

## THE EFFECTS ON THE QUALITY OF POULTRY MEAT OF SUPPLEMENTING FEED WITH ZINC-METHIONINE COMPLEX

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### ABSTRACT

**Background.** Recently, an increase in the consumption of poultry meat has been observed Worldwide. This is related to the growing production of this kind of meat. Intensive poultry meat production affects the level of bird welfare and meat quality. The meat industry is looking for new solutions that can reduce meat quality defects. One of them may undoubtedly be a feed reformulation, of which a supplementation with zinc can be taken into consideration. The aim of this study was to evaluate the impact of Zn supplementation of chicken feed on the technological and sensory quality of meat.

**Materials and methods.** The research was carried out on material taken from 60 carcasses. Half of the group (30 pieces) was fed with Zn in the form of nonorganic compounds (zinc oxide) and the other 30 chickens were fed zinc in its organic form, and amino acids (ratio 1:1). After the broilers were slaughtered, the meat quality was evaluated in the breast muscle, and was based on pH value, color parameters, natural drip loss, cooking loss, microbiological status, sensory quality, instrumental shear force and lipid oxidation status.

**Results.** The obtained results show that lower levels ( $p \leq 0.01$ ) of drip loss (1.04%), and higher amounts ( $p \leq 0.01$ ) of glucose (4.61 mmol/l) and protein (0.7%) were found in the meat from the group fed with zinc in organic form as an additive. Moreover, the meat from this group was less red ( $a^*$  value = -0.46 vs. 0.11) and less yellow ( $b^*$  value 8.41 vs. 10.16) at the same time ( $p \leq 0.01$ ). There were no significant differences between the examined groups for cooking loss, microbiological status, lipid oxidation and sensory quality.

**Conclusion.** It should be stated that Zn supplementation in a form with amino acids has a beneficial effect on the quality of poultry meat as far as drip loss reduction is concerned.

**Keywords:** poultry meat, Zn supplementation, drip loss, sensory quality, microbiology

### INTRODUCTION

According to recent research, poultry meat consumption has been growing recently. Unfortunately, today's intensive breeding of broilers contributes significantly to numerous breeding problems, which must be faced and gradually eliminated (Alfaig et al., 2014; Orkusz, 2015). One of the negative factors is the high density

of birds, which makes them very stressed. Secondly, fast muscle growth causes weakening of bones (the head of the tibia) and the formation of a series of muscle myopathies, such as white striping, wooden breast, spaghetti meat and deep pectoral myopathy (Cai et al., 2018). In addition, because of the high density of birds

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the development of pathogenic bacteria is observed, which makes it necessary to apply antibiotics and coccidiostats (Orkusz, 2015). In order to prevent muscle myopathy and overuse of antibiotics and coccidiostats during poultry breeding, feed supplementation with organic zinc may turn out to be useful.

Additionally, recent research shows that trace elements play an important role in animal nutrition. One of them is zinc, which is the second most abundant trace element (after iron) essential for all living organisms (Qin et al., 2011). This element has several important functions in the maintenance and development of the skeleton. Moreover, zinc is a structural component, a catalytic factor (enzyme cofactors in six main enzyme classes), a signaling mediator and a part of vitamins and hormones (Vallee and Auld, 1990). Zinc deficiency inhibits cell proliferation, whereas in multicellular organisms it also results in abnormal differentiation and development, leading to extensive abnormalities or syndromes (Coleman, 1992). Therefore, the supplementation of poultry feed with zinc seems to be necessary in order to avoid problems related to zinc deficiencies. That is why NRC (National Research Council; 1994) states that 40 mg Zn/kg in the diet is the optimal amount for broiler growth, whereas INRA (1995) recommends feed supplementations of 40 and 20 mg Zn/kg in basal feed and 30 to 40 mg Zn/kg in growing and finishing diets, respectively.

It is known that supplementing chicken feed with zinc influences the quality of poultry meat. Yang et al. (2011) showed that Zn supplementation in a chicken's diet (in the range from 0 to 200 mg) significantly affects the parameters of meat colour ( $L^*$  and  $b^*$ ) and water holding capacity. Moreover, Aksu et al. (2011) showed that Zn supplementation in chicken feed (as compared to the control group) also affects the parameters of meat colour ( $L^*$  and  $a^*$ ) and the course of oxidation processes in the meat (it reduces oxidation).

The organic Zn form is characterized by a better bioavailability than inorganic forms including Zn oxide and Zn sulphate. The organic sources of the element have been used with increasing frequency by the feed industry during recent years (Wedekind et al., 1992). In a study by Nassiri and Jahanian (2009), it was observed that the addition of a zinc-methionine complex to chicks' feed, instead of inorganic Zn sources,

increased antibody production titres against Newcastle and infectious bronchitis disease viruses. Furthermore, it was observed that the results of feeding broilers with zinc-methionine or zinc-lysine complex indicate higher bioavailability values of organic zinc sources (Jahanian and Yaghoubi, 2010). An improved bioavailability of a mineral source could reduce the amount of the mineral that needs to be added to the diet to meet the mineral nutritional requirements, which in turn would reduce the amount of mineral excreted to the environment (Cheng et al., 1998).

Johanian and Rasouli (2015) showed that Zn supplementation in chicken feed (organic versus non-organic source of Zn) significantly improved the growth performance, the level of uric acid and triglycerides in the serum, decreased abdominal fat in the carcass and increased carcass meat yield.

There is no data related to the impact of zinc complex and amino acid feed supplementation on the quality of carcass and chicken meat, in particular on the sensory quality, which is of great importance nowadays since consumers are increasingly taking this factor into account while buying meat. We hypothesize that the addition of zinc complex with amino acids to the feed positively influences the quality of poultry meat. Thus, the aim of this study was to evaluate the impact of the organic form of zinc supplementation of feed on the quality of poultry meat.

## MATERIALS AND METHODS

### Materials

Sample collection and preparation. At the beginning of the experiment, sixty thousand male Ross 308 chicks with an average body weight of 40 g were divided into 2 groups (control and trial) consisting of 30,000 animals each. Every bird was kept in their own flock. The conditions (temperature, humidity, ventilation, day/night cycle) were the same in each group. The flocks were located in Wielkopolska (Poland). The birds in the flocks were fed a standard basal soya bean-corn-wheat meal diet (Table 1). The dietary phases consisted of a starter 1 (0–10 day), starter 2 (11–21 day), grower (22–35 day) and finisher diet (36–42 day). The feed and water were provided *ad libitum*. The first group (the control one) was fed a basal diet supplemented with zinc oxide (as conventional inorganic sources)

**Table 1.** Composition and calculated nutrient content of basal diets, g/kg

Item	Starter 1 (0–10 days)	Starter 2 (11–21 days)	Grower (22–35 days)	Finisher (36–42 days)
Soybean meal	387.70	337.90	290.00	274.20
Maize	300.00	300.00	300.00	300.00
Wheat	240.20	292.00	337.30	351.80
Rapeseed oil	34.80	34.50	39.00	43.00
NaCl	2.00	2.00	2.00	2.00
NaHCO <sub>3</sub>	1.00	1.00	1.00	1.00
Limestone	10.50	8.60	8.00	7.50
Mono-Ca-phosphate	14.80	15.00	13.70	12.50
L-Lys (78%)	2.00	2.60	2.40	1.90
DL-Met (98%)	3.00	2.40	2.60	2.10
Vitamin-mineral Premix*	4.00	4.00	4.00	4.00
TOTAL	1000	1000	1000	1000
Calculated nutrient content				
Crude protein	225.00	210.00	195.00	190.00
Crude fat	57.20	54.16	60.94	64.85
ME, MJ/kg	12.07	12.27	12.60	12.79
Lys	13.15	12.50	11.30	10.50
Met + Cys	10.00	9.02	8.80	8.20
Ca	9.50	8.80	8.00	7.70
P (non-phytate)	4.50	4.30	4.00	3.70

\*Provided per kilogram of diet: vitamin A – 12 000 IU, vitamin D<sub>3</sub> – 3000 IU, vitamin E – 30 mg, vitamin B<sub>1</sub> – 1.5 mg, vitamin B<sub>2</sub> – 5.5 mg, biotin – 0.175 mg, vitamin B<sub>6</sub> – 3.5 mg, vitamin B<sub>12</sub> – 0.025 mg, vitamin K<sub>3</sub> – 3.0 mg, niacin – 35 mg, folic acid – 1.1 mg, pantothenic acid – 15 mg, choline chloride – 200 mg, betaine – 160 mg, Mn – 90 mg, Zn – 80 mg, Se – 0.2 mg, Cu – 15 mg, Fe – 55 mg, J – 1 mg, Ca – 0.93 g, antioxidant – 10 mg, coccidiostat (Salinomycin) – 70 mg.

The protein, Lys, Met + Cys, Ca and P (non-phytate) needs are consistent with those given for broilers in the new version of Nutritional recommendations and nutritional value of poultry feeds (2018).

by 94, 75, 75, 75 and 56 ppm during fattening (Table 2). However, in the second group, the zinc added to the diet was from an organic source (zinc-methionine complex; Availa®Zn Zinpro Corporation, Edina, MN, USA) with 66% of total zinc included in the diet. After 42 days of life, the broilers were slaughtered. The stunning was carried out using the gas (CO<sub>2</sub>) method (Meyn®, the Netherlands). Next, the poultry were

subjected to bleeding, defeathering and evisceration. The carcasses were chilled using cold air in a chilling tunnel (air flow 4 m/s, to a temperature of 2°C). After chilling, thirty breast fillets (*Pectoralis major* muscle) were randomly removed from the carcasses from each group (total 60 fillets) for further research.

The study was conducted under the authority of the Third Local Commission of Animal Experiment

**Table 2.** Zinc levels in both groups (control and trial) during fattening

Mineral source, ppm	Starter 1 (crumble)		Starter 2		Grower		Finisher	
	Con	Av <sup>®</sup> Zn	Con	Av <sup>®</sup> Zn	Con	Av <sup>®</sup> Zn	Con	Av <sup>®</sup> Zn
Zn (zinc oxide)	94	31.3	75	25	75	25	56	18.75
Availa <sup>®</sup> Zn		62.5	–	50	–	50	–	37.5
Total supplemented Zn	94	93.8	75	75	75	75	56	56.25

Con – control group, Av<sup>®</sup>Zn – trial group (with Availa<sup>®</sup>Zn).

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## Methods

### Technological analysis

The pH-value was measured (in triplicate) at 20 minutes pH<sub>1</sub> and 24 hours pH<sub>24</sub> after slaughter (by the use of a pH meter 330i produced by WTW<sup>®</sup>, Weilheim, Germany, equipped with special electrodes SenTix<sup>®</sup> SP Number 103645, to measure pH directly in meat – 3 measurements).

Colour parameters (CIE  $L^*a^*b^*$ ) were measured 24 hours after slaughter (using a CR-310 Konica Minolta<sup>®</sup> Chroma Meter, Osaka, Japan) at three locations on the dorsal surface of each breast fillet (in triplicate). The apparatus was calibrated before each measurement against a white and black tile. Colour was expressed according to the Commission International de l'Eclairage (CIE) system and reported as  $L^*$  (lightness),  $a^*$  (redness) and  $b^*$  (yellowness).

The percentage of drip loss was evaluated 24, 48 and 72 h after slaughter based on the methodology by Prange et al. (1977).

The cooking yield was determined for the meat samples (average of 265 g) taken from the *Pectoralis major* muscle of the carcasses and cooked. The cooking was conducted in a set of pots in which the samples were placed with 2 dm<sup>3</sup> of water each. The temperature was measured using a thermometer (TP-151-125-2-SPEC<sup>®</sup>, Poland) with the target of 80°C in the sample geometric center. After heat treatment, the samples were chilled to room temperature (~24°C). Afterwards, the weight after the heat treatment was measured (from the difference of weight before and after cooking).

The shear force and penetration force parameters were gauged using a ZWICKI 1120<sup>®</sup> universal testing machine (Zwick, Germany). Both analyses were conducted on samples of meat taken from the *Pectoralis major* muscle. The samples were cut after the heat treatment (cubes of 10 mm × 10 mm × 10 mm dimensions with an elongated arrangement of muscle fibers). During the test, the shear force was measured. The cutting was made using a Warner-Bratzler adapter with a flat knife. The depth of the knife penetration under maximum force was gauged (penetration force). The applied initial force was 0.5N. The speed of movement of the measuring head of 50 mm/min was used. The measurement range of the measuring head was 2-1000N. Each measurement was repeated six times.

### Chemical analysis

Chemical composition of the meat. The meat composition (the content of ash, protein, fat, and dry matter) of the *Pectoralis major* muscle was evaluated in an accredited laboratory of the Analytic Centre of Warsaw University of Life Sciences. All analyses were done in triplicate. The content of ash was measured using the weight method. The content of protein (expressed as the content of nitrogen) was determined using the Kjeldahl method. The content of fat (expressed as raw fat) was measured using the Soxhlet method. The dry matter was determined using the weight method.

**Content of elements (Ca, Fe, Mg, Zn).** The content of elements (Ca, Fe, Mg, Zn) was measured using ICP-AES (Inductively Coupled Plasma-Atomic Emission Spectroscopy).

**Glucose and lactate concentration in tissue, muscle glycolytic potential.** Glucose and lactate were

measured in drip loss by using an Accu-Chek Active<sup>®</sup> glucometer (Accu-Chek Sensor Comfort<sup>®</sup>, Roche, Germany) as it was described by Przybylski et al. (2016) and the muscle glycolytic potential was calculated according to a formula by Monin and Sellier (1985) and expressed as millimoles [mmol] of lactate.

**Lipid oxidation.** The level of lipid oxidation in raw meat was evaluated using the TBA method – based on the content of malondialdehyde (MDA) (Shahidi, 1990). 2 g of minced meat and 5 cm<sup>3</sup> 10% trichloric acid (TCA) were put into a centrifuge tube. The mixture was subjected to intensive mixing. Next, 5 cm<sup>3</sup> 0.02M 2-tiobarbituric acid (TBA) solution was added to the mixture and again the content of the tube was mixed. Afterwards, the tubes were centrifuged (4000 rpm). After centrifuging, the content of the tubes was filtered into glass tubes. The tubes were covered with plastic foil and put in a boiling water bath for 35 minutes in order to develop the colour. Simultaneously, the reagent test was prepared. The content of the tubes was cooled in cold water. After cooling, the absorbance was measured in solutions at a wavelength of  $\lambda = 532$  nm in a spectrophotometer (Thermo Scientific, Genesys 20, USA). The results were expressed as the content of malondialdehyde (MDA) in meat [mg/kg]. Each sample of meat was evaluated in duplicate. The level of lipid oxidation was measured in meat 7, 14 and 28 days after slaughter.

#### Microbiological analysis

The number of bacteria [log cfu/g] was evaluated using the plate method. Each time, 25 g of poultry meat was homogenized with 225 cm<sup>3</sup> of peptone water (BIOCORP, Poland). Subsequently, microbiological cultures were made using the flood method on PCA agar (LabM, United Kingdom). The plates were incubated under aerobic conditions at 30°C for 72 h. The analyses were done in triplicate.

**Eating quality analysis.** The sensory quality of meat was determined in the cooked meat samples (average of 265 g) taken from the *Pectoralis major* muscle of the carcasses. The cooking was conducted in a set of pots in which the samples were placed with 2 dm<sup>3</sup> of water each. The temperature was measured (TP-151-125-2-SPEC<sup>®</sup>, Poland) with a target of 75°C in the

sample geometric center. After the heat treatment, the samples were chilled to room temperature (~24°C) and prepared for sensory assessment. The meat samples were cut into portions of approximately equal size and weight (around 20 g) and placed in plastic odourless, disposable boxes covered with lids. To determine the sensory quality of meat, the QDA method (Quantitative Descriptive Analysis) was used. The unstructured, linear graphical scale (100 mm) was converted to numerical values (0–10 conventional units c.u.). The fifteen attributes were evaluated by a 10-person assessing panel. Within 3 h after the heat treatment, the meat samples were evaluated at room temperature (24 ±2°C). The assessors were experienced (4–16 years of sensory evaluation practice), with a good command of sensory methodology and a knowledge of the sensory quality of meat and meat products. The assessment was conducted in rooms with daylight. The assessors received hot tea without sugar to neutralize the taste between the evaluations.

#### Statistical analysis

The obtained data were developed using STATISTICA version 13.3 software (TIBCO Software Inc. 2017, Statistica – data analysis software system, version 13, <http://statistica.io>). The basic descriptive statistics (mean, standard deviation) were calculated. The normality of distribution of all analyzed traits was checked by Shapiro-Wilk test. A one-way analysis of variance from the feeding with added zinc as a fixed effect was performed.

## RESULTS AND DISCUSSION

The characteristics of the technological and microbiological meat quality, as well as the oxidation status in relation to the fed groups is presented in Table 3. The analysis of variance showed that the zinc source had a significant effect on the colour parameters  $a^*$  and  $b^*$ , drip loss, glucose level in the meat and the shear force of meat after heat treatment. The meat from the group which was fed zinc in complex with methionine appeared less red and less yellow (Table 3). The same results were obtained by Aksu et al. (2011) in relation to  $a^*$  parameter. These researchers also used an organic complex of zinc (but the  $b^*$  parameter was not significant in their study). However, Zakaria et al. (2017) did

**Table 3.** Characteristics of meat quality of both groups

Item	Group	
	control	Availa <sup>®</sup> Zn
Before heat treatment (raw meat)		
pH <sub>1</sub>	6.71 ±0.14	6.77 ±0.11
pH <sub>24</sub>	5.97 ±0.12	5.99 ±0.14
Colour parameters		
<i>L</i> *	53.76 ±2.16	54.07 ±2.88
<i>a</i> *	0.11 <sup>A</sup> ±0.79	-0.46 <sup>B</sup> ±0.59
<i>b</i> *	10.16 <sup>A</sup> ±1.35	8.41 <sup>B</sup> ±1.49
Drip loss, %	1.43 <sup>A</sup> ±0.60	1.04 <sup>B</sup> ±0.45
Glucose, mmol/l	23.17 <sup>A</sup> ±5.61	27.78 <sup>B</sup> ±7.15
Lactate, mmol/l	97.35 ±16.93	91.67 ±16.69
PG, mmol/l	142.53 ±22.46	147.85 ±25.65
Number of bacteria after 24 h, log cfu/g	3.16 ±0.24	3.10 ±0.59
Number of bacteria after 72 h, log cfu/g	3.38 ±0.31	3.44 ±0.28
The content of malondialdehyde, mg/kg	0.15 ±0.07	0.16 ±0.04
After heat treatment (cooking)		
Cooking yield, %	71.01 ±2.64	70.26 ±3.65
Colour parameters		
<i>L</i> *	83.73 ±1.29	84.21 ±0.88
<i>a</i> *	0.74 ±0.64	0.66 ±0.43
<i>b</i> *	16.49 ±1.02	16.30 ±0.93
Penetration force, mm	5.95 ±0.46	5.82 ±0.80
Shear force, N	20.69 <sup>A</sup> ±4.95	25.60 <sup>B</sup> ±4.28

Means with different superscripts column (A, B, C) differ significantly ( $P \leq 0.01$ ) from each other.

not find any significant effects of Zn sources on the meat colour of chickens. It must be pointed out that meat colour is one of the indicators of meat quality and Zn has the ability to bind myoglobin and increase its oxygenation, which allows the meat colour to be maintained. The lower *a*\* value in the meat from the group fed with zinc-methionine complex could be the result of better bleeding. The significant effect of bleeding on meat colour was showed by Hopkins et al. (2006). Additionally, Cai et al. (2018) showed significantly lower

*a*\* value of breast meat in normal meat with comparison to wooden breast. They observed that normal meat was significantly less red than other faulty breast meat (wooden breast and white stripping). In conclusion, it could be stated that the complex of zinc with methionine positively influences the quality of meat in terms of its colour. This conclusion can be confirmed by the results related to drip loss. As shown in Table 3, lower drip loss was observed in the group fed with an organic zinc source. Similar results were obtained by Mendes

et al. (2013), however, the differences demonstrated in the study proved to be insignificant. Saenmahayak et al. (2010) also failed to find a significant effect of a Zn source on drip loss level. Furthermore, Liu et al. (2011) showed that the Zn level has a bigger impact on drip loss than its source. For many years, drip loss has been widely recognized in meat science as an indicator of meat quality and a factor that could be applied to distinguish faulty meat from normal muscle (Strydom et al., 2016). Meat of a good quality is characterized by lower drip loss. Wynveen et al. (1999) showed the significant effects of ultimate pH on drip loss with a higher level in meat with a lower pH.

The level of lipid oxidation in raw meat coming from the studied groups was also not statistically different (Table 3). These results are in agreement with Sahin et al. (2005), who did not show the effects of organic Zinc on the level of malondialdehyde content in serum or liver, but in opposition to the Bun et al. (2011) study showing that the Zn supplementation reduced oxidative stress and increased antioxidant enzyme activity. In Table 4, the results of the chemical composition of the muscle are presented. In this study, the protein level in the Availa®Zn group was significantly ( $P \leq 0.05$ ) higher than in the control group.

**Table 4.** Chemical composition of pectoralis muscle and the content of selected mineral components in the breast muscles of both studied groups

Item	Group	
	control	Availa®Zn
Ash, %	1.16 ±0.03	1.16 ±0.03
Protein, %	22.35 <sup>A</sup> ±0.85	23.05 <sup>B</sup> ±0.40
Fat, %	1.86 ±0.88	1.76 ±0.70
Dry matter, %	24.97 ±0.84	24.92 ±0.81
Ca, mg/kg	46.46 ±6.76	42.91 ±3.53
Fe, mg/kg	4.00 ±0.23	3.82 ±0.39
Mg, mg/kg	296.60 ±15.57	300.20 ±9.55
Zn, mg/kg	6.25 ±0.52	6.02 ±0.48

Means with different superscripts column (A, B, C) differ significantly ( $P \leq 0.01$ ) from each other.

Saenmahayak et al. (2012) analyzed the influence of an organic complex of zinc on breast fillet yields. In their study, a significant impact was shown from the addition of ZnSO<sub>4</sub> to feed on increasing breast meat yield. This may have been due to the fact that zinc promotes protein biosynthesis (Coleman, 1992). Likewise, Zakaria et al. (2017) also supplemented broiler feed with organic zinc (Availa®Zn Zinpro Corporation, Edina, MN, USA). This study showed that feeding broilers with added organic zinc significantly ( $P \leq 0.05$ ) improves the level of protein in the blood. The high level of protein in the breast muscles from the Availa®Zn group may have been caused by the organic zinc sources, which have a higher bioavailability than inorganic mineral sources (Ao et al., 2006). Moreover, organic zinc improves the development of the immune system (Salim et al., 2011). It may have an impact on protein translation, as a healthy bird will use energy from glucose to create protein, not to mobilize the immune system to fight inflammation (Bun et al., 2011). Additionally, in the case of the inflammation process, the organism uses more proteins to enable the immune system to work (e.g. antibody synthesis) (Kvidera et al., 2016). The differences between groups in other parameters, such as pH value, lactate level and glycolytic potential value (PG) were insignificant. However, it is worth noting that the PG noted in the presented study was higher than that reported by Ylä-Ajos et al. (2007) in the same muscle. Similarly, ultimate pH was also lower. This result is in accordance with the statement that a higher PG is associated with a lower pH. The penetration force value was also insignificant, whereas the shear force parameter value was significantly ( $P \leq 0.05$ ) higher in Availa®Zn than the control group (Table 3). Similar results were obtained by Salim et al. (2011) and Mendes et al. (2013). In our study, the higher shear force value can be related to the higher content of protein (in Availa®Zn group), especially collagen content. Because of the higher content of collagen in the breast fillets, they were tougher (Salim et al., 2011). Saenmahayak et al. (2010) stated that Zn influences collagen formation. In the present study, glucose level was significantly ( $P \leq 0.05$ ) higher in Availa®Zn than the control group. This may have been caused by the inhibition of inflammatory processes by organic zinc (Prasad et al., 2011). As shown by Kvidera et al. (2016), an activated immune system uses more

**Table 5.** Eating quality of the *Pectoralis major* muscle in studied groups of broilers (QDA method;  $n = 18$ )

Attribute (0–10 c.u.)	Group	
	control	Availa®Zn
Meaty odour	8.33 ±0.34	8.36 ±0.28
Acid odour	1.21 ±0.37	1.14 ±0.31
Fatty odour	1.25 ±0.39	1.37 ±0.31
Other odour	0.97 ±0.40	0.99 ±0.52
Tone of colour	8.70 ±0.32	8.80 ±0.32
Homogeneity of colour	8.36 ±0.60	8.58 ±0.30
Tenderness	8.26 ±0.50	8.25 ±0.29
Juiciness	7.26 ±0.66	7.24 ±0.64
Meaty flavour	8.50 ±0.30	8.45 ±0.26
Acid flavour	1.12 ±0.27	1.12 ±0.22
Fatty flavour	1.10 ±0.27	1.15 ±0.28
Salty taste	1.25 ±0.23	1.35 ±0.31
Bitter flavour	0.78 ±0.17	0.85 ±0.18
Other flavour	1.02 ± 0.32	1.05 ±0.29
Overall quality	7.81 ±0.31	7.92 ±0.30

glucose. In the case of the content of mineral components (Ca, Fe, Mg and Zn), significant differences were not observed (Table 4).

In Table 5, the results regarding the eating quality of the studied meat samples are shown. It should be highlighted that there were no differences reflected in the eating quality of the meat of both studied groups. It can be even stated that the meat coming from both groups was characterized by good sensory quality. No differences in sensory texture attributes, like tenderness and juiciness, were observed, although the instrumental shear force parameter was significantly higher in the group fed with zinc with methionine (Table 3 and Table 5). The results obtained by Brambila et al. (2016) indicated that the differences in the sensory quality of poultry meat were rather noted in the case of white stripping or wooden breast defect.

In the case of the raw meat, the obtained results showed significant differences between the groups

in terms of colour parameters  $a^*$  and  $b^*$  and no significant differences in terms of lightness (colour parameter  $L^*$ ). The meat of the group fed zinc with methionine appeared to be less red and less yellow. No differences were observed in the case of pH, however, the drip loss was significantly lower in the group fed with feed with zinc with methionine (1.04%) in relation to the meat obtained from the broilers fed with forage supplemented with zinc oxide (1.43%). No significant differences between the analysed groups were found in terms of the meat cooking yield, nor in the colour parameters of the meat after the heat treatment.

The analysis of the eating quality did not show any significant differences between the groups; no differences in meat texture or flavour were observed.

It should be stated that Zn supplementation in a form with amino acids has a beneficial effect on the quality of poultry meat in the case of drip loss reduction at the level of 0.39% and a higher protein content of 0.70%.

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