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USE OF CHLORINE, BENZOATE AND LACTIC ACID AS DECONTAMINATORS TO MECHANICALLY SEPARATED POULTRY MEAT AND APPLICATION IN TRADITIONAL EGYPTIAN LUNCHEON

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SUMMARY

Mechanically separated meat was chemically decontaminated with various approved materials and then used for preparation of traditional Egyptian luncheon. The prepared luncheon was then kept at room temperature to study the effect of such treatments on its bacterial load and keeping quality. All the used chemicals significantly reduced the bacterial load of mechanically separated meat in comparison with control product in which untreated mechanically separated meat was incorporated. Combined use of chlorine and sodium benzoate was the most powerful treatment, where it was responsible for reduction of the different bacterial populations by about 1.5-3.5 $\log_{10}$ cycles. The same treatment exerted a much more effect than the other three treatments in extending the shelf life of luncheon to 7 weeks in comparison with 5 weeks in samples treated with either chlorine or lactic acid alone and only 2 weeks in untreated control samples. Combined treatment also reduced the used concentration of both chemicals without affecting the shelf life of the product.

INTRODUCTION

Mechanically separated meat is a paste- or batter-like product produced by using high pressure machinery that separates meat from flesh-bearing bones after boning or from poultry carcasses using mechanical means, by first crushing bone and adhering tissue and then forcing the crushed tissues into the mechanical meat/bone separation equipment. Therefore, it does not fit conveniently into most existing meat or food categories. The terms mechanically deboned meat (MDM), mechanically deboned tissue (MDT) mechanically separated meat/tissue (MSM)/(MST) or mechanically recovered meat (MRM) are used.

Mechanically separated meat has been used in certain meat and meat products since the late 1970's in many countries. It is an excellent ingredient with very good nutritional and functional properties for the formulation of many food products (Froning, 1981; Field, 1988), being used successfully in a wide variety of emulsified and other meat products e.g. frankfurters, various loaf products, fermented sausages, restructured chicken products, hamburger, patties, fresh and smoked sausages, and even to chunked and formed products (Froning et al., 1973; Froning, 1976; Lai et al., 1991; Lee et al., 1997; Pipova et al., 1997; Babji et al., 1998; Rongrong et al., 1998; Benitez et al., 2002). A major problem with products manufactured with MSM is the rapid onset of oxidative rancidity, which results in off-flavors and odors (MacNeil et al., 1973; Lee et al., 1975).

The last decade has seen an exponential increase in the consumer demand for meat products, which may be accompanied by many technological and processing faults that ultimately affect the safety and quality of the products. Such products may be subjected to organoleptic changes which make them unacceptable to the consumer. These organoleptic characteristics may include discoloration, the development of off odors, slime formation, changes in taste (Jackson et al., 1997; Jay, 1996). It is generally accepted that detectable organoleptic spoilage is a result of decomposition and the formation of metabolites caused by the growth of Gram negative microorganisms specially psychrotrophic bacteria including the proteolytic ones (Kakouri and Nychas, 1994; Nychas and Tassou, 1997).

In Egypt, meat processors rely on imported deboned deep frozen meat as a basic raw material for the production of the further processed beef products. Because of the increase price of the raw beef in the last few years, most processors replace beef partially or even totally by mechanically separated meat.

It is worth mentioning that mechanically separated meat is very perishable and has a short shelf life even under refrigeration because it usually presents high microbial load. The acceptability threshold above which MSM are no longer considered satisfactory are $5x10^6$, $5x10^4$ and $5x10^4$ for total plate, enterococci and Enterobacteriaceae counts respectively, whereas, the limits which are considered satisfactory are $5x10^5$, $5x10^3$ and $5x10^4$. Yuste et al. (1998, 2002) found that the initial population of aerobic mesophiles and psychrotrophes were between 8 and 9 Log_{10} CFU/g, and freezing did not significantly decrease these counts.

Mechanically separated meat may also be contaminated with some pathogenic as well as spoilage bacteria such as Pseudomonas if strict sanitary measures are not taken. Such contaminants are responsible for the development of spoilage (Gill, 1988; Johnston and Tompkin, 1992; Manke

et al., 1998). Therefore, trials were performed for decontamination of MSM. The majority of studies have been focused on the use of organic acids, which appear to be the most acceptable form of chemical decontamination that can reduce the numbers of pathogenic and spoilage organisms typically by 1-3 log_{10} cycles (Bolder, 1997). Yuste et al. (1998; 2002) observed that addition of nisin reduced the level of contamination by about 0.29-0.84 log_{10} CFU/g.

When mechanically separated meat is incorporated in beef products in a high proportion, the product usually deteriorates earlier. This complain initiate the idea to study the effect of some chemical decontaminators on the bacterial load of mechanically separated poultry meat and to evaluate the effectiveness of such chemicals and, second to follow the bacterial quality of traditional Egyptian luncheon formulated with treated mechanically separated poultry meat throughout its storage lifetime.

MATERIALS AND METHODS

Experimental design

A shelf life evaluation based on weekly examination of the product and panelists responses as well as bacteriological analysis was attained for the experimentally prepared traditional Egyptian luncheon formulated with untreated and chemically decontaminated mechanically separated meat. At the same time, the control and treated mechanically separated meat and luncheon batter were examined immediately after preparation.

Samples

Mechanically separated meat, provided by an industrial company, was manufactured from meat remaining on poultry carcasses and left-over from poultry processing and kept frozen until use.

Decontamination of mechanically recovered poultry meat

The bones after deboning process of chicken carcasses were collected and immersed in water chlorine solution at a rate of 200 and 500 ppm for 15 minutes before being cooled and crushed for mechanically separated meat production. Concerning the other decontaminators, 500 ppm of food grade sodium benzoate was added to the chlorine treated (200 ppm) mechanically separated meat, and a 0.5% food grade lactic acid (0.5 v/v) was added separately to untreated mechanically separated meat.

Formulation of the product

Traditional Egyptian luncheon was processed according to the Egyptian Standard Specification ESS 1114/1991, with recommended raw beef replaced with 50% of one of the chemically decontaminated mechanically separated meat. At the

same time, untreated mechanically separated meat was used for the production of control luncheon sample under the same circumstances.

Microbial analysis

Chemically-treated mechanically separated meat was microbiologically analyzed immediately after application of the decontaminators with an untreated sample used as control. Moreover, samples from each treatment were analyzed immediately after the production of the luncheon batter. Samples of the final product were examined at zero time and at one week intervals till the appearance of first signs of deterioration.

Sample homogenate was prepared by homogenizing ten grams in 90 ml of 0.1% peptone water for 1.5 min. using Lab blender, and appropriate decimal dilutions were prepared in peptone water (APHA, 1992). Microbial populations were estimated as follows; colony forming units of aerobic mesophiles incubated at 35°C for 48 hours after growth in standard plate count (Swanson et al., 1992); proteolytic bacteria at 30°C for 72 hours on skim milk agar (Lee and Kraft, 1992); mesophilic and thermoduric aerobic sporeformers at 35 and 55°C for 48 hours using tryptone soy agar (Stevenson and Segner, 1992); and Pseudomonas and Aeromonas spp at 30°C for 48 hours on GSP (Kielwein, 1969).

Statistical analysis:

All data were analyzed using Statistical Analysis System (SAS), Institute, INC, 1995). Comparisons between treatments within each analysis time and within a treatment at different storage times were tested. Significance was determined by the F-test and least square means procedure. Main effects were considered significance at $P< 0.05$.

RESULTS AND DISCUSSION

Mechanical separation is a way of getting every last piece of meat from the bone of a chicken, turkey, or other food animal. It is used for the production of a wide variety of popular and economical meat and poultry products. Therefore, its quality, good technological characteristics and comparatively low cost make the product a profitable and useful raw material. However, mechanically separated meat is very perishable and has a short shelf life even under refrigeration because it usually presents high microbial load, therefore, it is of a major concern to improve the microbiological quality and safety of such product (Froning, 1976; Kumar et al., 1986; Field, 1988)..

Bacteriological examination of mechanically recovered poultry meat revealed its heavy contamination with various bacterial groups specially the aerobic mesophiles, Pseudomonas and Aeromonas as well as proteolytic bacteria (8.48, 6.48 and

6.85 Log_{10} cycle respectively) (Table 1). Froning (1981) pointed out that the main reasons for such contamination may be poor hygienic measures and improper holding temperature during all phases of production and storage. Moreover, Ray et al. (1984) and Kumar et al. (1986) added that several aspects of the mechanical recovery process e.g. release of intercellular fluids rich in nutrients due to tissue maceration, incorporation of air and heat generated during mechanical deboning; the small particle size and so the large surface, and the high pH may contribute rapid microbial growth and multiplication in the mechanically recovered meat.

Data in table (1) clearly indicated that all the applied chemical decontaminator significantly ($p<0.05$) reduced the number of the investigated bacterial group in mechanically separated meat, with the most pronounced reduction (~1.5-3.5 log_{10} cycle) encountered in samples treated with both benzoic acid and chlorine. A lower but significant reduction also reported due to treatment with 500 ppm chlorine, then 200 ppm chlorine and finally the lactic acid. A matter which substantiate the report of Bolder (1997) that decontamination of poultry carcasses can reduce food spoilage bacteria as well as human foodborne infections, taking in consideration that there may be synergistic effects between two decontamination systems that individually have advantages which ultimately lower the used level of both.

The majority of studies have been focused on the use of organic acids, which appear to be the most acceptable form of chemical decontamination. The U.S. Food and Drug Administration (FDA) has no limitation on the concentration of lactic acid that can be used in food products (Kotula and Thelappurate, 1994). Also, chlorinated chill water has been shown to be effective in reducing cross contamination of Salmonella species and other bacteria from carcass to carcass in the poultry immersion chill tank (Thomson et al., 1979).

The bacteriological analysis of luncheon batter prepared with the chemically treated mechanically recovered poultry meat showed a lower but significant reduction in counts of the different bacterial groups than that reported for the mechanically recovered poultry meat itself, which may be due to the effect of other ingredient of the luncheon formula (Table 2). The combined treatment of benzoic acid and chlorine were the most effective treatment, followed by 500 ppm chlorine, 200 ppm chlorine, and finally lactic acid.

The bacterial profile of experimentally prepared luncheon with chemically treated mechanically recovered poultry meat (Fig. 1) clarified the significant effect of such treatments, where the shelf life of the room kept product extended from only 2 weeks for control samples processed with untreated MSM, to more than 6 weeks in the 1st three treatments and 5 weeks in the 4th one. All

the investigated bacterial groups reached the critical limit by the end of the 1st week in the control samples that become obviously organoleptically spoiled, with a bacteriological counts exceeding the acceptable limits at 15 days of storage. A comparable values were attained by the end of the 7th week for samples treated with benzoic acid and chlorine; the 6th week for samples treated with chlorine alone; and the 5th week for samples treated with lactic acid alone.

Table (1): Effect of different decontaminators on the bacteriological quality of mechanically recovered poultry meat log_{10} CFU/g.

Bacterial counts	Mechanically recovered poultry meat				
	Control	500 ppm Chlorine	200 ppm Chlorine	200 ppm Chlorine + 500 ppm benzoic acid	0.5% Lactic acid
Aerobic mesophilic	8.48^{a}	5.90^{b}	6.00^{b}	5.00^{c}	6.48^{d}
Anaerobic	2.48^{a}	2.00^{b}	2.00^{b}	< 2.00^{c}	2.00^{b}
Mesophilic aerobic sporeformers	2.48^{a}	2.00^{b}	2.00^{b}	< 2.00^{c}	2.00^{b}
Thermoduric aerobic sporeformers	<2.00^{a}	<2.00^{a}	<2.00^{a}	<2.00^{a}	<2.00^{a}
Proteolytic	6.85^{a}	5.30^{b}	5.60^{c}	5.00^{d}	5.63^{c}
Pseudomonas and Aeromonas	6.48^{a}	5.78^{b}	5.95^{b}	5.60^{c}	5.95^{b}

$^{a-d}$ Means within a row with no common letter differ significantly (P<0.05).

Table (2): Effect of using different decontaminators on the bacterial load of batter prepared from treated mechanically recovered poultry meat log10 CFU/g

Bacterial counts	Luncheon batter prepared with MRPM treated with				
	Control	500 ppm Chlorine	200 ppm Chlorine	200 ppm Chlorine + 500 ppm benzoic acid	0.5% Lactic acid
Aerobic mesophilic	7.20^{b}	6.52^{c}	6.70^{dc}	5.30^{a}	6.90^{d}
Anaerobic	2.30^{c}	2.00^{b}	2.00^{b}	< 2.00^{a}	2.00^{a}
Mesophilic aerobic sporeformers	2.78^{d}	2.30^{bc}	2.48^{c}	< 2.00^{a}	2.00^{b}
Thermoduric aerobic sporeformers	<2.00^{a}	<2.00^{a}	<2.00^{a}	<2.00^{a}	<2.00^{a}
Proteolytic	7.04^{c}	5.30^{b}	5.60^{c}	4.85^{a}	5.90^{d}
Pseudomonas and Aeromonas	5.50^{d}	4.11^{b}	4.38^{b}	4.04^{a}	4.68^{c}

$^{a-e}$ Means within a row with no common letter differ significantly (P<0.05).

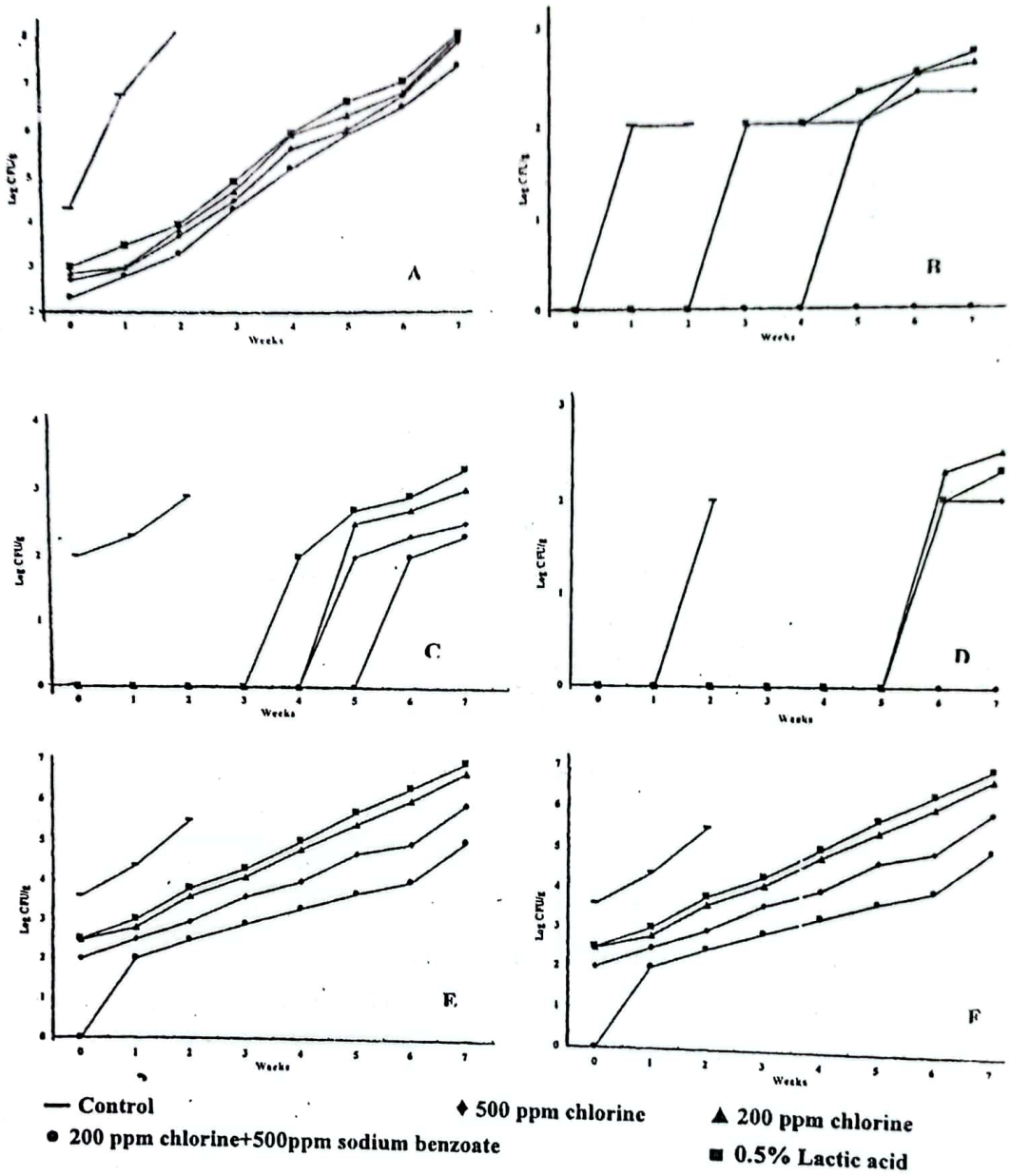

Fig (1): Behavior of different bacterial group during storage of Luncheon processed with treated MRPM. A, aerobic mesophilic; B, anaerobic' C, mesophilic aerobic sporeformer; D, thermoduric aerobic sporeformer; E, proteolytic; F, Pseudomonas and Aeromonas counts.

In conclusion, it is essential that all sanitary measures must be absolutely restricted and controlled for the production of mechanically separated meat. Moreover, careful handling, adequate refrigeration and limited storage time are essential to prevent microbial growth. If it is not frozen immediately, the material should be kept at a temperature of maximum 3°C measured in the meat and should be used for further processing within 48 hours. Finally chemical decontamination specially dipping the bones in 200 ppm chlorine before mechanical separation followed by addition of sodium benzoate during formulation of the product is proved to be a successful mean for mechanically separated meat production and it does not affect the aroma of the product in which mechanically separated meat was incorporated.

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