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Evaluation of shelf life of pre-packed cut poultry meat

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ABSTRACT

The results of the analysis of 67 samples of pre-packed cut chicken meat showed that the stability or shelf life of chicken meat (kept on 4 ºC) is six days. Ammonia content was significantly increased after day 3 of storage and reached a maximum level of 9.90 ± 2.3 mg% in chicken fillets and 8.35 ± 1.98 mg% in chicken legs at the end of the investigation on day 6. As regards microbiological quality and contamination with microorganisms, *Salmonella* spp. (7,5%), *S. aureus* (17.9%), *L. monocytogenes* (4,5%) and Enterobacteria (40.30%) were found in the analysed samples of fresh chicken meat. Sulphite reducing clostridia and *Campylobacter* spp. were not found. Total bacteria count in chicken breast fillets was 4.22 ± 0.84 $\log_{10}$ cfu/g on day 1, 4.65 ± 0.74 $\log_{10}$ cfu/g on day 3 and 5.14 ± 0.86 $\log_{10}$ cfu/g on day 6 of storage. After one, three and six days of storage, total bacteria count in chicken legs was 3.60 ± 0.93 $\log_{10}$cfu/g, 4.01 ± 0.76 $\log_{10}$cfu/g, and 4.56 ± 0.85 $\log_{10}$ cfu/g, respectively. The overall results of the study suggest that the potentially significant risk of meat deterioration and increase in the number and diversity of bacteria species depends on the processing of chicken meat. Considering the obtained results of the study, the indication of shelf life of chicken meat for sale should be supplemented with the note "best before".

Key words: shelf-life, poultry meat, ammonia, microbiological quality

Introduction

Shelf life is one of the most important parameters affecting the quality of poultry meat after its distribution to the market. It is the result of poultry management conditions, processing, distribution and storage conditions both on the market and in consumers'

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households. The procedures applied in the production, packaging, storage and market distribution of meat products must insure their hygienic quality and health safety until the expiry date, which should be properly and visibly indicated on each package. In retail trade it is crucial to observe strictly the manufacturer's instructions relative to storage conditions (temperature and period). It is well known from literature and practice that poultry meat is liable to rapid deterioration when kept under inadequate storage conditions. Consequently, poultry meat and meat products are often the cause of alimentary infections. Since poultry meat is not consumed raw, epidemics develop as the result of a secondary contamination in the course of production, storage or preparation (MULDER, 1999). The microflora of poultry are transferred from the primary production sites to production lines, and even further, by subsequent contamination (FRIES, 2002). The results of numerous investigations of the aetiology of food poisoning show that contamination with pathogenic bacteria primarily refers to *Salmonella* spp., *Campylobacter* spp., *Staphylococcus* spp., *Listeria* spp., *Aeromonas* spp., then *Yersinia enterocolitica, Escherichia coli* and *Clostridium perfringens* (ŽIVKOVIĆ, 1998; MULDER, 1999; BAILEY et al., 2001; CAPITA et al., 2002a).

The short period of shelf life of poultry meat at refrigerator temperature can be associated with its composition, but also with spoilage microorganisms present during poultry rearing and primary production. These microorganisms can multiply at a relatively low temperature, and the result of their metabolic activity is manifested as product spoilage (SINGH, 1993), and consequently, they are the most important factors of chicken meat shelf life. The shelf life of poultry meat depends on the initial number of microorganisms, which emphasises the importance of hygienic conditions and control during various stages of the production process (YASHODA et al., 2001). Decomposition processes are manifested by a change in specific sensoric properties of meat. In a majority of cases, the sensoric changes and the degree of contamination with microorganisms, and their biochemical activity, are in correlation with the meat ammonia content (ŽIVKOVIĆ, 1986; BILGILI, 2001; BAEZA, 2004).

In relation to the above, the aim of the study was to investigate the shelf life of fresh chicken meat.

Materials and methods

Assessment of the shelf life of chicken meat included sensoric and bacteriological examination and determination of ammonia content in 67 samples of retail cut meat (40 samples of chicken breasts without skin - "fillet", and 27 samples of chicken legs).

Samples of chicken meat were collected on several occasions, immediately after completed production in the slaughter plant. Within one hour at the latest, the samples were sent to the laboratory and stored in a refrigerator at the temperature of +4 ºC. Smaller pieces of meat (pre-packed cut chicken meat: chicken breasts without skin - fillets, and

chicken legs - drumsticks) were collectively packed and separated one from another with polyethylene foil. Examination was performed immediately after the arrival of samples in the laboratory and again after 3 and 6 days of storage.

On the basis of an assessment of sensor properties, and the odour and taste of meat after the cooking and roasting test, the examined meat samples were classified in three categories, as follows: acceptable for consumption (score 1; meat with all the characteristics of fresh chicken meat); suspicious (score 2; deviations in odour and colour, and watery meat); and unacceptable for consumption (score 3; marked deviations in sensor properties - foul odour, changes in meat appearance, colour, consistency and structure).

Determination of ammonia content was an auxiliary test procedure for confirmation of meat freshness or deterioration. The quantitative NH_3 micro-diffusion assay after Schmidt was used (ŽIVKOVIĆ and HADŽIOSMANOVIĆ, 1996). The results were interpreted as follows:

Fresh meat	=	0.85 - 3.40 mg% NH_3
Meat at risk of decomposition	=	3.50 - 8.00 mg% NH_3
Meat affected with initial degradation process	=	8.16 - 8.33 mg% NH_3
Meat with moderate deviation in odour	=	8.33 - 9.00 mg% NH_3
Markedly tainted meat (rotting)	=	> 9.00 mg% NH_3

Samples of chicken meat were bacteriologically analysed for the presence of *Salmonella* spp., *L. monocytogenes, S. aureus, Enterobacteriaceae, Campylobacter* and sulphite-reducing clostridia. The total count of aerobic mesophilic bacteria was also determined. Bacteriological analyses were performed according to the standard methods of isolation and species of bacteria according to ISO requirements (HRN EN ISO methods) as follows: *Salmonella* spp. (ANONYM., 2003) - Peptone water (37 ºC/24 h); Rappaport-Vassiliadis broth (37 ºC/24 h); XLD - agar (37 ºC/24 h); *Staphylococcus aureus* (ANONYM., 2004) - Giolliti-Cantoni broth (37 ºC/24 h); Baird-Parker agar (37 ºC/24 h); Coagulase test; *Listeria monocytogenes* (ANONYM., 1999) - Fraser broth - semi-strong (30 °C/20-24h); Fraser broth (30 °C/26 ± 2 h); Listeria Palcam-agar (35 °C/24 ± 2 h); Total viable count (ANONYM., 2008) - Plate Count Agar PCA (30 ºC/72 h) with the use of culture media of the manufacturers Biolife, Italy and bioMérieux, France. The isolation of *Enterobacteriaceae* was carried out by Enterobacteriaceae culture medium and VRBG - agar (37 ºC/24 h) and isolation of sulphite-reducing clostridia was carried out by Sulphite agar (Biolife; 24-72 h/37 ºC). API-tests (API 20E; API *Listeria*; API Staph; Biomerieux) and BBL Identification System (Gram Positive ID Kits; Becton-Dickinson) were used for biochemical determination.

Statistical software used for data analysis was the program Statistica 9.0 (StatSoft, Inc., USA).

Results

Study results are presented in Table 1 and Figs. 1 and 2.

Table 1. Results of organoleptic examination of chicken breasts (fillets) and legs during 6 days of storage

Product	Day 1		
	Acceptable, %	Suspect, %	Unacceptable, %
Fillet	80.00	20.00	0.00
Chicken leg	85.19	14.81	0.00
	Day 3		
	Acceptable, %	Suspect, %	Unacceptable, %
Fillet	27.50	62.50	10.00
Chicken leg	51.85	44.44	3.70
	Day 6		
	Acceptable, %	Suspect, %	Unacceptable, %
Fillet	17.50	52.50	30.00
Chicken leg	29.63	59.26	11.11

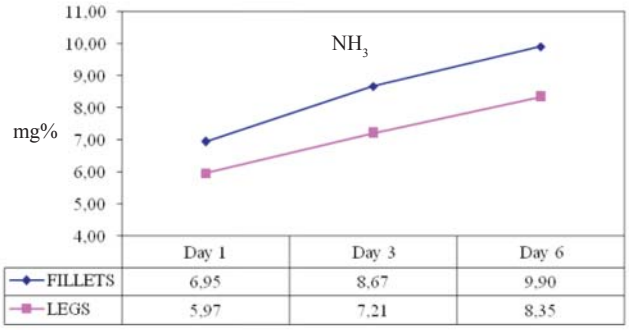
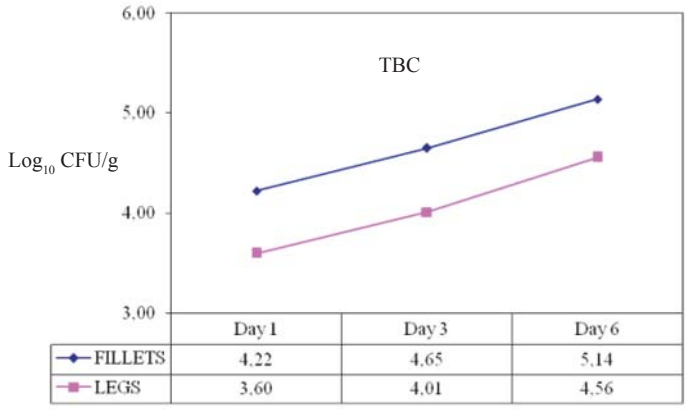


Fig. 1. Content of ammonia (mg%) in samples of chicken fillets and legs during 6 days of storage

The results of sensoric examination of chicken breasts (fillets) and legs during 6 days of storage are presented in Table 1. Already on day 1 of storage 20.00% of the examined fillets of chicken breasts showed deviations in odour and colour, and watery meat, as well as 14.81% of the chicken legs (Table 1). On day 1 no samples were marked as having

unacceptable sensoric properties. On day 3 only 27.5% of chicken breast samples had all the characteristics of fresh chicken meat, and 51.85% of chicken legs had characteristics of fresh meat. Most samples of chicken fillets showed deviations in odour and taste on day 3, as many as 62.5% of them, whilst 10.00% were evaluated as unfit for use (Table 1). At the same time 51.85% of chicken leg samples were evaluated as acceptable on day 3. Regarding the drumstick samples, only 3.70% were unacceptable on day 3 and 11.11% on day 6 of storage. The organoleptic finding of drumsticks was superior to that of chicken breasts without skin.

In Fig. 1. the ammonia content (mg%) in the samples of chicken fillets and legs during 6 days of storage is presented. Maximum average ammonia values in samples of chicken meat were found in chicken breasts without skin. High ammonia values were recorded in individual samples already on day 1 of storage, 6.95 ± 2.29 mg% on average. These high values suggest the beginning of the degradation process and the potential risk of meat spoilage, which also depends on the storage temperature. After 3 days of storage, the ammonia content amounted to 8.67 ± 2.38 mg% and after 6 days 9.90 mg% ± 2.62 mg% after 6 days (Fig. 1.). The ammonia content in chicken leg samples was lower throughout the period of storage. Ammonia content on day 1 of storage amounted to 5.97 ± 1.17 mg%, 7.21 ± 1.78 mg% on day 3, and 8.35 ± 1.98 mg% on day 6, respectively.



	Day 1	Day 3	Day 6
FILLETS	4,22	4,65	5,14
LEGS	3,60	4,01	4,56

Fig. 2. Total bacteria count in samples of breasts without skin (fillets) and legs during 6 days of storage

Contamination of poultry meat with pathogenic bacteria is of utmost importance for public health. In our investigation, *Salmonella* spp was isolated in 5 samples (7.46%) of pre-packed cut poultry meat (n = 67). In addition, *L. monocytogenes* was isolated in 3 of in total 67 examined samples (4.5%). Enterobacteria were found in 27 samples (40.3%) of chicken meat. *S. aureus* was isolated in 12 samples of chicken meat (17.9%) and their

count ranged from 1.70-4.04 $\log_{10}$ cfu/g. Sulphite-reducing clostridia and *Campylobacter* spp. were not found.

Fig. 2 shows the results of total bacteria count in samples of breasts without skin (fillets) and legs during the 6 days of storage. The highest total bacteria count was recorded in chicken breasts without skin (fillets), 4.22 ± 0.84 $\log_{10}$ cfu/g on day 1, 4.65 ± 0.74 $\log_{10}$ cfu/g on day 3, and 5.14 ± 0.86 $\log_{10}$ cfu/g on day 6 of storage (Fig. 2). A lower bacteria count was found in chicken leg samples in all examinations (3.60 ± 0.93 $\log_{10}$cfu/g at day 1. 4.01 ± 0.76 $\log_{10}$cfu/g at 3 day of storage, and 4.56 ± 0.85 $\log_{10}$ cfu/g on the last day of storage). The total bacteria count in chicken legs was similar at the end of the investigation to the bacteria count for chicken fillets on day 1 of the investigation.

A correlation between total bacteria count and amonnia content for chicken fillets and legs was found for all days of storage. In our investigation a positive correlation between total bacteria count and ammonia content was determined for chicken fillet samples on the first day of investigation ($r = 0.455$ $P<0.01$). On the third and sixth days a weak positive correlation occurred ($r = 0.286$ $P<0.01$ on day 3; $r = 0.228$ $P<0.01$) on day 6. A weak positive correlation was found between total bacteria count and ammonia content on all days ($r = 0.148$; $P<0.01$ day 1; $r = 0.216$ $P<0.01$ day 3; $r = 0.182$ $P<0.01$ day 6) for chicken leg samples.

Discussion

The results of investigation of the shelf life of chicken meat (Table 1.) suggest that 6 days of storage at refrigerator temperature (+4 °C) is the longest period for which chicken meat may be found to have impeccable sensoric properties or, frequently, suspicious properties, but still within the acceptable range. In their investigations SAWAYA et al. (1993) showed that only vacuum-packed chicken meat can have a shelf life of 7-8 days. KREYENSCHMIDT et al. (2002b) reported enzymatic changes in chicken carcasses, indicative of an initial deterioration process, that started after 6 days of storage at the temperature of +4°C, and therefore such meat could be declared suspicious (deviation in odour). The obtained results are in correlation with the conclusion pointing out that individual stages of the modern technological process of chicken meat processing were even incompatible with good manufacturing practice (GMP), and that the rate of meat processing and manipulation influenced both the shelf life and hygienic quality of chicken meat (ŽIVKOVIĆ, 1990). Other important factors are: the mode of presentation (chicken carcass, cut chicken meat), type of packing and packing material (individually packed cut chicken meat, PE foils, bags) or collectively packed cut meat (collective packing).

Our finding of Salmonella is very similar to results when *Salmonella* spp. was found in 10.6% of samples of pre-packed cut chicken meat (ŽIVKOVIĆ et al., 1997; KOZAČINSKI et al., 2006). In contrast, other authors report that contamination of chicken meat with

Salmonellae may be as high as 32.8% (ŽIVKOVIĆ, 2001), or even 36% (BAILEY et al., 2001).

Finding of *L. monocytogenes* in 3 of a total of 67 examined samples (4.5%) is consistent with the results of positive findings of *L. monocytogenes* in fresh broiler meat of 3.03% (KOZAČINSKI et al., 2006). Other authors (VITAS et al., 2004; BOHAYCHUK et al., 2006) reported a high incidence of *L. monocytogenes* in raw poultry (36.1%) and in raw chicken legs (34%). Sulphite-reducing clostridia were not found. Enterobacteria were found in 27 samples (40.3%) of chicken meat. Their number increased proportionally with duration of storage and was the highest on day 6. In our study the enterobacteria count was 1.69-3.78 $\log_{10}$ cfu/g. In some studies (KREYENSCHMIDT, 2002b), the enterobacteria count averaged $9x10^5$/g during the storage of chicken meat at the temperature of 4°C for 144 hours. In other (CAPITA, 2002b) 2.58-3.53 $\log_{10}$ cfu/g enterobacteria was found in samples of retail cut chicken meat. There are reports of about 4.5-4.6 $\log_{10}$ cfu/g enterobacteria found in chicken carcasses (ABU-RUWAIDA, 1994).

S. aureus was isolated in 12 samples of chicken meat (17.9%) and their count ranged from 1.70-4.04 $\log_{10}$ cfu/g. In a study on the shelf life of poultry meat (KREYENSCHMIDT, 2002a) *S. aureus* was isolated only in samples of retail cut chicken meat kept at the temperature of 10 °C (1000/g), whilst *Staphylococcus* spp. was found only in samples kept at 4 °C (5×10^4/g). It was pointed out (ALVARE-ASTORGA, 2002) that the finding of *S. aureus* was the reason for the inadequate microbiological quality of retail chicken meat in Spain (drumsticks 2.47 $\log_{10}$ cfu/g. and wings 3.48 $\log_{10}$ cfu/g bacteria). Similarly, some authors (ABU-RUWAIDA, 1994) emphasise the importance of the finding of *S. aureus* in chicken meat (4.1 $\log_{10}$ cfu/g), whilst the reported value was also 2.3-3 $\log_{10}$ cfu/g (MEAD, 1993).

Campylobacter spp. was not found in our investigation. It is in accordance with the results of ROASTO et al. (2005). They reported negative findings of bacteria in chicken breasts and legs, although bacteria was determined in carcases (28.0%) and chicken wings (31.3%).

In the study of ALVARE-ASTORGA et al. (2002) of total bacteria count in cut poultry meat, in drumstick samples total bacteria count amounted to 5.79 $\log_{10}$ cfu/g. The value recorded in our study was lower (4.56 $\log_{10}$ cfu/g) even after 6 days of storage. A high average total bacteria count of above mentioned authors was found in chicken wings (5.85 $\log_{10}$ cfu/g). The total bacteria count in chicken fillets in our study was 4.22 $\log_{10}$ cfu/g at the day 1 and at the end of storage 5.14 $\log_{10}$ cfu/g. Similar results were observed in the investigation of BALAMATSIA et al. (2006) at the beginning of storage the total bacteria count was 5.1 $\log_{10}$ cfu/g, but it was higher (7.0 log cfu/g) after approximately 4 -5 days of storage at 4 ºC.

The results of total bacteria count in chicken legs at the end of the investigation, which was similar to the bacteria count for chicken fillets at the day one of investigation,

may be explained by the conclusion that reasons may be found in the mode of production (ŽIVKOVIĆ, 1986). Total bacteria count influences the shelf life of poultry in retail sales. Results are also in correlation with the conclusions that shelf life also depends on the specific part of chicken meat analyzed (cut chicken meat), the type of packing, including vacuum packaging and modified atmosphere packaging (HINTON et al., 2002; BALAMATSIA et al., 2006) or individually or collectively packed cut meat (KOZAČINSKI et al., 2006).

There was a positive correlation between total bacteria count and ammonia content in chicken fillets samples on day 1 of the investigation. Later data showed a weak correlation for the same parameters in day 3 and day 6. In chicken legs, the correlation between bacteria count and ammonia content was weak. We should keep in mind that in the total bacteria count, specific spoilage bacteria and psychrophilic bacteria are some of the microbial flora of poultry. Further investigations should determine spoilage bacteria and their influence on ammonia content in the poultry meat.

If all the results are taken into consideration (sensoric examination, chemical and microbiological analysis), the general conclusion is that, depending on the duration of storage, organoleptic properties are subject to changes in odour and taste, that ammonia content increases, as well as total bacteria count, which is consistent with the conclusions of other authors (ŽIVKOVIĆ, 1986; 2001) In general, it may be concluded that the duration of storage at +4 ºC affected the sensor properties of meat, and that certain deviations were detected in samples of chicken fillets already after one day of storage. Ammonia content increased with each additional day of storage, especially in the case of chicken fillet samples. The higher initial content of ammonia in chicken fillets in the relation to drumsticks could be explained by higher initial contamination and deterioration caused by bacteria in processing (ŽIVKOVIĆ, 1986; ABD EL ATTY et al., 1997). Total bacteria count increased from day 3 to 6 of storage by 1 $\log_{10}$. The potential risk of rapid growth and multiplication of bacteria after 6 days of storage should be pointed out, since it may lead to meat spoilage.

Consequently, caution is required when determining the shelf life of retail chicken meat. Sensoric changes, indicative of deterioration, were not detected in a large number of samples, nor were significant microbiological changes. Nevertheless, in our opinion the relative declarations for poultry meat should be supplemented.

Conclusions

The evaluation of shelf life of fresh retail chicken meat during 6 days of storage showed that the odour and taste of meat undergo changes. The most significant deviations in the sensor properties of meat were found in samples of chicken fillets. Ammonia content increased proportionally with the duration of storage, and it was an indicator

of suspicious meat quality and the beginning of the deterioration process, especially in the case of chicken fillets after 6 days of storage. An identical increase occurred in total bacteria count, so that it increased many times from day 3 to 6 of storage. There was a positive correlation between total bacteria count and ammonia content in chicken fillet samples at the beginning of storage, but a weak correlation by the end of storage. In chicken legs, the correlation between bacteria count and ammonia content was weak. Subsequent investigations should focus on findings of specific spoilage bacteria to determine the influence on ammonia content during storage of 6 days.

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SAŽETAK

Rezultati pretrage 67 uzoraka pilećega mesa u komadima pokazali su da je održivost pilećeg mesa držanoga na temperaturi od 4 ºC šest dana. Sadržaj amonijaka je rastao nakon trećeg dana pohrane do maksimalne količine od 9,90 ± 2,3 mg% u uzorcima pilećih prsiju, odnosno 8,35 ± 1,98 mg% u uzorcima bataka i zabataka

na kraju istraživanja, šestoga dana pohrane. U mikrobiološkoj pretrazi utvrđene su bakterije *Salmonella* spp. (7,5%), *S. aureus* (17,9%), *L. monocytogenes* (4,5%) i enterobakterije (40,30%). Sulfitreducirajuće klostridije i *Campylobacter* spp. nisu utvrđeni. Ukupni broj bakterija u uzorcima pilećih „filea" bio je 4,22 ± 0,84 $\log_{10}$ cfu/g prvoga, 4,65 ± 0,74 $\log_{10}$ cfu/g trećega i 5,14 ± 0,86 $\log_{10}$ cfu/g šestoga dana pohrane. Prvoga, trećega i šestoga dana pohrane ukupni broj bakterija u pilećim batacima i zabatacima iznosio je 3,60 ± 0,93 $\log_{10}$ cfu/g, 4,01 ± 0,76 $\log_{10}$ cfu/g, odnosno 4,56 ± 0,85 $\log_{10}$ cfu/g. Rezultati istraživanja upućuju da potencijalni, značajniji rizik razgradnje mesa i povećanje broja i vrsta bakterija ovisi o načinu rasijecanja piletine. Uzimajući u obzir rezultate istraživanja preporučeni rok održivosti piletine u maloprodaji treba upotpuniti s oznakom „održivo do".

Ključne riječi: održivost, piletina, amonijak, mikrobiološka kakvoća