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Effect of various chemical decontamination treatments on natural microflora and sensory attributes of chicken liver

Einfluss unterschiedlicher chemischer Dekontaminationsmethoden auf die natürliche Mikroflora und sensorische Eigenschaften von Hühnerleber

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Summary

This study was undertaken to determine the effect of different chemical decontamination methods on the microbiological and sensory attributes of chicken liver during refrigerated storage (+4 ± 1 °C). Chicken liver samples were dipped into sterilized water (1 min), lactic acid (1.5%, 1 min or 5 min), acetic acid (1.5 %, 1 min or 5 min), trisodium phosphate (15 %, 15 min or 20 min) or were not treated (control). Microbiological analyses were carried out at 0, 2 and 4 days of storage. Also, sensorial attributes were evaluated by panelists. As result of the study, decontamination with acetic acid, lactic acid or trisodium phosphate could not substantially improve the microbiological quality of chicken liver during refrigerated storage. On the other hand, sensorial attributes of the samples were adversely affected by treatments except the treatments with acetic acid.

Keywords: decontamination, poultry, pathogen

Zusammenfassung

Diese Studie wurde unternommen, um die Wirkung verschiedener chemischer Dekontaminationsmethoden auf mikrobiologische und sensorische Eigenschaften von Hühnerleber während der Kühllagerung (+4 ± 1 °C) zu ermitteln. Die Hühnerleberproben wurden in sterilisiertes Wasser (1 min), Milchsäure (1,5 %, 1 min oder 5 min), Essigsäure (1,5 %, 1 min oder 5 min) bzw. Trinatriumphosphat (15 %, 15 min oder 20 min) getaucht oder wurden nicht behandelt (Kontrolle). Mikrobiologische Analysen wurden an den Tagen 0, 2 und 4 der Lagerung durchgeführt. Daneben wurden sensorische Eigenschaften durch ein Expertenpanel analysiert. Insgesamt ergab die Studie, dass Dekontamination mit Essigsäure, Milchsäure oder Trinatriumphosphat die mikrobiologische Qualität von Hühnerlebern während der Kühllagerung nicht wesentlich verbessert. Auf der anderen Seite wurden die sensorischen Eigenschaften der Proben durch die Behandlungen negativ beeinflusst, mit Ausnahme der Dekontamination mit Essigsäure.

Schlüsselwörter: Dekontamination, Geflügel, Pathogene

Introduction

According to the FAO (2006), 30 % of the world's total meat consumption is poultry and the consumption of poultry increases every year (del Rio et al., 2007). The high consumption rate of poultry meat and offal is a concern for marketing high quality and safe products. Chickens naturally carry a wide variety of bacteria into processing plants and these microorganisms can be transferred to chicken carcasses during processing (Capita et al., 2000). Most of these microorganisms like *Salmonella, Campylobacter jejuni, Staphylococcus aureus, Listeria monocytogenes* and *Clostridium perfringens* can survive in poultry products during refrigerated storage (Waldroup, 1996). To eliminate these microorganisms, it is very important to establish a hygienic processing program in the plant. In addition to general hygienic management practices, the microbiological load of the poultry meat and edible offal like liver can be reduced substantially by the application of chemical decontaminants (Capita et al., 2000). Organic acids, bases like NaOH, halogens, hydrogen peroxide, alcohols, mannose and ozone are used to reduce carcass contamination. Also, phosphates have been used as antimicrobial surface treatments to reduce populations of pathogens, prevent the growth of spoilage microorganisms and extend the shelf life of poultry products (Kim and Marshall, 1999). Today, monopotassium phosphate, monosodium phosphate, sodium pyrophosphate and trisodium phosphate are used for surface decontamination of carcasses. Organic acids and their salts like acetic, lactic, sorbic and propionic acid exert antimicrobial activity and have been traditionally used as food preservatives and are generally recognized as safe substances approved by FAO and WHO (Surekha and Reddy, 2000; Gonzales-Fandos and Dominguez, 2007).

Liver and liver products are rich and economical sources of essential nutrients that are readily available to consumers. Edible offal and especially livers are regarded as highly perishable foods because of their high content of nutrients and poor hygienic conditions under which they are collected, handled and processed (Devatkal and Mendiratta, 2007). Liver is known to spoil more easily than meat. During slaughter of poultry, while eviscerating the intestinal system, liver and the other offal could be contaminated with undesired pathogenic microorganisms.

To our knowledge, there are many studies on microbiological attributes and decontamination of beef, pork and sheep liver (Shelef, 1975; Gill and Delacy, 1982; Hanna et al., 1982; Herrero et al., 1999; Devatkal and Mendiratta, 2007), but there are less researches on the microbiology of chicken liver.

The aim of this study was to compare the microbiological loads of chicken livers treated by using different chemical decontaminants during refrigerated storage.

Materials and Methods

Materials

Chicken liver samples were collected from a local retailer in İzmir, Turkey. Liver samples were collected on the day of slaughter and were packaged in clean polyethylene bags. Samples were subjected to microbiological analyses immediately after reaching the microbiological laboratory of our department. Chemical, microbiological and sensory analyses were performed on treatment day, 2nd and 4th days of the refrigerated storage.

Treatments

Chicken livers were randomly assigned to treatments. Sterile water, lactic acid, acetic acid and trisodium phosphate were used as treatment solutions for different dipping times. Eight different treatments were performed on chicken livers. For each treatment, 100 g liver sample was submerged into 500 ml of sterile water (**W,** 1 min), lactic acid (**LA-S,** 1.5 % v/v, 1 min; **LA-L,** 5 min), acetic acid (**AA-S,** 1.5% v/v, 1 min; **AA-L,** 5 min) or trisodium phosphate (**TSP-S,** 15 % w/v, 15 min; **TSP-L,** 20 min). The pH values of the treatment chemicals were 7.45, 3.05, 3.50 and 12.60 for sterile water, lactic acid, acetic acid and trisodium phosphate, respectively. Untreated control samples **(C)** were also used in the study. After treatment, the liver samples were drained for 30 s using a sieve, then packaged aerobically in sterile polyethylene bags. Liver samples were immediately put into a refrigerator (+4 ± 1 ºC).

Analytical Methods

Determination of pH

For determination of the pH values, 10 g sample was weighted and homogenized in 100 ml of distilled water. Then, the pH value was determined using a pH-meter (HI 9321 Microprocessor, Hana Instruments, Woonsocket, RI, USA) (Ergönül and Kundakçı, 2007).

Microbiological quality evaluation

As for the microbiological analyses, total mesophilic aerobic bacteria **(TMAB),** psychrophilic bacteria **(PB),** total coliform **(COL),** yeast and mould **(YM)** and lactic acid bacteria **(LAB)** counts of chicken samples were determined according to ICMSF (1986).

For serial dilutions, 0.1 % peptone water was used. For enumeration of TMAB and PB, Plate Count Agar (Oxoid, Basingstoke, Hampshire, UK) was used as medium and plates were incubated at +30 ºC and +6 ºC, respectively. Violet Red Bile Agar was used for total coliform count, whereas MRS (Man Ragosa Sharp) Agar was used for LAB count and plates were incubated at +37 ºC.

For enumeration of total yeast and mould count, Yeast Extract Glucose Chloramphenicol Agar was used and plates were incubated at +25 ºC. Microbiological data were converted to logarithms.

Sensory Analysis

Liver samples were subjectively evaluated for odor, color and overall acceptability during refrigerated storage by a six-member, semi-trained panel. Odor, color and overall acceptability were scored on a 6-point descriptive scale, where below 3 is considered as unacceptable. Distinct putrid, sweet or sour odors, a persistent dull color or unusual appearance were evaluated as unacceptable (Devatkal and Mendiratta, 2007). Each group of samples was labeled, at random, with three-digit numbers. Panelists were asked to evaluate each group of samples in randomized order.

Statistical Analysis

The design was completely randomized. The analysis of variance was done using the PROC GLM procedure of SAS (version 8.2., SAS Institute, Cary, NC, USA, 2001). LSMEANS for treatments were generated and separated when significant ($p<0.05$) using the Duncan procedure.

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Results and Discussion

Changes in pH values of liver samples

As seen in Table 1, pH values of liver samples after treatment, prior to refrigerated storage were 6.43, 6.95, 6.40, 6.08, 6.07, 5.96, 7.00 and 8.31 for the samples C, W, LA-S, LA-L, AA-S, AA-L, TSP-S and TSP-L, respectively. The highest pH value (8.31) was obtained for the sample TSP-L, which was treated with trisodium phosphate (pH 12.6) for 15 minutes, whereas the lowest pH value was obtained as 5.96 for the sample AA-L, which was treated with acetic acid (pH 3.5) for 5 minutes.

When pH values obtained on treatment day and on the 4th day of storage were compared, it was seen that there was a decrease in pH value of samples W, LA-S and TSP-L. This decrease is due to the breakdown of glucose by the liver microflora. The decrease in glycogen content and fall in pH might also be caused by the production of lactic acid by autolytic changes in stored liver (Devatkal and Mendiratta, 2007). Devatkal and Mendiratta (2007) reported that the initial pH value of untreated buffalo liver was 6.43 prior to storage, but at the end of the 6th day of refrigerated storage, the pH value was reported as 5.96. Similar results for the changes in pH value during storage were obtained for sheep liver by Gill and Delacy (1982), for beef liver by Shelef (1975) and Herrero et al. (1999). According to statistical analyses, it was determined that the effect of using different decontamination solutions on the changes of the pH value was significant ($p<0.05$). On the other hand, storage time had no significant effect on the changes of the pH value of the samples ($p>0.05$).

Changes in microbiological attributes of liver samples during storage

As seen from Table 2, TMAB counts of samples C, W, LA-S, LA-L, AA-S, AA-L, TSP-S and TSPS-L were 6.22, 4.95, 5.51, 3.79, 6.03, 4.30, 6.81 and 3.65 log cfu/g just after the treatments. It is apparent that dipping into water and decontamination solutions except TSP-S decreased the total microbiological count of liver samples ($p<0.05$). On the other hand, TSP-S treatment increased the TMAB count adversely. Using lactic acid and acetic acid solutions for 5 min (LA-L and AA-L) were the most effective treatments. On the other hand, Kim and Marshall (1999) revealed that using TSP as decontamination medium was an effective method for decreasing the total microbiological load of chicken leg samples.

On the second day of the cold storage of treated samples, TMAB counts were 7.00, 6.89, 6.54, 5.38, 8.33, 4.32, 7.99 and 3.90 log cfu/g for C, W, LA-S, LA-L, AA-S, AA-L, TSP-S and TSP-L, respectively. TMAB counts of samples W, LA-L and AA-S increased rapidly from 4.95 to 6.89 log cfu/g, from 3.79 to 5.38 log cfu/g and from 6.03 to 8.33 log cfu/g. The TMAB count of the sample AA-L did not change in the first two days of storage.

On the fourth day of storage, TMAB counts of C, W, AA and TSP all increased. When compared to 2nd day results, only the TMAB count of LA-L decreased to 4.65 from 5.38 log cfu/g. According to the results, TMAB counts of C, W, AA-S and TSP-L increased at least 1 log cfu/g during refrigerated storage. Only a slight increase was observed for the sample AA-L (from 4.30 to 4.71 log cfu/g).

The same patterns were observed for the psychrophilic bacteria counts of the samples. As seen from Table 2, PB counts were 5.88, 5.12, 4.88, 3.71, 5.65, 4.32, 5.06 and 3.67 log cfu/g on the treatment day for C, W, LA-S, LA-L, AA-S, AA-L, TSP-S and TSP-L, respectively. Similar to the TMAB counts of the samples, the PB counts increased during refrigerated storage and reached 8.40, 8.37, 8.08, 5.77, 7.49, 4.54, 8.00 and 7.06 log cfu/g, respectively. Statistically significant increases were observed for all treatments ($p<0.05$). On the other hand, minimum increase was observed for the treatment AA-L (from 4.32 to 4.54 log cfu/g). It is thought that by increasing the concentration of acetic acid solution, it could be possible to decrease the PB and TMAB counts of the liver samples.

Treatment solutions LA-L and AA-L were found to be effective for decreasing the coliform bacteria counts of the samples. When the last day counts of the samples were compared, it was seen that the COL count of TSP-L increased approximately 1 log cfu/g. But it was observed that COL counts of liver samples decontaminated using LA-L and AA-L decreased by the end of the refrigerated storage.

As seen from Table 2, initial LAB counts of samples C, W, LA-S, LA-L, AA-S, AA-L, TSP-S and TSP-L were 3.61, 3.16, 4.78, 2.30, 4.92, 2.85, 4.50 and 2.40 log cfu/g, respec-

TABLE 1: *Changes in pH values of liver samples during refrigerated storage.*

Sample	pH		
	0	2	4
C	6.43^{dA}	6.57^{eC}	6.53^{dB}
W	6.95^{eC}	6.67^{fB}	5.92^{aA}
LA-S	6.40^{cB}	6.49^{dC}	6.37^{cA}
LA-L	6.08^{bB}	5.98^{aA}	6.52^{dC}
AA-S	6.07^{bA}	6.22^{bB}	6.25^{bC}
AA-L	5.96^{aA}	6.40^{cC}	6.25^{bB}
TSP-S	7.00^{fA}	6.99^{gA}	7.06^{eB}
TSP-L	8.31^{gC}	8.21^{hB}	7.11^{fA}

Values indicated with different small letters in the same column are statistically different ($p<0.05$); values indicated with different capital letters on the same line are statistically different ($p<0.05$).

TABLE 2: *Changes in microbiological attributes of liver samples during refrigerated storage.*

	C			W			LA-S (1.5 %), 1 min			LA-L (1.5 %), 5 min			AA-S (1.5 %), 1 min			AA-L (1.5 %), 5 min			TSP-S (15 %), 15 min			TSP-L (15 %), 20 min		
	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4	0	2	4
TMAB	6.22^{a}	7.00^{b}	8.25^{c}	4.95^{a}	6.89^{b}	8.03^{c}	5.51^{a}	6.54^{b}	7.51^{c}	3.79^{a}	5.38^{c}	4.65^{b}	6.03^{a}	8.33^{b}	9.44^{c}	4.30^{a}	4.32^{b}	4.71^{b}	6.81^{a}	7.99^{b}	8.97^{c}	3.65^{a}	3.90^{b}	6.54^{c}
PB	5.88^{a}	6.93^{b}	8.40^{c}	5.12^{a}	6.48^{b}	8.37^{c}	4.88^{a}	6.59^{b}	8.08^{c}	3.71^{a}	4.94^{b}	5.77^{c}	5.65^{a}	6.90^{b}	7.49^{c}	4.32^{b}	4.00^{a}	4.54^{c}	5.06^{a}	6.56^{b}	8.00^{c}	3.67^{a}	4.53^{b}	7.06^{c}
LAB	3.61^{a}	4.85^{b}	6.40^{c}	3.16^{a}	4.40^{b}	6.24^{c}	4.78^{a}	5.46^{b}	7.06^{c}	2.30^{a}	4.10^{c}	3.44^{b}	4.92^{a}	5.39^{b}	6.37^{c}	2.85^{a}	3.18^{b}	3.20^{b}	4.50^{a}	4.79^{b}	7.04^{c}	2.40^{a}	2.69^{c}	4.32^{b}
COL	3.54^{a}	4.93^{b}	6.35^{c}	2.85^{a}	4.76^{b}	6.60^{c}	4.34^{a}	5.13^{b}	6.23^{c}	3.52^{b}	4.63^{c}	3.23^{a}	4.20^{a}	5.22^{b}	6.06^{c}	3.81^{c}	3.61^{b}	3.04^{a}	4.32^{a}	4.93^{b}	6.48^{c}	3.48^{b}	3.10^{a}	4.65^{c}
YM	2.23^{a}	2.52^{b}	3.65^{c}	2.48^{a}	2.69^{b}	3.47^{c}	3.11^{a}	3.99^{b}	5.27^{c}	2.04^{c}	1.78^{b}	1.70^{a}	3.10^{a}	3.91^{b}	4.26^{c}	1.85^{b}	0^{a}	0^{a}	3.10^{a}	4.00^{b}	5.24^{c}	1.48^{b}	0^{a}	2.19^{c}

Values indicated with different upperscript letters on the same line are statistically different ($p<0.05$).

TABLE 3: *Sensorial analysis scores of chicken samples during refrigerated storage.*

Treatment	Odor			Color			Overall acceptability		
	0	2	4	0	2	4	0	2	4
C	5.50^{cE}	3.83^{bE}	1.50^{aA}	5.83^{cG}	4.83^{bF}	1.83^{aA}	5.83^{cF}	4.00^{bE}	1.33^{aA}
W	5.67^{cF}	3.17^{bC}	3.00^{aD}	6.00^{cH}	4.67^{bE}	3.67^{aG}	6.00^{cG}	3.92^{bD}	3.33^{aF}
LA-S	4.67^{cD}	3.50^{bD}	2.50^{aB}	4.00^{bC}	4.33^{cD}	3.33^{aE}	4.50^{cD}	4.08^{bF}	3.00^{aD}
LA-L	4.33^{cC}	4.00^{bF}	3.50^{aF}	2.00^{aA}	2.50^{bB}	2.50^{bC}	2.67^{aA}	3.17^{cC}	3.08^{bE}
AA-S	5.50^{cE}	3.00^{bB}	3.17^{aE}	5.17^{cF}	2.83^{aC}	3.50^{bF}	5.33^{cE}	3.00^{aB}	3.42^{bG}
AA-L	4.00^{cB}	3.50^{aD}	3.67^{bG}	3.33^{bB}	2.50^{aB}	3.67^{cG}	2.83^{bB}	3.17^{bC}	3.83^{cH}
TSP-S	2.83^{cA}	2.58^{bA}	1.50^{aA}	4.17^{cD}	2.33^{aA}	2.83^{bD}	3.17^{bC}	2.25^{aA}	2.25^{aB}
TSP-L	4.33^{bC}	4.83^{cG}	2.83^{aC}	4.50^{bE}	5.00^{cG}	2.00^{aB}	4.50^{bD}	5.00^{cG}	2.75^{aC}

Values indicated with different small letters in the same column are statistically different ($p<0.05$); values indicated with different capital letters on the same line are statistically different ($p<0.05$).

tively. At the end of the storage period, it was observed that the final LAB counts of the samples increased to 6.40, 6.24, 7.06, 3.44, 6.37, 3.20, 7.04 and 4.32 log cfu/g, respectively. It is apparent that the treatments did not lower the LAB counts of the samples. On the other hand, the treatments LA-L and AA-L had a significantly decreasing effect on the yeast and mould counts of the samples. Initial YM counts of the samples LA-L and AA-L were 2.04 and 1.85 log cfu/g, whereas, at the end of the storage period, these values were 1.70 and 0 log cfu/g, respectively.

Changes in sensorial attributes of liver samples during storage

The sensorial attributes of liver samples during storage are given in Table 3. As seen, odor, color and overall acceptability scores of the control sample were 5.50, 5.83 and 5.83 out of 6.0, respectively. At the end of the refrigerated storage, these values declined to the levels of 1.50, 1.83 and 1.33, which were under the acceptability level of 3.0. According to the sensorial analysis scores obtained on the treatment day, it was determined that using W, LA, AA or TSP as treatment solutions affected the odor, color and overall acceptability scores of the samples ($p<0.05$). Only the odor scores of LA-L, AA-S and AA-L were above the acceptability limit of 3.0 at the end of the refrigerated storage.

It was found that using W, LA-S, AA-S or AA-L treatments was effective in keeping the color scores of the samples which were 3.20, 3.50 and 3.59 at the end of the storage. In general, using treatment solutions for decontamination of liver samples affected the sensorial scores adversely. The overall acceptability scores of samples W (3.33), LA-L (3.08), AA-S (3.42) and AA-L (3.83) were above the level of 3.0, whereas the overall acceptability score of LA-S was 3.00. A higher overall acceptability score was obtained by the sample AA-L (3.83).

Conclusion

The present study shows that decontamination with acetic acid, lactic acid or trisodium phosphate can not substantially improve the microbiological condition of chicken liver held in refrigerated storage. The results obtained from sensorial evaluations showed that the organoleptic properties of the samples were adversely affected by treatments, however, samples treated by acetic acid (AA-S and AA-L) were found to be more acceptable than untreated or water-treated samples by the end of the refrigerated storage.

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