخزين . وقد أعطــت المعاملات المنفردة التالية علي أفخاد الدجاج الطازج: البسترة الــسريعة, الـــرش بحـــامض اللاكتيك, التعبئة في جو غازي معدل فترة صلاحية ٧ , ١١ , ١٢ يوماً حينما خزنت علـــي ٥ ْم علي التوالي. بينما كانت فترة الصلاحية للمعاملات المشتركة التالية: البسترة السريعة + الرش بمحلول حامض اللاكتيك المنظم ١٠% كمعاملة, البسترة السريعة +التعبئة فـــي جـــو غـــازي معدل، الرش بمحلول حامض اللاكتيك المنظم ١٠% + التعبئة في جو غاري معدل، وأخيـــراً المعاملة المشتركة لكل من البسترة السريعة + الرش بمحلول حامض اللاكتيك المنظم ١٠% + التعبئة في جو غازي معدل هي ١٢ و١٤و١٦و١٨ يوماً علي التوالي فـــي حـــين أن أفخـــاد الدجاج الغير معامل لم تزيد فترة صلاحيتها عن خمسة أيام فقط.