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Full Length Research Paper

Microbiological properties of mechanically deboned poultry meat that applied lactic acid, acetic acid and sodium lactate

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After the removal of the usual meat cuts, there is always an amount of meat which is firmly attached to the bones. Mechanically deboned meat is a product which is separated from the bones. During deboning process, microbial growth on the products is high. In our experimental trials, poultry chest bone samples were kept in 0.2, 0.3 and 0.5% concentrated lactic acid, 0.2 and 0.3% acetic acid; 1 and 2% concentrated sodium lactate for 10 min then passed through deboning process. Then, the samples were packaged and stored for 4 days at +4°C. According to the results of microbiological analysis, the most effective bacterial decrease for TAMB counts was seen in 2% sodium lactate applied group with a ratio of nearly 15% decrease. *Escherichia coli* counts were lower for all organic acid applied samples than control groups ($P < 0.05$). As a conclusion; 0.2 and 0.3% LA, 1 and 2% SL concentrated organic acid applications are the most successful applications of mechanically de-boned meat decontamination for both microbiological and sensorial criteria. The shelf-life of MDPM was prolonged 1 day by the experimental solutions.

Key words: Mechanically deboned meat, poultry meat, microbial growth, meat microbiology, acid application.

INTRODUCTION

Meat removed from bones by machines is generally termed mechanically deboned meat (MDM), mechanically deboned tissue (MDT) mechanically separated meat/tissue (MSM)/ (MST) or mechanically recovered meat (MRM). In normal, after the removal of the usual meat cuts, there is always an amount of meat which is firmly attached to the bones. Mechanically deboned meat is a product which is separated from the bones. Regulation (EC) 853/2004 defines 'Mechanically separated meat' (MSM) as the product obtained by removing meat from flesh-bearing bones after boning or from poultry carcasses, using mechanical means resulting in the loss or modification of the muscle fiber structure. MSM must not be re-frozen after thawing. The raw material used to produce MSM must comply with the requirements for fresh meat. Early deboning or mechanical separation machines were developed for fish in Japan in the late 1940s, as a result of the need of the fish processing industry. The mechanical separation of poultry began in the late 1950s in the U.S.A. The rising price of meat and therefore the cost of producing processed meat-products have fastened to optimize the use of all available protein sources. From there on, the mechanically separated meat of poultry started to be used in the manufacture of several products, such as sausages, bolognas, salamis and dry soups (Field, 1998; Froning, 1981). It's reported that mechanically deboned poultry meat has good nutritional and functional properties and suitable to use in the composition of many meat products (Field, 1998).

Poultry meat and its derivatives are among the food-products that cause the most concern to public health authorities, owing to the associated risks of bacterial food-poisoning (Baeumler et al., 2000; Beli et al., 2001). The large surface area, the release of cellular fluids and the heat generated during mechanical deboning all enhance bacterial count and growth (Kumar et al., 1986).

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On the other hand, mechanically deboned chicken meat is made from the deboning and cutting of parts with lower commercial value, such as the back and the neck although deboning process can be applied to whole part of poultry carcasses (Barreto, 1995). This undesired way of deboning process decreases the quality of mechanically deboned poultry meat with the other reasons and also makes it short shelf-lived product with high microbial load (Field, 1998). The composition and storage stability of the final product is affected by the raw materials and conditions used for mechanical deboning. According to Regulation (EC) 853/2004, mechanically deboned poultry meat must be produced from the feet, neck skin and head bones of the poultry. Raw poultry surface and the other parts were known as high microbial load. Many decontamination methods were reported. Among these methods, acid treatment is most commonly used, cheap and simple and fast resulted one (Hinton and Corry, 1999). Potassium and sodium lactates are commercially available as pH neutral aqueous solutions (60%), recommended for extending shelf-life in cured and uncured meat and poultry products (Food Safety Inspection Service, 2000).

The objective of this study was to improve the microbial quality of mechanically deboned minced poultry meat by adding lactic and acetic acid, sodium lactate before deboning process. Microbiological load differences were determined between the additive applied and chemical non-applied products. On the other hand, some sensory and physico-chemical properties were also evaluated.

MATERIALS AND METHODS

Broiler chicken breast cages separated from their carcasses were obtained from a commercial poultry meat manufacturer. These bones were transferred to processing area with maximum temperature +2℃. For each trial, 20 samples were used and dipped into 0.2, 0.3 and 0.5% lactic acid (Sigma-Aldrich, St. Louis, MO, USA), 0.2 and 0.3% acetic acid (Sigma-Aldrich, St. Louis, MO, USA), 1 and 2% sodium lactate (Sigma-Aldrich, St. Louis, MO, USA) for 10 min under laboratory conditions. The sample and solution ratio was 1:9. Chemical non-applied samples were washed with pressurized water at 15℃ for 1 min. After draining for 10 min the samples were passed through deboning process by Beehive RSTD-06 type de-boner. Deboner was washed and disinfected properly before using for next deboning process. Comparison was made between the additive applied and chemical non-applied samples during 4 days storage under refrigeration at 4℃.

Twenty-five grams of MDPM samples were homogenized in 225 ml of maximum recovery diluent (MRD) by blending (Patterson and Cassells 1963**)** and additional decimal dilutions were also prepared in MRD (Oxoid, CM0733B). Standard plate count agar (Oxoid, CM0463) was used in order to enumerate total aerobic mesophilic and psychrophilic bacteria and inoculated plates were incubated at 30℃ for 72 h and 7℃ for 10 days respectively (ICMSF 1986). Tryptone Bile X-glucuronide medium (TBX) (Oxoid, CM0945) which is a selective, chromogenic medium for the detection and enumeration of *Escherichia coli* in food, was used to count *E. coli* MDPM samples (ISO 2001). 1 ml of the homogenate was pipetted into a sterile petri dish. TBX medium was added and allowed to set. Then the dishes were incubated at 44℃ for 18 to 24 h. IMVIC test was applied to the bluish colonies produced after the incubation process and the results were determined for *E. coli*.

For the sensory analysis, the method reported by Peryam and Pilgrim (1957) was used after modification in this study. The samples were evaluated by a group of 8 panelists who were experienced. The system for evaluation was based on hedonic scale. According to this scale, numbers from 1 to 9 presents the sensorial values. The numbers refers to these values: 1: the worst, 2: very bad, 3: bad, 4: below medium, 5: medium, 6: above medium, 7: good, 8: very good, 9: the best. Hanna pH 211/213 model pH meter was used in order to measure pH of the samples. Before measuring the pH of the samples, they were homogenized with neutral saline water. Statistical software SPSS for Windows was used to determine the differences between the groups in the microorganism numbers that were obtained from the surface samples. Variance analysis method was used in the repeating groups. Kruskall-Wallis test was applied to determine the difference in the microorganism numbers between the personnel (SPSS Inc. 2004).

RESULTS

Turkish food codex also gave the specifications of mechanically deboned meats. According to Turkish food codex (Kodeksi, 2007), *E. coli* should be 5×10^3 and total aerobe bacteria count should be 5×10^6 colony forming unit in 1 g of sample. Comparing to the control samples (5.377 log cfu/g), the counts belonging to the aerobic mesophilic bacteria were reduced as 10 to 15% with sodium lactate treatment, 6% with acetic acid treatment and 7 to 8% with lactic acid treatment at the initial day ($P > 0.05$). On the other hand, although the chemical solutions used, the aerobic mesophilic bacteria counts increased in all samples during the storage. The aerobic mesophilic bacteria count reached the limit value as defined by the Turkish food codex (Kodeksi, 2007) in the control samples after 3rd day of the storage. Therefore, the control samples were not evaluated after this day, since they lost their organoleptic properties and hygienic quality.

During storage period, the least increase for TAMB counts was seen in sodium lactate applied samples. The most effective bacterial decrease for TAMB counts was seen in 2% sodium lactate applied group with a ratio of nearly 15% decrease.

E. coli counts were lower for all organic acid applied samples than control groups ($P < 0.05$). The most effective bacterial decrease for *E. coli* counts was seen in 0.5% lactic acid applied group with the ratio of 20% decrease and 0.3% lactic acid applied group with the ratio of 12%. 0.3% acetic acid, 2% sodium lactate applications fallowed the other mentioned acid applications. The differences between 0.2% LA, 1% SL and 0.2% AA applied samples for *E. coli* analysis found was non-significant ($P > 0.05$). During storage period, the least increase for *E. coli* counts was seen in 0.5 and 0.3% lactic acid and 2% sodium lactate, respectively. Total aerobic psychrophilic bacteria counts were lower for all organic acid applied samples than control groups

Table 1. Effects of chemical applications on sensorial properties of the samples.

Applications (%)	Color*mean±Sx	Appearence* mean±Sx	Juiceness* mean±Sx	Odor* mean±Sx	General acceptabilities* mean± Sx
0.5 LA	3.900 ± 0.057^{a}	3.966 ± 0.120^{a}	3.966 ± 0.120^{a}	6.200 ± 0.115^{b}	4.300 ± 0.057^{a}
0.2 LA	7.16 ± 0.088^{b}	7.600 ± 0.057^{b}	7.000 ± 0.057^{b}	7.800 ± 0.057^{c}	7.400 ± 0.057^{c}
0.3 LA	7.033 ± 0.066^{b}	7.600 ± 00.57^{b}	7.033 ± 0.033^{b}	7.766 ± 0.033^{c}	7.500 ± 0.057^{c}
0.2 AA	7.600 ± 0.057^{c}	7.700 ± 0.057^{b}	7.100 ± 0.057^{b}	5.000 ± 0.057^{ab}	5.666 ± 0.088^{b}
0.3 AA	7.733 ± 0.033^{c}	7.700 ± 0.057^{b}	7.166 ± 0.033^{b}	4.800 ± 0.057^{a}	5.633 ± 0.033^{b}
1 SL	7.700 ± 0.057^{c}	7.666 ± 0.033^{b}	7.066 ± 0.033^{b}	7.700 ± 0.057^{c}	7.466 ± 0.066^{c}
2 SL	7.666 ± 0.033^{c}	7.633 ± 0.033^{b}	7.000 ± 0.057^{b}	7.700 ± 0.057^{c}	7.500 ± 0.057^{c}
Control	7.933 ± 0.033^{c}	7.866 ± 0.033^{b}	7.866 ± 0.033^{c}	7.933 ± 0.033^{c}	7.933 ± 0.033^{d}

* P<0.05 Differences between groups containing different letters in the same column are significant. Sx : Standard error of means; LA: lactic acid; AA: acetic acid; SL: sodium Lactate; control: Non applied groups.

(P < 0.05). The most effective bacterial decrease for TAPB counts was seen in lactic acid applied group with the ratio of nearly 14% decrease. Sodium lactate applications fallowed the lactic acid applications. The differences between organic acid concentrated samples for total aerobic mesophilic bacteria analysis found were significant (P < 0.05). The final bacterial counts of the samples treated with the solutions were between 5.62 and 6.03 log cfu/g. Microbiological analysis results were given in Table 2.

According to the results of pH measurements; no abnormal results were measured and pH values of all samples were parallel with the chemicals added. The pH values of 0.5, 0.2 and 0.3% concentrated lactic acid applied samples were 5.6; 6 and 5.8 respectively. The pH values of 0.2 and 0.3% acetic acid applied samples were 5.9 and 5.7. The pH values of 1 and 2% concentrated sodium lactate applied samples were 6.0 and 6.1. The samples in control group had the pH value of 6.20.

According to the results of color evaluation; chemical non-applied group took the highest average score (7,933) and 0.5% of lactic acid applied samples took the sensory lowest score (3.900). The scores of 0.2 and 0.3% LA; 0.2 and 0.3% AA; 1 and 2% SL applied groups were 7.166; 7.033; 7.600; 7.733; 7.700 and 7.666 as shown in Table 1, respectively.

According to the results of physical appearance evaluation; as we mentioned for color evaluation, chemical non-applied group took the highest average score (7.866). The lowest score (3.966) belonged to 0.5% of lactic acid applied group. The sensory scores of 0.2 and 0.3% LA, 0.2 and 0.3% AA, 1 and 2% SL applied groups were obtained as 7.600; 7.600; 7.700; 7.700; 7.666 and 7.633 as shown in Table 1, respectively.

The results were similar for juiciness evaluation. The control, chemical non-applied group took the highest average score (7,866) and 0.5% of lactic acid application took the lowest score (3.966). The scores of 0.2 and 0.3% LA; 0.2 and 0.3% AA; 1 and 2% SL applied groups were obtained as 7.000; 7.033; 7.100; 7.166; 7.066 and 7.000 as shown in Table 1, respectively.

The highest score (7.933) of odor evaluation belonged to chemical non-applied group and the lowest score was obtained from 0.3% AA applied group (4.800). General acceptability of the samples was also evaluated and highest score was again belonged to the control group (7.933). The similar results were also taken from the groups that contained 2% SL and 0.3% LA. These samples were scored as 7.500. The results of 1% SL, 0.2 and 0.5% LA, 0.2 and 0.3% AA were 7.466; 7.400; 3.033; 4.300; 5.666; and 5.633 as shown in Table1, respectively.

The statistical difference of the evaluation results of all groups was found significant (P < 0.05). For the sensorial evaluations of all groups; samples of chemical non-applied control group took the highest scores and the samples with lowest scores belonged to 0.5% lactic acid applied groups. For all sensorial analysis, 0.5% LA took lower points than control group. These results of all groups were found significant. The lowest scores were taken for color, physical appearance and juiciness evaluations. The general acceptability of the samples was also affected by these criteria. The color of high acid concentrated samples got lighter and they were juicier. Panelists do not prefer lighter color for meats because this appearance seems to be unnatural. Differences between control group and all acid concentrated samples for color and physical appearance evaluations found non-significant.

DISCUSSION

Tosun and Tamer (2000), investigated the effects of lactic acid application and plunging methods on microbiological quality of poultry meat. According to this study, it was reported that lactic acid application reduced microbiological count of carcasses. 1% lactic acid application significantly lowered the microbiological load

Table 2. Effects of chemical applications on microbiological loads of the samples.

Applications (%)		*E. coli (log cfu/g)* mean ± Sx				Total aerobe mesophilicbacteria (log cfu/g) mean± Sx			
		Day				Day			
		1	2	3	4	1	2	3	4
Lactic acid	0.5%	2,820± 0.0028^{a}	2.938± 0.0026^{a}	3.026± 0.0174^{a}	3.085± 0.0014^{a}	4.971± 0.0033^{c}	5.153± 0.0043^{c}	5.500± 0.0190^{c}	5.769± 0.0143^{c}
	0.2%	3.114± 0.0017^{c}	3.243± 0.0006^{d}	3.531± 0.0008^{f}	3.623± 0.0003^{f}	4.978± 0.0022^{c}	5.221± 0.0078^{d}	5.589± 0.0097$^{d\ e}$	5.844± 0.0071^{d}
	0.3%	3.014± 0.0176^{b}	3.084± 0.0037^{b}	3.232± 0.0052^{b}	3.308± 0.0025^{b}	4.988± 0.0038^{c}	5.225± 0.0083^{d}	5.633± 0.0054$^{e\ f}$	5.862± 0.0055^{d}
Acetic acid	0.2%	3.126± 0.0092^{c}	3.224± 0.0075^{d}	3.553± 0.0100^{e}	3.553± 0.0099^{e}	5.109± 0.0069^{e}	5.362± 0.0020^{f}	5.683± 0.0016^{f}	5.791± 0.0004^{c}
	0.3%	3.012± 0.0049^{b}	3.103± 0.0034^{b}	3.388± 0.0017^{d}	3.460± 0.0010^{d}	5.053± 0.0054^{d}	5.328± 0.0123^{e}	5.577± 0.0188^{d}	5.694± 0.0030^{b}
Sodium lactate	1%	3.140± 0.0010^{c}	3.420± 0.0004^{e}	3.481± 0.0008^{e}	3.552± 0.0004^{e}	4.900± 0.0018^{b}	5.035± 0.0011^{b}	5.165± 0.0096^{b}	5.230± 0.0002^{a}
	2%	3.018± 0.0018^{b}	3.175± 0.0083^{c}	3.303± 0.0013^{c}	3.390± 0.0010^{c}	4.657± 0.0021^{a}	4.925± 0.0007^{a}	5.078± 0.0005^{a}	5.205± 0.0001^{a}
Control	---	3.381± 0.0024^{d}	3.580± 0.0048^{f}	3.854± 0.0066^{g}	---	5.377± 0.0025^{f}	5.620± 0.0039^{g}	5.832± 0.0003^{g}	---

Applications (%)		Total aerobe psychrophilic bacteria (log cfu/g) mean± Sx			
		Day			
		1	2	3	4
Lactic acid	0.5%	4.978± 0.0051^{a}	5.187± 0.0017^{a}	5.550± 0.0042^{b}	5.755± 0.0017$^{b\ c}$
	0.2%	4.997± 0.0022$^{a\ b}$	5.390± 0.0066^{c}	5.591± 0.0063^{b}	5.770± 0.0090^{d}
	0.3%	5.077± 0.0024$^{b\ c}$	5.293± 0.0065^{b}	5.654± 0.0081^{c}	5.783± 0.0012^{d}
Acetic acid	0.2%	5.630± 0.0046^{f}	5.757± 0.0052^{f}	5.871± 0.0055^{e}	6.036± 0.0191^{e}
	0.3%	5.490± 0.0065^{e}	5.675± 0.0022^{e}	5.780± 0.0034^{d}	5.780± 0.0034^{d}
Sodium lactate	1%	5.201± 0.00008^{d}	5.440± 0.00007^{d}	5.591± 0.00002^{b}	5.732± 0.00002^{b}
	2%	5.108± 0.0738$^{c\ d}$	5.310± 0.0002^{b}	5.491± 0.00001^{a}	5.623± 0.00002^{a}
Control	---	5.699± 0.0015^{f}	5.942± 0.0035^{g}	6.050± 0.0001^{f}	---

* $P < 0.05$ Differences between groups containing different letters in the same column are significant. Sx: Standard error of means control: Non applied group.

in comparison to control groups. Each carcass had 1.259 log reduction for mesophilic bacteria count, 1.685 log reduction for coliform bacteria count and 2.023 log reduction for *E. coli* count when 1% concentrated lactic acid was applied. The results were 2.502; 3.876 and 3.820 respectively, when 3% concentrated lactic acid was applied.

Uğur et al. (1995) tried, 0.1, 0.3 and 0.6% concentrated acetic acid; in that study broiler carcasses were plunged into acetic acid solutions for 10 min at 10°C and prechilling was applied. In comparison to control groups that was chilled with water, acetic acid applied groups had lower total mesophilic bacteria count. Marel et al. (1998)

studied on the microbiological quality of chicken carcasses. 1 and 2% concentrated lactic acid were applied; for this progress, the experimental chicken carcasses were cooled just after acid application and stored at 0℃. During the storage period, total mesophilic and psychrophilic bacteria counts were reduced 1 log/g after acid application.

As a result of another study, addition of 0.5, 1 and 2% concentrated sodium lactate to kofte dough, cause better microbiological quality and longer shelf life (Cetin and Bostan, 2002). Papadopaulos et al. (1991) reported that sodium lactate application reduced total bacteria. Wit and Rombouts (1990) reported that sodium lactate had a little effect on *E. coli.* All these experimental studies we mentioned show similarity to the results we obtained from our study. Carpenter et al. (2011) concluded that lactic acid washes added small decontaminating capacity as compared to water, and only acetic acid displayed residual activity to prevent growth of pathogens.

According to the results of microbiological analysis, it has been seen that 0.5% LA was very effective on microbiological counts. On the other hand, these concentrations of organic acid applications caused to get lower scores than the average scores for general acceptability. As the conclusion of this study, 0.2 and 0.3% LA, 1 and 2% SL concentrated organic acid applications are the most successful applications for mechanically de-boned meat decontamination for both microbiological and sensorial criteria.

MDPM is important for preventing the animal protein shortage. Microbiologically, MDPM can be easily spoiled due to high temperature during production. High pH, moisture and fat contents were also effective on the microbiological quality of the product. This study can be accepted as pre-study to develop MDPM consumption and enhance storage capability. The shelf life of MDPM can also be extended by different preservatives, frozen storage and pressure treatment.

Kolsarici and Candogan (1999) published a similar report from their study of 5% concentrated potassium sorbate and 3% concentrated lactic acid trial on chicken breast and leg. According to the evaluations of the panelists; no significant differences were obtained between control and potassium sorbate applied groups, on the other hand lactic acid applied groups gained lower panelist scores than control and potassium sorbate applied groups. It was reported that chicken carcasses plunged into 2% concentrated lactic acid for more than 1 min, had color loss on their skins (Smulders et al., 1986; Izat et al., 1990).

Mulder et al. (1987) reported that a little color loss was obtained in 0.5 and 1% concentrated lactic acid application but no negative effect was seen on odor. Bautista et al. (1997) studied on turkey carcasses and reported that lactic acid applications over 1.24% concentrations cause color lightening on skin. According to the reporters' conclusion, color lightening depends on oxidation. Snijders et al. (1985) reported that 1 to 2% concentrated lactic acid application just after slaughter, had no effect on the sensorial properties and aroma of meat. Uğur et al. (1995) reported that chicken carcasses plunged into 0.1, 0.3 and 0.6% concentrated lactic acid and acetic acid had no effect on skin color, taste and odor of chicken carcasses. According to the conclusion of another study, application of 2% concentrated sodium lactate to kofte dough, did not cause a negative effect on odor, taste and color (Cetin and Bostan, 2002).

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