Use of Organic Acids for Decontamination of Mechanically Separated Poultry Meat and its Use in the Production of Traditional Egyptian Luncheon

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1. Abstract

Mechanically separated poultry meat (MSPM) has widely been used as an economical raw material to replace the more expensive beef in meat products, especially emulsion-type products. In this study, MSPM was chemically decontaminated using a variety of permitted organic acids before being utilized in the processing of a traditional Egyptian luncheon. After that, the product was left at room temperature to observe how these treatments affected its keeping quality. Both the bacterial populations and the deterioration criteria of the MSPM were greatly reduced by all the utilized organic acids. The most effective treatment that reduced the various bacterial populations by ~3.5 $\log_{10}$ was the lactic acid one. The shelf life of the luncheon was increased to 4 months in decontaminated MSPM, compared to only one month for the control sample due to the significant reduction in the bacterial populations as well as the reduction in pH and both protein and lipid oxidative changes.

Keywords: Decontamination, Luncheon, Bacteriological quality, MSPM, Organic acids.

2. Introduction

The poultry processing industry has recently shifted from whole carcass production toward filleting and portioning to meet customer demand. As a result, an enormous amount of carcass parts (frames, wings, necks, backbones, and skin) are accumulated and therefore, constitute a major challenge to the poultry industry [1]. To handle these materials, mechanical separation systems have been developed to acquire meat from the bones of food-producing animals. After deboning, the flesh-bearing bones are crushed before being squeezed into the mechanical meat/bone separator with the resultant material referred to as mechanically separated poultry meat (MSPM) [2]. In general, MSPM is considered a profitable and valuable raw material with good technological and functional properties. Since the 1960s, MSPM is widely used for the formulation of a wide range of well-liked and reasonably priced beef and poultry products including emulsified meat products e.g., frankfurters, different loaf products, fermented sausages, restructured chicken products, hamburgers, patties, fresh and smoked sausages, even chunked and formed products [3]. In Egypt, meat processors rely on imported deboned deep-frozen beef as a primary raw material, however, due to the recent increase in the price of raw beef, most processors now partially or entirely substitute MSPM for beef at a relatively low cost. MSPM often has a high microbial load, a short shelf life even under refrigeration, and a rapid onset of oxidative rancidity, which causes off-flavors and

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odors [4, 5]. Therefore, when MSPM makes up a large proportion of beef products, the product typically goes to spoilage sooner [6]. As a result, the poultry industry is highly concerned about how to improve the bacteriological quality and safety of such a product because the composition and storage stability of the final product is affected by the quality of the raw materials [7].

The decontamination process is a good solution to save such valuable material. Among the methods of decontamination, organic acids treatment is the most suitable, cheap, simple, and applicable one. Benzoic, acetic, and lactic acids have been used as food preservatives and are generally recognized as safe [8]. Most of the research recommended the use of organic acids in the final chilling water of poultry carcasses since they seem to be the most acceptable form of chemical decontamination. However, the use of such acids directly in the raw materials used for further processing of various products is doubtful. As a result of this complaint, it was valuable to assess the efficacy of various organic acids on the bacterial load and deterioration criteria of MSPM and to monitor the effect of such treatment on the quality of the traditional Egyptian luncheon for the duration of their storage life.

3. Materials and Methods

3.1. Experimental design

A shelf-life experiment based on monthly enumeration of selected bacterial populations and determination of deterioration criteria was conducted. Three separate replicates of traditional Egyptian luncheon were conducted at different times (3 samples were examined in each replicate) to explore the effect of each of benzoic, acetic, and lactic acids on the different quality attributes of MSPM, luncheon batter, and cooked luncheon immediately after processing (zero-time) and during the storage period for four months against negative control which did not receive any treatments to determine any deviation that may have been caused by any of the treatments on the safety and acceptability of the product under study.

3.2. Experimental samples

After the preparation of chicken carcasses, the unfrozen bone-bearing tissues, wings, and neck were crushed and then forced into a high-pressure separation machine (AM2C, Quimper, France) to produce the MSPM. Before being frozen, 500 ppm of food-grade benzoic acid, 0.25% each of food-grade lactic and acetic acid acids (v/v) was added separately to the MSPM. The MSPM was then separately mixed in a paddle mixer for a couple of minutes, portioned into 10 kg portions, packed in polyethylene packs, frozen at -60°C for 12 hours, and finally kept at -18°C till use. The emulsion luncheon sausage batter was produced following Good Manufacturing Practices. The control luncheon batter was formulated with 60% MSPM, 8% plant oil, 1.6% sodium chloride, 0.3% ppm polyphosphates, 100 ppm sodium nitrite, 15% corn starch, 15% ice water, and Q.S oleoresin spice mix. The other three groups were produced similarly to the control but with organic acid-treated MSPM. For the production of emulsion luncheon sausage, frozen MSPM blocks were ground with Laska meat grinder (K 65, Austria) using a 5 mm mincing plate, chopped with the non-meat additives in a K-65 Laska bowl chopper (Germany) at 4000 ×g before the ice was added, chopped for 2ºC, then the starch was added and chopped to 10ºC final batter temperature. All the prepared luncheon batters were filled in 85 mm Viskase polyamide casing (Walsroder, GmbH, Germany) and left for a couple of hours at 4ºC before cooking in a Maurer-Atmos oven (Middle by GmbH Kindlebindstr 100-D78479, Germany) using a complete humid cooking program to 72ºC core temperature.

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After cooking, the sausage was showered for one hour. All experimentally produced luncheons as well as MSPM and luncheon batter were analyzed for bacteriological quality and deterioration criteria.

3.3. Bacteriological examination

3.3.1. Preparation of homogenate and serial dilution

Ten grams from both treated and untreated MSPM samples in addition to the raw luncheon batter and cooked luncheon were obtained under complete aseptic condition and homogenized with 90-ml sterile Ringer's solution (Merck, Darmstadt, Germany) in a sterile bag for 2 min using stomacher (Lab blender 400, Seward, UAC house Friars Road, London SE 19 UG-model No. 6021) to provide dilution of 10^{-1}. From the original homogenate, tenfold serial dilution was prepared [9].

3.3.2. Analysis of different bacterial loads.

Aerobic mesophilic bacteria were enumerated by spreading 0.1 ml from each dilution over the surface of double sets of Plate Count Agar plates (PCA Oxoid CM0463B, Hampshire, England) followed by incubation at 35˚ C for 48 h [10]. Proteolytic bacteria were counted by inoculation of skim milk agar and then incubated at 30 ºC for 72 h [11]. For enumeration of total pseudomonas and aeromonas, 0.1 ml from each sample homogenate was separately inoculated into duplicate Petri-dishes of *Pseudomonas* selective agar medium base (Hi Media) supplemented with glycerol and evenly spread. The inoculated plates were incubated at 25 °C for 48 hours after which all developed colonies (greenish-yellow colonies) were enumerated. The average count was calculated and recorded [12]. All bacterial counts were expressed as colony-forming units per gram (CFU g^{-1}) of sample

3.4. Deterioration criteria (pH, Total Volatile Basic Nitrogen "TVBN", and Thiobarbituric Acid Reactive Substance "TBARS)

The pH value was measured by homogenizing 5 g of each with 20 ml of distilled water for 30 seconds [13]. The pH was measured using a pH meter (Lovibond Senso Direct) with a probe-type electrode (Senso Direct Type 330) where three reading for each sample was obtained and the average was calculated. The reference method of perchloric acid extraction adopted by the European Union [14] was followed for the determination of TVBN content (mg/100g). The "TBARS" expressed as mg malonaldehyde/kg sample was measured according to the method of Du and Ahn [15].

3.5. Statistical analysis

The values given in each treatment are the mean values ± standard errors (SE) from three replicates. Data were subjected to analysis of variance (ANOVA) using SPSS software for Windows (SPSS 21.0 for Windows; SPSS Inc., Chicago, IL, USA). Comparison of means was carried out by Duncan's multiple-range test and significance was considered at $p < 0.05$.

4. Results

Data in Table (1) indicated that all the applied organic acids significantly ($p<0.05$) reduced the number of the investigated bacterial group and the deterioration criteria, with the most pronounced reduction (~3.5 $\log_{10}$/g) recorded for the MSPM samples treated with lactic acid followed by that treated with benzoic acid. However, a lower but significant reduction (~2.2-3.00 $\log_{10}$/g) was also reported due to the treatment of acetic acid.

The pH of MSPM is relatively high and allows most microorganisms to grow. In this

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study, the addition of organic acids decreased the pH of MSPM by about 1 unit to reach about 5.19 to 5.43 (Table 1). Organic acids penetrate the cell membrane and acidify the interior of the cell, thus interfering with the cellular metabolism and decreasing the cell's ability to propagate [8]. Both protein and lipid oxidation criteria (Table 1) revealed that untreated MSPM had a noticeably high TVBN and TBARS.

The bacteriological analysis of luncheon batter prepared with the organic acids treated MSPM showed a significant reduction in counts of the different bacterial groups than that reported for the MSPM itself (Table 2). The bacterial profile of luncheon experimentally prepared with organic acids treated MSPM (Fig. 1) clarified the significant effect of such treatments, where the shelf life of the room-kept product extended from only one month in the control product processed with untreated MSPM, to about 4 months in the luncheon produced with chemically decontaminated MSPM. However, such levels were not recorded in all the treated groups till the end of 4 months of storage. Once more, the application of lactic acid exerted the most significant antimicrobial and antioxidative effects followed by benzoic acid and finally acetic acid. Concerning the deterioration criteria of luncheon samples (Table 2), a relatively higher pH was observed in the control group.

Both TVBN and TBARS of organic acid-treated luncheon samples revealed significantly ($P < 0.05$) lower values than the control samples at 0-time and during storage for four months (Fig. 1). TBARS and TVBN of control untreated luncheon samples exceed the permissible limit only after one month of storage, whereas, the treated samples did not exceed these limits till the end of 4 months of storage. Organic acids help in extending the shelf life of MSPM luncheon sausage.

5. Discussion

The relatively high bacteriological pollution of MSPM is probably due to several aspects of the mechanical separation process e.g., fine meat grinding, aeration during the separation process, and the high pH which contributes to the propagation of the microorganism [16].

High pressure during the separation process, contact with air, the increase in temperature and release of the intercellular fluids rich in nutrients, and the high levels of hem pigments and unsaturated fatty acids of the bone marrow all catalyze the oxidation of both proteins and lipids [17]. Oxidized lipids change the functional characteristics of protein and may cause some unacceptable changes in the quality of the product [18]. The lower TVBN and TBARS organic acids treated samples resulted from their effective antioxidant activities.

The higher values of deterioration criteria in control samples may be attributed to metabolites accumulated due to the growth of spoilage microorganisms on protein [19]. Formulation of luncheon sausage with MSPM may promote lipid oxidation of the product because MSPM contains more polyunsaturated fatty acids and hemoproteins which are more susceptible to both chemical and biochemical oxidation [20]. Moreover, Andreo et al. [21] found that the thermal processing of meat emulsion tends to promote lipid oxidation by disrupting cell membranes and releasing pro-oxidants.

6. Conclusion

The detection of antibodies to Q fever in all examined regions, suggests the need for active surveillance employing a "One Health" approach to understand the epidemiology and distribution among people

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and animals. Therefore, further studies are necessary to fully understand the environmental and management issues within dairy cattle farms

Conflict of interest
Nothing to declare

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Table 1: Effect of acetic acid, lactic acid and benzoic acid on the bacterial load and deterioration criteria of MSPM

	Control	Acetic acid	Lactic acid	Benzoic acid
Bacterial load				
Aerobic mesophilic	$7.50^{a}\pm0.65$	$4.49^{b}\pm0.39$	$3.96^{c}\pm0.48$	$4.11^{d}\pm0.18$
Proteolytic	$6.23^{a}\pm0.43$	$4.02^{b}\pm0.76$	$3.16^{c}\pm0.29$	$3.88^{c}\pm0.26$
Pseudomonas and Aeromonas	$6.42^{a}\pm0.22$	$4.33^{b}\pm0.56$	$3.02^{c}\pm0.68$	$3.25^{c}\pm0.38$
Deterioration criteria				
pH	$6.51^{a}\pm0.55$	$5.43^{b}\pm0.42$	$5.23^{c}\pm0.37$	$5.19^{c}\pm0.19$
TVBN	$7.38^{a}\pm0.78$	$5.62^{b}\pm0.51$	$5.21^{c}\pm0.29$	$5.00^{c}\pm0.24$
TBARS	$0.28^{a}\pm0.08$	$0.19^{b}\pm0.04$	$0.11^{c}\pm0.01$	$0.09^{c}\pm0.01$

[a-d] Means within a row with no common letter differ significantly ($P<0.05$).

Table 2: Effect of acetic acid, lactic acid and benzoic acid on the bacterial load and deterioration criteria of batter prepared from treated MSPM

	Control	Acetic acid	Lactic acid	Benzoic acid
Bacterial load				
Aerobic mesophilic	$6.20^{a}\pm0.87$	$4.92^{b}\pm0.25$	$3.30^{c}\pm0.19$	$4.10^{d}\pm0.26$
Proteolytic	$6.04^{a}\pm0.59$	$4.40^{b}\pm0.32$	$3.25^{c}\pm0.27$	$3.91^{d}\pm0.27$
Pseudomonas and Aeromonas	$4.50^{a}\pm0.26$	$4.09^{b}\pm0.41$	$3.04^{c}\pm0.34$	$3.48^{d}\pm0.31$
Deterioration criteria				
pH	$6.21^{a}\pm0.38$	$5.54^{b}\pm0.18$	$5.60^{b}\pm0.36$	$5.34^{c}\pm0.41$
TVBN	$6.39^{a}\pm0.11$	$5.17^{b}\pm0.23$	$4.93^{c}\pm29$	$4.55^{c}\pm0.36$
TBARS	$0.19^{a}\pm0.02$	$0.11^{b}\pm0.01$	$0.09^{b}\pm0.01$	$0.06^{b}\pm0.01$

[a-d] Means within a row with no common letter differ significantly ($P<0.05$).

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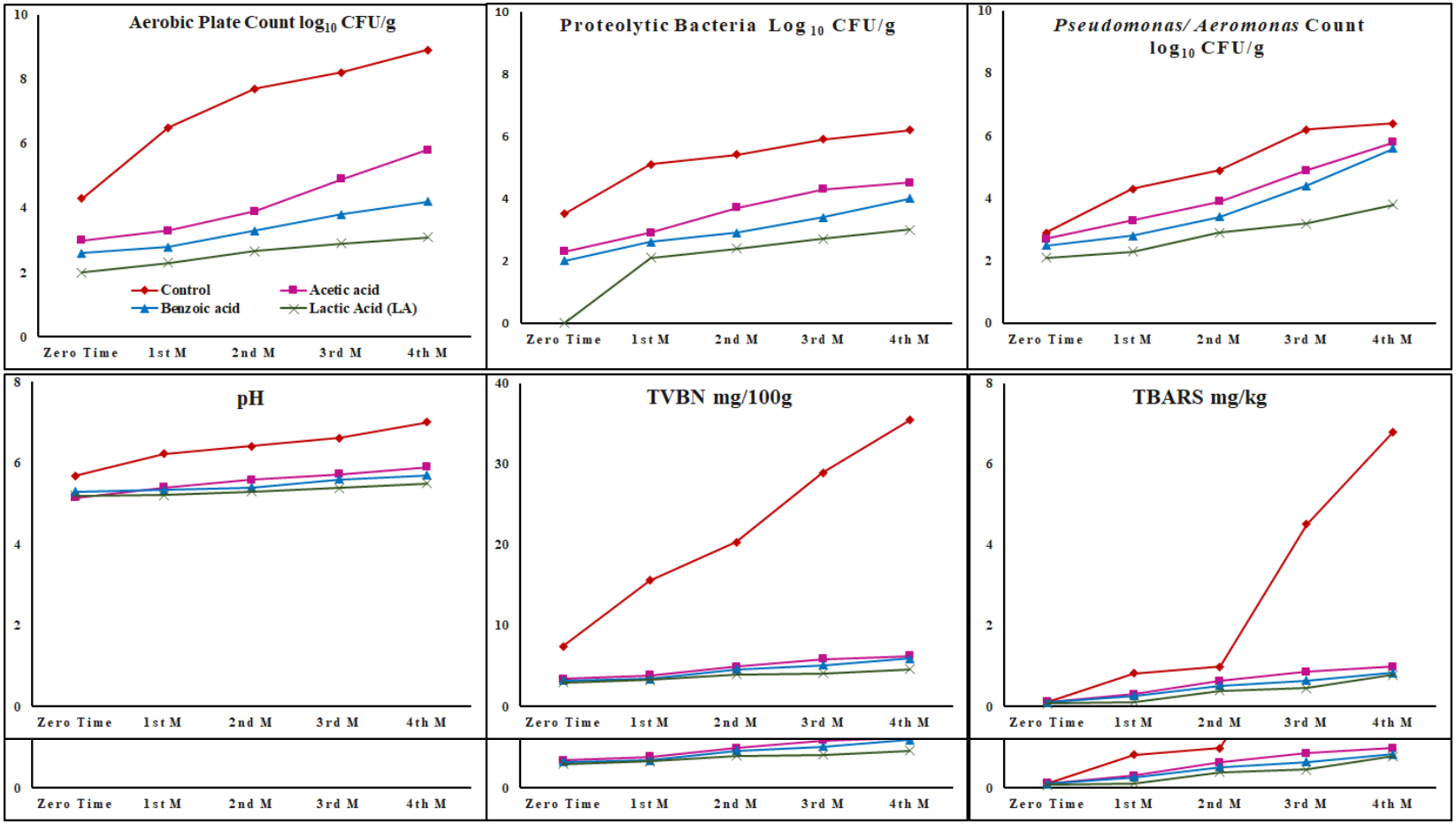

Fig. 1: Changes in the bacterial load and deterioration criteria of luncheon formulated with organic acids-treated MSPM during storage