VARIABILITY OF SELECTED PARAMETERS OF HYGIENIC QUALITY OF FRESH, MARINATED AND GRILLED POULTRY MEAT IN RELATION TO ITS STORAGE CONDITIONS

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ABSTRACT
The aim of research was to verify scientifically variability of selected parameters of hygienic quality of fresh (A), marinated (B-E) and grilled (G) poultry meat in relation to its storage conditions. Marinated meat was kept under various conditions (12 hours and 48 hours at a temperature of 0 to 4 °C and 5 to 8 °C) until it was heat-treated. Using microbiological and physico-chemical methods, poultry meat was analysed in fresh, marinated, as well as the grilled state. During the experiment period, water activity, pH, salt, and fat content, but also TVC - total viable count of microorganisms, coliforms, MFF - microscopic filamentous fungi and yeasts were analysed. The value of a°w ranged from 0.92 (EG) to 0.99 (AG and D). The range of mean pH values ranged from 5.82 to 6.15. The salt content was lowest in fresh meat (0.16 g/100g), in samples of marinated meat it ranged from 0.38 to 0.47 g/100g. Thus, in neither case was the maximum permitted salt content (1.3 g/100g) exceeded. The difference between the lowest and the highest fat content was very observable. The lowest value of fat content 3.40 g/100g was obtained in the sample AG. On the contrary, the highest fat content (10.24 g/100g) was detected in the sample D. The average TVC value in fresh poultry meat was 4.01 log CFU/g. In marinating process, the value increased to 4.21 log CFU/g (12 hours, 0 to 4 °C) and to 4.65 log CFU/g (48 hours, 5 to 8 °C). Microorganisms were present in number of less than 1.10⁵ CFU/g in grilled meat. The number of microscopic filamentous fungi and yeasts was low in fresh meat and marinated meat (<4.10⁵ CFU/g). After grilling they were not detected. Coliforms indicating the cross contamination were not present in the samples. All the obtained results were statistically evaluated. The data were processed to the analysis of variance (ANOVA) in the general linear models (GLM), Scheffe’s test and Pearson correlation coefficients (r).

Keywords: poultry meat, marinating, grilling, food safety, analysis

INTRODUCTION
Meat represents very important source of protein in the human diet to serve as a primary ingredient in other main dish. Meat composition is almost the same in red and white meat, except for its fat content (Jayasena et al., 2013). Meat is composed of water, protein and amino acids, minerals, fats and fatty acids, vitamins, and other bioactive components, in addition to small amounts of carbohydrates (Biswas and Mandal, 2019). Poultry is accessible in fresh and frozen form, whole body, non-portioned or portioned. Poultry meat might be boneless, variously spiced, raw or variously processed. Muscles, called breasts, when on chest, wings and thighs form a part of the poultry carcass. Poultry meat is overall characterized by low energy value and high nutrient content. Many factors such as type of poultry, genetic factors, feed, agricultural systems, and method of culinary preparation influence some aspects of meat composition (Bordoni and Danesi, 2017). Meat can be prepared by various methods that can be classified under two main categories: 1. dry heat cooking i.e., roasting, browning, pan-frying, stir-frying and outdoor grilling. 2. moist heat cooking such as braising and cooking in a liquid (Istrati et al., 2015; Ruiz-Carrasant et al., 2019; Bassam et al., 2022). Fat is an important quality parameter, which contributes to the taste and juiciness of meat. Fats in meat exist in two forms (intermuscular and intramuscular fat). By their storage in the muscles, marbling is created. Poultry breast muscle has a low content of overall fat and saturated fat. Majority of poultry fat is stored under the skin. Breast muscle contains more protein, thigh muscle has a higher content of fat and cholesterol (Guld et al., 2016). Food industry increasingly strives to manufacture products with added value reaching a wider spectrum of customers and it aims for the production to be accompanied by relatively low financial inputs. Marinating of raw meat is one of the ways to achieve it (Mozurienė et al., 2016). Marinating is a widespread processing method used for improving the sensory and textural properties such as softness, juiciness, taste, colour, and aroma of food. The acidic or alkaline nature of marinade and antimicrobial or antioxidant activity of some marinade components may have a positive effect on shelf life of prepared meals (Lyton et al., 2018). Marinating is a commonly used method, which includes injection or dipping to disperse a solution of water, salt and other ingredients in marinated meat (Blanchi et al., 2016). Salt is the most important marinade ingredient, which improves the meat structure by increasing meat pH, ionic strength, moisture, softness of meat and actomyosin dissociation. In general, salt is used to improve the taste and softness of meat. Sodium chloride improves the binding properties of poultry meat by increasing the solubility of myofibrillar proteins (Susanti et al., 2018). Other ingredients such as vinegar, lemon juice, wine, salt brine, essential oils, herbs, spices, and organic acids may be present in the marinating solution. Many of them have strong antioxidant and antimicrobial properties due to the content of bioactive ingredients. It is known that organic acids, flavonoids, and polyphenols are commonly used as natural marinade ingredients that are safe for consumer health. Mostly vitamin C and flavonoids have antioxidant functions, while polyphenols have antibacterial functions (Istrati et al., 2015; Susanti et al., 2018). Some bioactive substances may even contribute to reducing the production of harmful chemicals. Studies have shown that marinating meat with spices (onion and garlic), beer, wine, and lemon, which are rich in phenolic components, can effectively reduce the levels of polyaromatic hydrocarbons in processed meat (Wang et al., 2018). The composition of the marinade can also significantly contribute to reducing the growth of microorganisms. The nature of microbial communities present on meat is very diverse, depending on the species of the animal from which the meat was obtained and on the subsequent meat processing. Fresh meat is a substrate that provides all nutrients (sugars, amino acids, vitamins) and has pH values and water activity compatible with microbial development. After the initial contamination of raw meat, the number of microbial cells can increase rapidly (Zagorec and Champomier-Verge, 2017). Microbial growth is influenced by storage conditions. Meat storage temperature is considered the most important factor affecting spoilage. In addition to the temperature of stored poultry meat, which should be between 2 and 4 °C, its colour, smell, weigh or consistency must be checked (Wahyono and Utami, 2018). In addition to the temperature of the meat, the microbial growth is also affected by the availability of oxygen. Therefore, depending on their affinity to oxygen, bacteria differ in their competitive growth potential in aerobic and anaerobic conditions (Casaburi et al., 2015). Among the most common causative agents are microorganisms such as Campylobacter, Salmonella spp., Escherichia coli and Yersinia. These are basically pathogens that can contaminate raw and processed meat and poultry products, which can lead to
foodborne infections if the products are not properly processed or heat-treated before consumption. The risk is particularly higher if the meat is contaminated with the bacteria Listeria monocytogenes, which grow even at refrigerated temperatures (Graziani et al., 2017; Huang et al., 2019). Grilling meat and its effect on the reduction of microorganisms has been reported in several studies (Baylan et al., 2011; Graziani et al., 2017; Wang et al., 2019; Naser and Ali, 2022).

In accordance with the afore mentioned, the aim of the work was to examine the variability of selected parameters of hygienic quality of poultry meat in fresh and marinated state, up to its culinary treatment by grilling.

**MATERIAL AND METHODS**

**Material**

In the context of the above objective, the work focused on analysing selected microbiological and physico-chemical parameters of the quality of fresh, marinated, and grilled poultry meat. All processes were continuous, while marinated meat (B-E) was kept under various conditions (12 hours and 48 hours at a temperature of 0 to 4 °C and 5 to 8 °C) until it was heat-treated (Table 1). Chicken breasts weighing 100 g were pounded to approximately the same size at a temperature of 0 to 4 °C and 5 to 8 °C until it was heat-treated (Table 1).

**Table 1 Labelling of meat samples**

| Sample name | Description                  |
|-------------|------------------------------|
| A           | Fresh meat                   |
| AG          | Fresh grilled meat           |
| B           | Marinated meat after 12 hours of storage at a temperature of 0 to 4 °C |
| BG          | Marinated meat after 12 hours of storage at a temperature of 0 to 4 °C - grilled |
| C           | Marinated meat after 12 hours of storage at a temperature of 5 to 8 °C |
| CG          | Marinated meat after 12 hours of storage at a temperature of 5 to 8 °C - grilled |
| D           | Marinated meat after 48 hours of storage at a temperature of 0 to 4 °C |
| DG          | Marinated meat after 48 hours of storage at a temperature of 0 to 4 °C - grilled |
| E           | Marinated meat after 48 hours of storage at a temperature of 5 to 8 °C |
| EG          | Marinated meat after 48 hours of storage at a temperature of 5 to 8 °C - grilled |

**Methods**

During the research, microbiological and physico-chemical analyses were carried out in poultry meat before and after grilling. The experiments were repeated five times independently at different time intervals.

**Microbiological indicators of hygienic quality**

Total viable cells (TVC), microscopic filamentous fungi (MFF) and coliform bacteria (CB). Plate dilution method was used to determine mentioned microorganisms and the samples were prepared by embedding or smear. A brief description of microbiological determinations is given in the Table 2.

- Determination of coliforms – VRBL agar (Violet Red Bile Lactose). This agar is intended for the reproduction and isolation of growth-demanding bacteria, especially intestinal pathogenic microorganisms. Components of VRBL agar: agar, crystal violet, lactose, sodium chloride, neutral red, yeast extract, bile salts, meat peptone.
- Determination of total viable count of microorganisms – PCA agar (Plate Count Agar). This agar is a non-selective growth medium and is commonly used to monitor total bacterial growth in the sample. Components of PCA agar: agar, glucose, enzymatic casein hydrolysate, yeast extract.
- Determination of microscopic filamentous fungi – DRBC agar (Dichloran Rose-Bengal Chloramphenicol agar). This agar is used as a selective medium to isolate and determine the count of yeasts and filamentous fungi (MFF) found in foods with water activity (a_w) greater than 0.95. Components of DRBC agar: agar, dextrose, dihydrogen phosphate potassium, magnesium sulphate, dichloran, bengal red, meat peptone.

Individual culture mediums were prepared by weighing the corresponding amount of dehydrated nutrient soil and subsequently mixing in distilled water. Culture medium (except the VRBL agar) was subsequently sterilized in an autoclave at the temperature of 121 °C, pressure of 120 kPa, for 15 minutes.

**Physico-chemical indicators of hygienic quality**

Water activity (a_w), pH, salt, and fat content. Measurements of individual parameters were repeated three times in each sample.

- Determination of water activity – FA-st lab device (GBX Scientific Ltd).
- Determination of pH – pH meter (Testo). Before each measurement, the probe was cleaned with a disposable cloth and rinsed with distilled water.
- Determination of salt content – Chloride analyser 926 M devise. The devise measures chloride ions in a water solution. A sample volume of 0.5 ml is required for the measurement and the result is shown in mg/l Cl or mg % (mg/100ml NaCl).
- Determination of fat content – Soxlet device (JV Selecta). The analysis itself was preceded by drying the meat sample for 12 hours at the temperature of 105 °C.

While determinations of water activity and pH were made directly by measuring on the devices, the salt and fat content were recalculated according to the below formulas.

**Calculation of salt content in %:**

\[ x = \frac{a}{A} \times 0.0084 \]

**Calculation of fat content in %:**

\[ x = \frac{100 \times a}{b} \]

\[ x = \frac{NaCl \text{ in } %}{\text{fat content in } %} \]

\[ A = \text{value from the device in } mg/l \]

\[ a = \text{weight of extracted fat in } g \]

\[ b = \text{weighing of the original sample before drying in } g \]

Under the Ministry of Health of the Slovak Republic Decree No. 125/2017, marinated meats belong to semi-finished products and can be stored for a maximum of 48 hours at a temperature of 0 to 4 °C (in Table 1 marked by letter D). In terms of health safety, it is not possible under the mentioned decree to store loaded meats at higher temperatures or freeze them before heat treatment (~ 18 °C). These requirements have also been applied in our analyses and have been supplemented by additional storage conditions resulting from the experience of Slovak households.

**Table 2 Methodology for microbiological analysis**

| Microorganism | Dilution       | Volume       | Culture medium   | Cultivation | Slovak technical norm/ISO |
|---------------|----------------|--------------|------------------|-------------|--------------------------|
| Coliforms     | 10⁰, 10¹, 10² | 1 ml embedding | VRBL agar       | 30±1 °C, 24 hours | STN EN ISO 4832           |
| TVC           | 10⁰, 10¹, 10² | 1 ml embedding | PCA agar        | 50±1 °C, 72±3 hours | ISO STN 4833              |
| Yeast and MFF | 10², 10³     | 0.1 ml smear  | DRBC agar       | 25±1 °C, 5 days | ISO 7954                  |

Laboratory analyses were carried out in the microbiological and physico-chemical laboratory of the Institute of Food Sciences, Faculty of Biotechnology and Food Sciences of the Slovak University of Agriculture in Nitra.

**Statistical evaluation**

The obtained data were statistically evaluated according to the indicators of descriptive characteristics, i.e., X – arithmetic mean and SD – standard deviation, the result of which is information on the accuracy of the measurement. Analysis of variance (ANOVA) was used to compare groups, i.e., the assumption of agreement of variance was verified by the F test (F). Statistical comparison of differences between storage conditions was made using Scheffe’s test. For the results, the p value of the respective achieved statistical significance was evaluated at the selected level of significance α = 0.05. The linear relationship between the two variables was tested according to the Pearson correlation coefficient (r). The values of (r) are set between +1 and -1, and a value of 0 means that there is no linear relation between the data in the file. According to Cohen (1988) the value (r) between the two variables means: less than 0.1 is trivial dependence, 0.1 to 0.3 is weak dependence, 0.3 to 0.5 is medium dependence and more than 0.5 is strong dependence. The result of the correlation relationship (r) between the two variables was statistically tested at a significance level of α = 0.05, α = 0.01, and α = 0.001. For statistical evaluation of the results was used the SAS program package, version 8.2.
RESULTS AND DISCUSSION

Presence of microorganisms in poultry meat before and after grilling

Under the Ordinance No. 06267/2006-SL of the Ministry of Agriculture of the Slovak Republic and the Ministry of Health of the Slovak Republic the TVC assessment in terms of microbiological criteria for pre-prepared and prepared meals is not stated. However, Chapter 4, second part of the Foodstuffs Code stipulates that the complete absence of the total number of microorganisms is the condition for commercial sterility. This information may be considered inaccurate and misleading in relation to other types of microorganisms referred to in the legislation. In practice, operators therefore set their own limits for TVC. It must be noted that although the determination of total count of microorganisms is not strictly intended for both pre-prepared and prepared meals, we wondered how many microorganisms would be present in the analysed meat samples.

Average value of TVC in fresh poultry meat was 4.01 log CFU/g, which is in accordance with maximum permitted value of TVC 5.10\(^d\), i.e. 5.70 log CFU/g under the Commission Regulation (EC) No. 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuff.

Kačáňová et al. (2021) tested microbiological quality of chicken breast Sous vide meat and in first day of analysis was TVC 5.24 log CFU/g.

In the process of marinating the value increased to 4.21 log CFU/g (B: 12 hours, 0 to 4 °C) and to 4.65 log CFU/g (E: 48 hours, 5 to 8 °C). In the sample representing the legislative requirements in terms of storage conditions (sample D) the total viable count of microorganisms was at the level of 4.3 log CFU/g (Figure 1). A microbiological analysis of grilled marinated meat (BG, CG, DG and EG) found that fewer than 10 specific colonies (<1.10\(^d\) CFU/g) grew on Petri dishes. The results have also shown that despite a slight increase of TVC in marinated meats, microorganisms were inactivated during the grilling process. Statistical analysis using the Sheffe’s test has shown that comparable conditions of storage of marinated meat up to the time of heat treatment had no effect on TVC of marinated grilled meat (P<0.05).

The average value of TVC in the study of Szosland-Faltyn et al. (2014) was in the range of 5.87-7.47 log CFU/g. This level of microbial contamination is consistent with Wang et al. (2019), who found the presence of TVC in poultry meat at a level of 6.8 log CFU/g. Higher amounts of TVC were detected in all samples of marinated meat. The reason for this may be the use of spices, which can be a source of microbial contamination. Marinades prevent the growth of unacceptable microorganisms due to their low pH, high level of salts, sorbates, benzoates, and varied spices. The antibacterial activity of marinades depends on several factors, such as pH and temperature (Karam et al., 2019). As for marinades with a relatively high pH (pH>4.5), these may have a positive effect on the overall sensory quality of the final product, but no effective slowdown in the growth of microorganisms is guaranteed. In contrast, marinades with a lower pH can slow down microbial growth, but often lead to undesirable changes in sensory and nutritional terms. The research should focus on the inclusion of new ingredients that could lead to the improvement of the microbial, nutritional, and sensory quality of meat products (Lytwy et al., 2018). Food contamination with microscopic filamentous fungi and yeast is a very useful indicator for evaluating the food quality. Microscopic filamentous fungi commonly contaminate meat and meat products and cause spoilage by producing mycotoxins that can cause liver damage and food poisoning in humans (Zakki et al., 2017).

As shown in Table 3, the presence of these types of microorganisms in fresh poultry meat samples was recorded in the amount of <1.10\(^d\) CFU/g, or <4.10\(^d\) CFU/g. The count of CFU <4.10\(^d\) CFU/g was determined mainly in marinated meat stored at the temperature of 5 to 8 °C (E). After grilling, neither microscopic filamentous fungi, nor yeasts were found in any of the meats. It can be assumed that the absence of microscopic filamentous fungi in meat samples indicates the strict observance of hygienic conditions in every step of processing. Also, the processed meat was not contaminated with any component of the marinade. The absence of yeast in heat-treated meat (AG, BG, CG, DG, EG) may have been influenced by the effect of garlic, which was part of the marinade.

Shuford et al. (2005) confirm the inhibitory effects of garlic on yeasts that are attributed to allicin. This sulphur-containing compound is formed in fresh cloves of garlic in the amount of 3 to 5 mg/g. Filamentous microcymes and yeasts do not form the predominant part of the meat microflora. Spices added to the marinade can significantly contribute to the contamination. Research of Szosland-Faltyn et al. (2013) suggests that used marinades have very little effect on the detected counts of filamentous microcymes and yeasts. The same results were recorded by Ismail et al. (2000). Contamination with filamentous microcymes and yeasts usually occurs because of meat handling, processing, and packaging. Another reason may be washing the meat with contaminated water, air and temperature fluctuations during transport and storage (Sharaf and Sabra, 2012). Similarly, Zakki et al. (2017) confirm that the contamination of meat occurs due to poor hygiene conditions at the slaughterhouses and poor personal hygiene of workers handling the meat. It was also found that the thigh muscle has a higher microbial load compared to the breast muscle of poultry meat.

The last microorganisms observed in fresh, marinated, and grilled meat were coliform bacteria. It is commonly known that they are the main indicator of faecal pollution, or their presence indicates cross-contamination. Their occurrence was not recorded in any of the analysed samples.

**Determination of \(a_\alpha\), pH, salt, and fat content in poultry meat before and after grilling**

Meat is a biological material, in which biochemical processes take place very complexly and many of them are not yet sufficiently explored. These processes create substances that can interact synergistically or antagonistically, in other cases they can function as precursors. During meat storage, it undergoes maturation, gradual autolysis and later even proteolysis, which also results in a change of the reaction environment (change in pH, water activity) (Tkáčová and Angelovičová, 2013). Water activity serves not only as a useful indicator of microbiological stability of food, but also as an indicator of sensory properties of food. Water activity is also an important indicator of chemical stability. This parameter helps to control the course of non-enzymatic reactions in food (Manefle et al., 2017). Our results have shown that in poultry meat samples – fresh, marinated, and grilled, the average water activity values ranged from 0.96 to 0.98 (Figure 2). The lowest value of \(a_\alpha\) (0.92) was measured in a sample of marinated meat after 48 hours of storage at the temperature of 5 to 8 °C – grilled (EG). On the contrary, the highest value of \(a_\alpha\) (0.99) was found in fresh grilled meat (AG) and marinated meat after 48 hours of storage at the temperature of 0 to 4 °C (D). Meat samples after heat treatment (AG, BG, CG, DG, EG) did not show a significant difference in \(a_\alpha\) value compared to the samples of fresh meat (A) and marinated meat stored under different conditions until heat treatment (B, C, D, E). The variation coefficient ranged from 0.26 to 1.71 %. Statistically significant differences (P<0.05) were found only in two cases — between marinated grilled meat (EG: 48 hours, 5 to 8 °C) and fresh meat (A) or marinated grilled meat (BG: 12 hours, 0 to 4 °C). There was a statistically insignificant difference between the other samples (P>0.05).

Durack and Alonso-Gomez (2012) classified meat as a rapidly perishable food based on water activity value. Mani-López et al. (2012) report that average values

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**Table 3** Evaluation of MFF and yeast in poultry meat samples before and after grilling

| Analyse order | A | AG | B | BG | C | CG | D | DG | E | EG |
|---------------|---|----|---|----|---|----|---|----|---|----|
| 1.            | <4 | d  | <4 | <4 | <4 | <4 | <4 | <4 | <4 | <4 |
| 2.            | <4 | <4 | d  | d  | d  | d  | d  | d  | d  | d  |
| 3.            | <4 | <4 | d  | d  | d  | d  | d  | d  | d  | d  |
| 4.            | <4 | <4 | d  | d  | d  | d  | d  | d  | d  | d  |
| 5.            | <4 | <4 | d  | d  | d  | d  | d  | d  | d  | d  |

**Amount of yeast in meat samples [CFU/g]**

| Analyse order | A | AG | B | BG | C | CG | D | DG | E | EG |
|---------------|---|----|---|----|---|----|---|----|---|----|
| 1.            | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 2.            | <1 | <1 | d  | d  | d  | d  | d  | d  | d  | d  |
| 3.            | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| 4.            | <1 | <1 | <1 | d  | d  | d  | d  | d  | d  | <1 |
| 5.            | <1 | <1 | <1 | d  | d  | d  | d  | d  | d  | d  |

Legend: <1/d = <1.0 CFU/g, <4/d = <4.10 CFU/g
of fresh meat water activity range in the interval of 0.98±0.01. Similar values of water activity have also been measured in our samples. Casaburi et al. (2015) state that the course of pH changes in poultry meat is dependent on the storage temperature, whereas when stored at the temperature of 4 °C, the pH of meat was satisfactory until the fifth storage day. Meat stored at the temperature of 22 °C had a faster increase in pH values, from which it can be assessed that the temperature is a limiting factor during meat spoilage. Mani-Lopez et al. (2012) report that the average pH value of fresh meat ranges from 5.5 to 6.5. In another study Sharaf and Sabra (2012), have reported that the pH value of fresh poultry meat ranged from 6.0 to 6.2. Marinating and decreasing pH value of the marinate had no significant effect on the reduction of pH values of the meat core. High pH values of meat create conditions for faster bacterial degradation of meat even though the meat is stored at refrigerated temperatures (Milićević et al., 2015).

The results of our analyses have shown that the average pH values ranged from 5.82 to 6.15 (Figure 2). The highest value (6.30) was recorded in the sample of marinated grilled meat after 48 hours of storage at the temperature of 5 °C (EG). The lowest value of pH (5.53) was recorded in the sample of fresh meat (A). The variation coefficient ranged from 0.65 to 3.85%. Statistical analysis according to the Scheffe’s test has shown that the individual methods of storage and processing of meat did not affect the increase or decrease of the pH of meat (P>0.05).

Figure 2 Average value of aw and pH in poultry samples depending on storage conditions

Salt is one of the essential ingredients of the marinade. It is one of the oldest and most used preservatives. Adding salt to the marinade will improve the taste of the product, inhibit the growth of Clostridium botulinum, and increase moisture retention. The antimicrobial effects of salt are based on its ability to lower water activity. The salt effect on microorganisms depends on the salt portion in the water phase of food (Alvarado and McKee, 2007). The amount of salt to be added to the marinades is determined by the taste of the final product, because at a high concentration it already has an adverse effect on the finished product. In meat preparations, the salt concentration ranges approximately from 1.5 to 2% to allow the extraction and solubilisation of myofibrillar proteins and in marinades it usually ranges from 4 to 10% (Susanti et al., 2018). In their study, Petracchi and Baéza (2011) found a direct influence of salt content in poultry meat on increasing its pH. A significant effect of adding salt on the pH of the meat was found even with addition of 0.2% salt to meat.

The salt content was the lowest in fresh meat (0.16 g/100g), in individual samples of marinated meat it ranged from 0.38 to 0.47 g/100g. In no case was the maximum allowed salt content (1.3 g/100g) exceeded. Statistical analysis according to the Scheffe’s test revealed that, depending on the conditions of meat storage and processing, there was a statistically significant difference (P<0.05) only between fresh meat (A) and other samples. Statistical significance was not confirmed between marinated and grilled samples (P>0.05).

Poultry fat is characterized by a higher content of polyunsaturated fatty acids than the fat of other slaughter animals. It is these fatty acids that are subject to the most oxidative changes that worsen the organoleptic properties and the shelf life of food (Tkáčová and Angelovičová, 2013). The lowest value (3.40 g/100g) was recorded in the fresh grilled meat (AG). The highest value (10.24 g/100g) was recorded in the marinated meat sample after 48 hours of storage at the temperature of 0 °C (D). Figure 3 shows that there are significant differences between average values of fat content. Average values ranged from 3.90±0.32 to 9.18±1.02 g/100g. Compared to fresh and marinated meat (A, B, C, D, E), grilling decreased the fat content in meat. The juice, and therefore fat from the meat, was released during grilling.

Figure 3 Average fat content in poultry meat samples

Depending on the method of meat storage and processing, a statistically significant difference (P<0.05) between fresh meat (A) and marinated meat was observed after 12 hours of storage at the temperature of 5 °C (C). A statistically significant difference was also found between A and D; between A and E; between BG and D; between BG and E. There was no statistically significant difference between the other samples (P>0.05).

Table 4 Statistical evaluation of differences in fat between different conditions of meat storage and processing

| Indicator | AG | B | BG | C | CG | D | DG | E | EG |
|-----------|----|---|----|---|----|---|----|---|----|
| pH        | -  | - | -  | + | +  | + | +  | - | -  |
| aw        | -  | - | -  | - | -  | - | -  | - | -  |

- +: Statistically significant difference according to Scheffe’s test (P<0.05)
- ++: Statistically highly significant difference according to Scheffe’s test (P<0.01)
- +++: Statistically very highly significant difference between variables (P<0.001)
- *: Statistically significant difference between variables (P<0.05)
- #: Statistically insignificant difference between variables (P>0.05)

Table 5 Correlation relationships between indicators aw, pH and salt in fresh/marinated meat (A, B, C, D, E) and in grilled meat (AG, BG, CG, DG, EG)

| Sample | A | B | C | D | E |
|--------|---|---|---|---|---|
| aw     | - | - | - | - | - |
| pH     | - | - | - | - | - |
| salt   | - | - | - | - | - |

- *: Statistically significant correlation (P<0.05)
- **: Statistically highly significant correlation (P<0.01)
- ***: Statistically very highly significant correlation (P<0.001)
Even more interesting were the results of the correlation analyses between indicators as, pH and salt within individual combinations of prepared meat samples. Table 5 shows that between water activity, in which almost the same values were measured, and other indicators, there was found mostly negative linear relationship of various intensity, statistically insignificant (P>0.05). Only in the case of samples B, BG, D and DG other types of linear relationships were recorded with statistical significance.

Every producer, distributor and seller of food products should prioritize high-quality, fresh, and safe food in terms of health. Meat is a risky commodity and is associated with many food scandals. Since meat as a rich source of nutrients is a part of the daily diet of people and its consumption is constantly increasing, greater attention should be paid to its safety.

CONCLUSION

One of the current trends in gastronomy is marinating and grilling meat. The aim of the work was to examine the variability of selected parameters of hygienic quality of poultry meat in fresh and marinated state, up to its culinary treatment by grilling. Under the Decree of Ministry of Health of the Slovak Republic No. 125/2017 on requirements for catering facilities, the meat intended for grilling must be stored for a maximum of 48 hours at a temperature of 0 to 4 °C. Performed microbiological analyses of meat have shown that the temperature range from 0 to 4 °C is truly the most suitable one and it also respects the requirements for storage of fresh poultry meat, but in terms of storage we have achieved better microbiological quality results at 12 hours. However, from a culinary point of view, this period is not sufficient for the penetration of substances from the marinade into the meat. It is therefore necessary to find in practice such a combination of temperature and time conditions, so that both hygienic and culinary criteria are met, respecting the legislative regulations. The results have also shown that the combination of marinating and grilling is among the most effective methods for the elimination of microorganisms. An important factor is the very composition of the marinade and the grilling conditions. In general, it is necessary to carry out official controls of meat at every stage of its processing. Especially because of the latest cases with poultry meat. In addition to official controls, self-controls by meat producers and processors, as well as operators of catering facilities, should be carried out more often. No less important is the education of the population in the handling of poultry meat.

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REFERENCES

Alvarado, C. & McKee, S. (2007). Marination to Improve Functional Properties and Safety of Poultry Meat. The Journal of Applied Poultry Research, 16(3), 113-120. ISSN 1553-0437

Bassam, S. M., Noleto-Dias, C. & Farag, A. (2022). Dissecting grilled red and white meat: A review on the discovery, production mechanisms, influencing factors, and chemical hazards. Food Chemistry, 371(1), 131-139. https://doi.org/10.1016/j.foodchem.2021.131139

Baylan, M., Ozcan, B. D. Kucukgulme, A. & Yaran, Y. (2011). Effects of cooking methods on electrophoretic patterns of rainbow trout. Italian Journal of Animal Science, 10(3), 175-177. https://doi.org/10.4081/ijas.2011.v13.s3

Bianchi, M., Petracci, M. & Cavani, C. (2016). The use of marinates to improve poultry meat quality. Italian Journal of Animal Science, 8(2), 757-759. https://doi.org/10.4081/ijas.2009.42.745

Biwas, A. K. & Mandal, P. (2019). Meat quality analysis: Advanced evaluation methods, techniques, and technologies, Academic Press, 1st edition. ISBN: 9780128192344

Bordoni, A. & Danesi, F. (2017). Poultry Quality Evaluation. London: Elsevier. 386. ISBN: 978-0-08-100763-1. http://dx.doi.org/10.1016/B978-0-08-100763-1.00011-8

Casaburi, A., Piombino, P., Nychas, G. J., Villani, F. & Casaburi, A. (2011). Harmonization of methodologies for the assessment of poultry meat quality, up to its culinary treatment by grilling. World's Poultry Science Journal, 67(1), 137-151. ISSN 1743-4777. https://doi.org/10.1007/s11250-010-9171-3

Commission regulation (EC) No 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs Durack, E. & Alonso-Gomez, M. (2012). The Effect of Thawing and Storage Temperature on the Microbial Quality of Commercial Frozen Ready Meats and Experimental Reduced Salt Frozen Ready Meals. Journal of Food Research, 1(2), 997-1301. ISSN: 212-4813. http://dx.doi.org/10.5539/jfr.v1n2p99

Graziani, C., Losaiting, C., Iuzzo, I., Ricci, A., Scavia, G. & Pasquali, P. (2017). Foodborne Diseases. London: Elsevier. 576 p. ISBN 978-0-12-385007-2. http://dx.doi.org/10.1016/B978-0-12-385007-2.00005-X
on the meat total bacteria. *Food and Nutritient Journal*, 6(1), 106-112. ISSN 2347-467X. [http://dx.doi.org/10.12944/crnfsj.6.1.11](http://dx.doi.org/10.12944/crnfsj.6.1.11)

Szosland-Faltyn, A., Bartodziejska, B., Królaski, J. & Polak, E. (2014). Comparison of the microbial quality of pork and poultry meat with or without grill marinade available in Polish detail markets. *Academic Journals*, 8(4), 383-388. ISSN 1996-0808. [https://doi.org/10.5897/AJMR2013.6382](https://doi.org/10.5897/AJMR2013.6382)

Tančinová, M., Kačanirová, M., Felišiová, S. & Mašková, Z. (2017). *Mikrobiológia potravin*. Nitra: SPU. 239. ISBN 978-80-552-1642-3.

Tkáčová, J. & Angelovičová, M. (2013). Aetheroleum and fat oxidation of chicken meat. *Potravinářstvo*, 7(1), 76-79. ISSN 1337-0960. [https://doi.org/10.5219/267](https://doi.org/10.5219/267)

Wahyono, N. D. & Utami, M. M. D. (2018). A Review of the Poultry Meat Production Industry for Food Safety in Indonesia. *Journal of Physics Microbiology*, 953, 1-4. ISSN 1742-6596. [https://doi.org/10.1088/1742-6596/953/1/012125](https://doi.org/10.1088/1742-6596/953/1/012125)

Wang, C., Xie, Y., Qi, J., Yu, Y., Bai, Y., Dai, C., Li, C., Xu, X. & Zhou, G. (2018). Effect of Tea Marinades on the formation of polycyclic aromatic hydrocarbons in charcoal-grilled chicken wings. *Food Control*, 93(12), 325-333. ISSN 0956-7135. [https://doi.org/10.1016/j.foodcont.2017.12.010](https://doi.org/10.1016/j.foodcont.2017.12.010)

Wang, C., Xie, Y., Wang, H., Bai, Y., Dai, C., Li, C., Xu, X. & Hou, G. (2019). The influence of natural antioxidants on polycyclic aromatic hydrocarbon formation in charcoal-grilled chicken wings. *Food Control*, 98(6), 34-41. ISSN 0956-7135. [https://doi.org/10.1016/j.foodcont.2018.11.012](https://doi.org/10.1016/j.foodcont.2018.11.012)

Zagorec, M. & Champomier-Verge, M. C. (2017). *Lawrie’s Meat Science*. London: Elsevier. 730. ISBN 978-0-08-100694-8. [http://dx.doi.org/10.1016/B978-0-08-100694-8.00006-6](http://dx.doi.org/10.1016/B978-0-08-100694-8.00006-6)

Zakki, S. A., Qureshi, A. H., Ghias, W., Sharif, M. & Ansar, F. (2017). Microbial Quality Evaluation and Prevalence of Bacteria and Fungus in Different Varieties of Chicken Meat in Lahore. *Journal of Pharmacy & Pharmaceutical Sciences*, 5(1), 30-37. ISSN 1482-1826