QUALITY ANALYSIS OF RAW BROILER CARCASSES ALONG A COLD CHAIN

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Abstract

Cooling technologies are used intensively in food industry, beginning with processing and continuing with storage, supply chain and marketing of perishable foodstuffs, particularly in the meat industry. In this article we analyzed the refrigerated broiler carcasses quality along a short cold chain: transport from factory to retailer, storage to retailer store and to consumer until the product is losing the shelf life. The purpose of this study is to verify the quality and freshness of broiler carcasses on a real life cold chain. The quality parameter analyzed for broiler carcasses are: pH, easily hydrolysable nitrogen, the freshness index (FI) based on biogenic amines, and psychotropic microbiota. We recorded the temperature and relative humidity variation in the refrigerated van and at home refrigerator. The broiler meat pH is increasing with 14 % between the first and the last day of shelf life along the considered cold chain. The easily hydrolysable nitrogen had at the 5th day of meat refrigeration a 31 % increase from the first day of refrigeration. The freshness index proposed by the authors for chicken meat was calculated based on mathematical relation of biogenic amines: spermine, spermidine, cadaverine, putrescine, histamine and tyramine. For a fresh product the value of FI is bigger, at the last day of analysis the value of FI being 1.20. The psychotropic bacteria is increasing in number over time, at the last day of shelf life being double the number determined in the first day of analysis. Although the studied cold chain was a short one, the values of physic-chemical and microbiological determinations give us an overview of the quality of raw broiler carcasses.

Key words: chicken meat, cold storage, refrigeration, consumer, retailer.

The success of refrigerated chicken meat quality on consumer table relies upon effective management of the cold chain, which is a term used to describe the series of interdependent operations in the production, distribution, storage and retailing of chilled foods. Controlling the links that compose the cold chain is vital to preserve the safety and quality of refrigerated foods and comply with legislative directives.

After slaughter a poultry carcass has to be chilled to reduce and then maintain the temperature of the meat below a value that will ensure a high quality, safe product. Primary and secondary chilling of poultry carcasses are carried out to produce a safe product by reducing the temperature of the meat to a point where the rate of growth of spoilage microorganisms is reduced and the growth of most pathogenic microorganisms is prevented. They also have an effect on the major quality indicators of flavor, appearance and meat texture. (C. James *et. al*. 2006)

The transport and distribution sections of the chill chain are particularly important to control in order to ensure both safety and quality. The major tool at our disposal is the temperature monitoring of foods at each point within the cold chain. The distribution of refrigerated foods is the weaker link of the system. Conditions during transportation and at the retail level are out of manufacturer's direct control and often deviate from specifications.

The different points of transport, from cold storage to the retail outlet, and then to the consumer refrigerator, are critical points for the meat's overall quality and safety. In general, the vehicle must be provided with a good refrigerated system, while another weak point of the distribution is the transport period from the product purchase to the consumer domestic refrigerator, a matter that has only limited reported in the literature with published data quantifying this parameter. The last but not the least part of the chill chain is related to refrigerated distribution. This stage is less studied probably due to difficulties in data collection, concerning temperature conditions in domestic refrigerators and freezers, consumer habits and approximate storage periods before consumption. (Nychas *et al*., 2008)

Temperature control is completely lacking from the store to domestic storage and until the

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time of preparation and consumption. In South European countries 30% of refrigerated foods were kept above 10 °C in retail cabinets and household refrigerators and even in North Europe 5% were above 13 °C in retail and 21% above 10 °C in households (Kennedy *et al*., 2005). Since in practice significant deviations from specified conditions often occur, temperature monitoring and recording should be a prerequisite for food chain control (Wells and Singh, 1989).

The cold chain extends from the raw material supplier through to the consumers' refrigerator, and all the steps in between. To preserve quality and safety in frozen foods, temperature requirements exist for each major stage of the cold chain.

So far, sensory and microbiological analyses are most often used to evaluate the freshness, spoilage or safety of meat and meat products (European Commission, 2005).

The microbiological analysis, or the molecular tools (PCR, RT-PCR, DGGE) are often misleading and scientists have shown that it is more meaningful to measure the responsible for spoilage microflora fraction (Nychas *et al*., 2007).

Unfortunately, microbiological analyses are lengthy (traditional, conventional microbiology), costly and high-tech (molecular tools), and destructive to test products; therefore, efforts have been made to replace both microbiological and sensory analyses with biochemical changes occurring in muscle (e.g., various microbial metabolic products, termed as chemical spoilage indices – CSI), that could be used to assess meat spoilage (Huis in't Veld, 1996).

The purpose of this study is to verify the quality and freshness of broiler carcasses on a real life cold chain.

MATERIALS AND METHODS

The refrigerated broiler carcasses were analyzed along a cold chain, from a Romanian company cooling storage until a consumer refrigerator.

Analyzed cooling links of the refrigerated broiler cold chain were: the cooling storage at the broiler meat producer, the insulated refrigeration van, the retailer cold storage room and self-service display case and the consumer fridge (domestic refrigerator).

We recorded the temperature and air humidity variation in refrigerated van and in the consumer fridge using OPUS 10 THI thermohygrometer (Instrumentation Group, USA). Transportation time from the meat producer to the retailer took in medium, 5 hours. Sampling was done as per Romanian Recommendation Norm 24/01/2005 (***, 2005). Samples were carried to the analysis laboratory into a insulated bag.

The dry matter determination was done according to STAS 9065/3- 73. The pH was measured using a standardized method - STAS 9065/8-74 with a WTW Ino Lab pH 730 pH-meter (Mettler Toledo, USA).

The easily hydrolysable nitrogen (EHN) was determined according with STAS 9065/7-74.

Microbiological analysis was performed according to Baston (Baston *et al.*, 2010).

The determination of biogenic amines amount using high performance liquid chromatography was performed according to the method proposed by Food Research Institute from Helsinki, Finland (Eerola *et al.*, 2001) and described in Baston (Baston *et al*., 2008). The concentration of each biogenic amine was expressed in mg/kg d.w.

Freshness index (FI) was calculated based on a mathematical relation proposed by Baston in his doctoral thesis: [(spermine + spermidine)/cadaverine + putrescine + histamine + tyramine)]. (Baston, 2009).

The statistical analysis of the obtained data was done using SPSS 13 software for 3 samples in each of the storage days. The results obtained are presented only as the mean. The differences among means were determined using the method of the smallest squares and the significance level was $p< 0.05$.

RESULTS AND DISCUSSIONS

At the first day of analysis, the sampled broiler meat was frozen at the meat factory and analyzed at our laboratory. The values found are presented in table 1.

Table 1

Refrigerated broiler meat parameters at the meat producer

Parameter	Value
pH	5.80
EHN (mg/100g)	17.00
FI	10.27
Psychotroph count (log UFC/cm^2)	3.98

pH and EHN values are low, according to Romanian norms for chicken meat freshness. The recommended limits for chicken meat freshness are: pH = 5.8…6, easily hydrolysable nitrogen = 25 mg / 100 g (***, STAS 7031-83). Also, the psychrotroph bacteria count is low.

The meat were loaded into the van and transported at the customer, which in this case is the retailer. After the arrival at the retailer, we sampled the same broilers and the mixed meat were taken for analyze. The values are presented in table 2. The meat was stored in the retailer storage room at 3°C. We recorded the variation of temperature and time inside the van nearly and at the top of the door, as they are in figure 1.

Table 2

Refrigerated broiler meat parameters after transportation

Parameter	Value
pH	5.86
EHN (mg/100g)	17.08
FI	10.03
Psychotroph count (log UFC/cm^2)	4.10

Relative with the data presented in table 1, the pH and the EHN are the same the freshness index is slightly decreasing, and the psichrotroph count is slightly increasing. So, we can say that at transportation, for the mobile link of the studied cooling chain, the broiler meat do not undergoes important transformations.

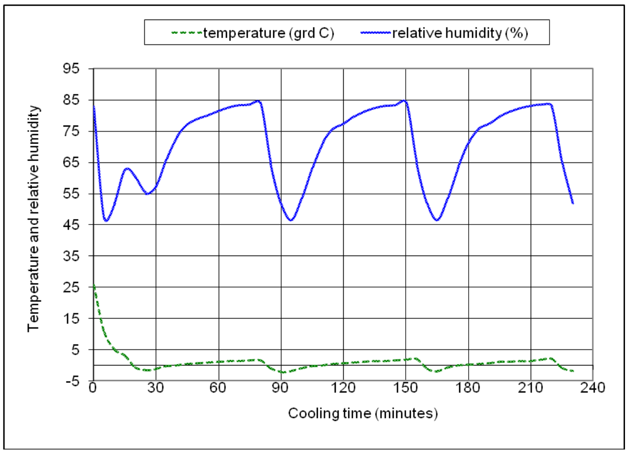

Figure 1 **Temperature and relative humidity variation in refrigerated van.**

The initial humidity and temperature are high because they were recorded after the door was closed. The air temperature inside the van decreased under 0°C after twenty-five minutes. After that it can be observed that from time to time, the humidity and the temperature are varying cyclically. The upper an the lower limit for the air temperature inside the van were -1.5…3°C and the relative humidity varied between 45…85%.

At the retailer storage room we took the samples and the values that we found are in table 3. The samples were took the second day after broiler slaughter.

Table 3

Refrigerated broiler meat parameters from the retailer storage room

Parameter	Value
pH	5.9
EHN (mg/100g)	17.6
FI	9.43
Psychotroph count (log UFC/cm^2)	4.35

For the second day of refrigerated storage and also for the second day of broiler meat shelf-life, the pH, EHN and psychrotroph count are slightly increasing, the freshness index decreasing. This is due to a minor microbial activity and also to some meat biochemical transformations. The broiler carcasses were then moved into the self-service display case temperature was 4 °C.

In the third day of storage, the meat were at the forth link of the cooling chain. We sampled again the carcasses and the analyzed data are presented in the table 4.

Table 4

Refrigerated broiler meat parameters from the retailer display case

Parameter	Value
pH	6.1
EHN (mg/100g)	23.4
FI	2.37
Psychotroph count (log UFC/cm^2)	5.95

Due to the intrinsic factors (meat enzymes and microbiota activities) and extrinsic factors (the temperature of the air at the surface of carcasses that was higher than the temperature set at the cooling equipment with 3…4°C) the meat freshness is decreasing. The determined values are close to the superior limit of chicken meat freshness. The pH and the psichrotroph count are very good indicators that the broiler meat freshness is almost lost. The meat were "purchased" then from the retailer, transported without any refrigeration equipment and stored to the home refrigerator. This is in fact the first interruption in the cooling chain. Outside, the air temperatures were around 30°C and we considered a 30 minutes of transportation between the retailer and final consumer. The parameters analyzed at the last day of storage that is also the last day of broiler meat shelf-life recommended by the producer, are presented in table 5.

Table 5

Refrigerated broiler meat parameters from the domestic refrigerator

Parameter	Value
pH	6.5
EHN (mg/100g)	24.7
FI	1.2
Psychotroph count (log UFC/cm^2)	7.97

From the determined data, the pH and the EHN characterizes a meat that is closed to an initial alteration. The psichrotroph count is higher, two times than the initial value determined at the first day of chicken meat shelf-life. The freshness index surely indicate that the meat enter alteration because we determined in the doctoral thesis a limit value of 2.0 for FI. In figure 2 we also presented the time and relative humidity variation in the fridge. After the door was closed, the temperature and relative humidity is decreasing, the values then are stabilizing and being cyclical. The temperature inside the fridge varied between a highest and a lowest limit of 4.5°C and 6.0°C, and the relative humidity between 38% and 63%.

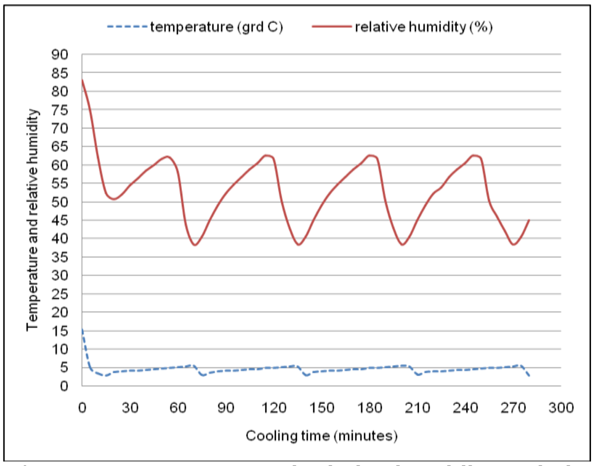

Figure 2 **Temperature and relative humidity variation in the domestic refrigerator.**

CONCLUSIONS

For a short and interrupted cooling chain, the broiler meat loses its freshness sooner than the limit date declared by the producer on the package.

The cold chain was interrupted in two points: at the retailer display cabinet and at the transportation to the consumer fridge.

The freshness index and the upper limit proposed is a good indicator of the chicken meat freshness.

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