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PRINCIPAL COMPONENT ANALYSIS OF SENSORY PROPERTIES OF CHICKEN BREAST MUSCLE SUPPLEMENTED WITH DIFFERENT FEED ADDITIVES

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ABSTRACT

The objective of the present study was to examine the effect of different dietary supplements (bee pollen, propolis, and probiotic) on sensory quality of chicken breast muscle. The experiment was performed with 180 one day-old Ross 308 broiler chicks of mixed sex. The dietary treatments were as follows: 1. basal diet with no supplementation as control (C); 2. basal diet plus 400 mg bee pollen extract per 1 kg of feed mixture (E1); 3. basal diet plus 400 mg propolis extract per 1 kg of feed mixture (E2); 4. basal diet plus 3.3 g probiotic preparation based on *Lactobacillus fermentum* added to drinking water (E3). Sensory properties of chicken breast muscle were assessed by a five-member panel that rated the meat for aroma, taste, juiciness, tenderness and overall acceptability. The ANOVA results for each attribute showed that at least one mean score for any group differs significantly ($p \leq 0.05$). Subsequent Tukey's HSD revealed that only C group had significantly higher mean score ($p \leq 0.05$) for each attribute compared with E2 group. As regards the E1 and E3 groups, there were not significant differences ($p > 0.05$) in aroma, taste and tenderness when compared to C group, with the significantly lowest juiciness value ($p \leq 0.05$) found in E3 group and significantly lower values of overall acceptability in both groups ($p \leq 0.05$). In addition, it is noteworthy that control group received the highest raking scores for each sensory attribute, i.e. the supplements did not influence positively the sensory quality of chicken breast meat. Principal component analysis (PCA) of the sensory data showed that the first 3 principal components (PCs) explained 69.82% of the total variation in 5 variables. Visualisation of extracted PCs has shown that groups were very well represented, with E2 group clearly distinguished from the others.

Keywords: chicken meat; sensory attribute; dietary supplement; PCA

INTRODUCTION

The high consumption of poultry, leads to concern that the products marketed should be safe, have a low spoilage rate and high quality, and show the right composition, packaging, colour, taste and appearance **(Ntzimani et al., 2010)**. Meat quality is a generic term used to describe properties and perceptions of meat such as colour, freshness, and texture **(Maltin et al., 2003; De Lourdes Pérez-Chabela and Totosaus, 2012; Ramachandraiah et al., 2015)**.

Consumer evaluation of eating quality is the major determinant of meat quality and is primarily associated with tenderness, juiciness and flavour **(Markus et al., 2011; Font-i-Furnols and Guerrero, 2014; Choe et al., 2016)**. Options for measuring meat quality included consumer or trained taste panels and objective measurements. Whilst objective measurements (such as shear force and compression) have the advantage of being relatively cheap, they are rather simplistic, one-dimensional measures of a complex set of interactions which occur when cooked meat is chewed and masticated in the mouth **(Watson et al., 2008)**.

Human subjects can go beyond the physical components to describe a wide range of factors involved in mastication and afterfeel/aftertaste sensations, such as appearance, flavour, juiciness, and texture. Sensory panels provide complementary information to instrumental method, and neither can be replaced **(Liu et al., 2004)**.

Previous studies have showed that sensory analysis allows producers to identify, understand, and respond to consumer preferences more efficiently **(Liu et al., 2004; Fanatico et al., 2007; Saha et al., 2009; Sow and Grongnet, 2010; Chumngoen and Tan, 2015)**. Instruments do not account for the juiciness and other moisture-related characteristics that panelists may perceive while chewing, and panels may identify and quantify more specific texture attributes that are not measured instrumentally **(Liu et al., 2004)**. Sensory attributes detectable by human senses may also serve as references

during the selection of foods **(Chumngoen and Tan, 2015)** and may consequently help the manufacturers to increase competition in the market for other producers **(Adeyemo and Sani, 2013)**.

Poultry meat has very complex composition and besides its natural compounds, animal species, age, and sex, nutritional and sensory quality may be affected by diet of birds **(Ivanović et al., 2008; Listrat et al., 2016)**.

There is a variety of feed additives that could be added to the feed or drinking water of a poultry flock to improve production and meat quality. Most of the feed additives as alternatives to antibiotics need to be thoroughly tested in live birds. The possibility of using the alternative compounds including bee products and probiotics in the diet of broiler chickens is being researched. According to that the sensory properties are important factor that influence meat quality, the objective of present study was to determine the effect of bee pollen, propolis and probiotic supplementation on sensory quality of chicken breast meat. Another objective was to highlight and visualise the sensory attributes that determine the differences among the groups of chicken meat using principal component analysis (PCA).

MATERIAL AND METHODOLOGY

Animals and experimental design

The experiment was carried out in test poultry station of Slovak University of Agriculture in Nitra. A total of 180 one day-old broiler chicks of mixed sex (Ross 308) were randomly divided into 4 groups, namely, control (C) and experimental (E1, E2, E3). Each group consisted of 3 replicated pens with 15 broiler chickens per pen.

The experiment employed a randomized design, and dietary treatments were as follows: 1. basal diet as control (group C), 2. basal diet plus 400 mg bee pollen ethanol extract per 1 kg of feed mixture (group E1), 3. basal diet plus 400 mg propolis ethanol extract per 1 kg of feed mixture (group E2), 4. basal diet plus 3.3 g probiotic preparation added to drinking water (group E3). Besides, the groups were kept under the same conditions.

The chickens were fed *ad libitum* over the entire experimental period (42 days) with a diet formulated to meet nutrient requirements for broiler chickens **(Bulletin of the Ministry of Agriculture and Rural Development of the Slovak Republic, 2005)**. Drinking water was also supplied *ad libitum*. Ingredients and nutrient content of the basal diets is presented in Table 1. The chickens received two phases feeding program, starter HYD-01 (1 – 21 d) and grower HYD-02 (22 – 42 d) diets. The feed mixtures both starter and grower were produced without any antibiotics and coccidiostats.

The chickens were submitted to a continuous lighting program and were reared on the floor covered with dry wood shavings, in a temperature-controlled room; room temperature in test poultry station was adjusted at 33 °C in the first week and gradually decreased by 2 °C, and finally fixed at 23 °C thereafter.

Bee pollen and propolis had origin in the Slovak Republic. The extracts were prepared from minced bee pollen and propolis in the conditions of the 80% ethanol in the 500 cm^3 flasks, according to **Krell (1996)**. The commercial probiotic preparation used in the experiment was based on *Lactobacillus fermentum* (1×10^9 CFU per 1 g of bearing medium).

At the end of experiment, 10 broiler chickens from each

Table 1 Composition of feed mixtures.

Ingredients (%)	Starter HYD-01 (1st – 21st day of age)	Grower HYD-02 (22nd – 42nd day of age)
Wheat	34.00	37.00
Maize	33.92	37.52
Soybean meal (48% N)	23.00	18.00
Fish meal (71% N)	5.00	3.00
Dried blood	-	1.00
Fodder lime	1.00	0.95
Monocalcium phosphate	0.80	0.70
Fodder salt	0.10	0.10
Sodium bicarbonate	0.15	0.20
Lysine	0.15	0.12
Methionine	0.18	0.21
Bergafat (palm kernel oil)	1.20	0.70
Euromix BR 0.5%[1]	0.50	0.50
Nutrient composition ($g.kg^{-1}$)		
Linoleic acid	13.53	14.05
ME_N ($MJ.kg^{-1}$)	12.07	12.16
Fibre	30.50	29.67
Crude protein	212.40	191.61
Ash	27.00	20.90
Ca	8.22	7.18
P	6.55	5.86
Na	1.77	1.70

Note: [1]Active substances per kilogram of premix: vitamin A 2 500 000 IU; vitamin E 20 000 mg; vitamin D3 800 000 IU; niacin 12 000 mg; D-pantothenic acid 3 000 mg; riboflavin 1 800 mg; pyridoxine 1 200 mg; thiamine 600 mg; menadione 800 mg; ascorbic acid 20 000 mg; folic acid 400 mg; biotin 40 mg; kobalamin 8.0 mg; choline 100 000 mg; betaine 50 000 mg; Mn 20 000 mg; Zn 16 000 mg; Fe 14 000 mg; Cu 2 400 mg; Co 80 mg; I 200 mg; Se 50 mg.

group were selected and slaughtered at the slaughterhouse of Slovak University of Agriculture in Nitra. After evisceration, the carcasses were kept at approximately 18 °C for 1 h post mortem and thereafter longitudinally divided into two parts. Afterwards, the half-carcasses were stored at 4 °C until 24 h post mortem.

Breast meat samples (*pectoralis major*) from the left half-carcasses were then collected for evaluation of sensory attributes, whereas the right half-carcasses were assigned to different analysis. The samples (boneless breast without skin) were individually packaged in labeled bags and stored at -18 °C for 1 month prior to sensory analysis.

Sensory evaluation

The sensory attributes of the roasted chicken meat (breast muscle) were analyzed. Before the roasting, breast meat samples were removed from the freezer and allowed to thaw in the refrigerator overnight.

Roasting was done in the electric oven (Gorenje B 3300 E), without added fat or oil, at 200 °C with regular turning of the samples until the meat was done. The meat samples were subsequently removed from the oven and left to cool at room temperature.

After that, they were trimmed of subcutaneous fat and connective tissue, sliced into uniform sizes (about 2 cm), and immediately presented to each panelist on plain white porcelain plates. Sensory evaluation was carried out in a climate-controlled sensory analysis laboratory equipped with individual booths.

Sensory profiles were determined by a 5-member semi-trained panel. Panelists were staff and PhD. students in Department of Animal Products Evaluation and Processing, Slovak University of Agriculture in Nitra; three were women and two were men, ranging from 27 to 57 years of age. They had more than 3 years of food sensory panel experience and poultry meat experience.

Panelists were provided with water for mouth-cleansing before and between samples. The samples were presented to the panelists monadically. Sensory evaluation was conducted over an 8-wk period (n = 10).

Sensory attributes of breast meat samples including aroma, taste, juiciness, tenderness, and overall acceptability on a five-point hedonic scale. The scale for each attribute ranged from 0 to 5 as follows: aroma (1 = very poor, 5 = very good), taste (1 = very poor, 5 = very good), juiciness (1 = extremely dry, 5 = extremely juicy), tenderness (1 = extremely tough, 5 = extremely tender), and overall acceptability (1 = not acceptable, 5 = extremely acceptable).

Statistical analysis

The statistical analysis, including graphical presentations, was performed using the XLSTAT **(Addinsoft, 2016)** package program. Rating scores mean for each sensory attribute and standard deviation were calculated. The data were analyzed by analysis of variance (ANOVA). A Tukey's honestly significant difference (HSD) post hoc test was then carried out to determine sensory attributes means, which significantly differ for the chicken meat samples. The level of significance was established at $p \leq 0.05$. A principal component analysis (PCA) was performed to distinguish the groups of chicken breast muscle, and to visualise the data on a 2-dimensional map that allows depicting the differences between the groups as much as possible.

RESULTS AND DISCUSSION

The mean scores of sensory characteristics (aroma, taste, juiciness, tenderness, and overal acceptability) of chicken breast meat samples are shown in Table 2. There was significant difference between control and group E2 with respect to aroma attribute ($p \leq 0.05$), with the lowest value found in that group (4.03 ±0.170) and the highest one found in control (4.22 ±0.122). Statistically significant differences ($p \leq 0.05$) were detected among values in E2 and C, E1, and that in E3 group in terms of taste attribute, with the lowest value found in the E2 group (4.00 ±0.244) and the highest one found in control (4.18 ±0.225). Values for juiciness were significantly different ($p \leq 0.05$) between control and E2, E3 groups, with the lowest value observed in E3 (3.51 ±0.338).

Of all five attributes, tenderness was the most sensitive parameter since there was significantly lower tenderness values in breast muscle of chickens after the supplementation of all the feed additives investigated in present study. Similar results ($p \leq 0.05$) were also detected in overall acceptability of these groups as E2 group (3.74 ±0.304) was considered as the least acceptable for panelists whereas C group (4.07 ±0.221) was considered as the most acceptable.

The results of present study are consistent with those of **Haščík et al. (2012, 2013)** who found positive effect of bee pollen and propolis on some sensory attributes of chicken meat.

Similar findings were reported by **Mellen et al. (2014)**

Table 2 Mean scores of chicken breast samples' sensory characteristics with corresponding results of one-way ANOVA and Tukey's (HSD) test (mean ±*SD*).

Group	Sensory attribute				
	Aroma	**Taste**	**Juiciness**	**Tenderness**	**Overall acceptability**
C	4.22 ±0.122^{b}	4.18 ±0.225^{b}	3.81 ±0.360^{b}	4.06 ±0.365^{d}	4.07 ±0.221^{b}
E1	4.16 ±0.259^{b}	4.11 ±0.251^{b}	3.72 ±0.342^{bc}	3.80 ±0.368^{bc}	3.95 ±0.272^{bc}
E2	4.03 ±0.170^{a}	4.00 ±0.244^{a}	3.58 ±0.269^{ac}	3.65 ±0.422^{ac}	3.74 ±0.304^{a}
E3	4.20 ±0.249^{b}	4.13 ±0.228^{b}	3.51 ±0.338^{a}	3.74 ±0.350^{bc}	3.89 ±0.252^{c}
***F*-value**	8.43	5.16	8.44	10.85	13.53
***P*-value**	<0.0001	0.0019	<0.0001	<0.0001	<0.0001

Note: C – control group; E1, E2, E3 – experimental groups; mean – average; *SD* – standard deviation; $^{a–d}$ means within a column with the same superscript are not significantly different ($p > 0.05$) depending on the results of Tukey's test.

who investigated effect of different feed additives on sensory quality of chicken meat.

The results of study **Teye et al. (2015)** indicated that palm kernel oil residue inclusion up to 17.5% in broilers has no significant (p >0.05) effects on sensory characteristics of the meat.

In another study, **Ntzimani at el. (2010)** investigated sensory attributes of chicken breast fillets treated with natural antimicrobials, namely EDTA, lysozyme, rosemary and oregano oil and their combinations. In the study, there was well acceptance to the panelists in all the treatments except for oregano oil that was not as pleasant when compared to others.

The findings of **Dinçer et al. (2014)** demonstrated that juiciness and flavour scores of breast meat in chickens after feed restriction did not show any significant differences.

Chulayo et al. (2011) found tender, juicier and a good flavour in chicken meat supplemented with *Aloe ferox* and *Agave sisalana* compared to the other supplement (*Gunera perpensa*).

In the study of **Adeyemo and Sani (2013)**, there was a significant difference ($p \leq 0.05$) in tenderness and juiceness in meat of chickens fed hydrolyzed cassava peel meal as compared to control. However, there was no significant difference in overall acceptability and flavour of chicken meat among the groups.

Liu et al. (2004) investigated the effects of various postchill deboning times on sensory attributes of broiler breast meat. The results indicated differences due to the deboning times. There was a significant reduction in the values of two flavour attributes, seven texture attributes, and one afterfeel-aftertaste attribute for muscles deboned from 2 to 24 h *post mortem*.

Fanatico et al. (2007) reported no significant differences in overall acceptance, appearance, texture, or flavour of the breast meat among a slow-growing genotype and a fast-growing genotype of broilers.

Bartlett and Beckford (2015) determined effect of sweet potato root meal as partial replacement for corn in the diet on consumers' sensory perception. The results revealed that an inclusion level of sweet potato root meal up to 30% in the diet of broilers was more acceptable to consumers, despite no significant differences in sensory attributes.

Horsted et al. (2011) demonstrated that sensory profiles differed between conventional standard broilers and organic niche broilers.

On the contrary, **Miezeliene et al. (2011)** found no significant effect (p >0.05) on most sensory attributes of chicken breast meat after addition of selenium in broilers diet.

Principal component analysis (PCA)

PCA enables to distinguish the obsservations (samples) and to identify the most important variables in a multivariate data matrix.

The data matrix (200 observations and 5 variables, i.e. attributes) was used to perform PCA. First three components (PCs), which explained 69.82% of the total variation in 5 variables (PC1 = 28.55%, PC2 = 21.89%, PC3 = 19.39%), have been used.

The correlation coefficients among variables of sensory quality of chicken breast meat are shown in Table 3. There were several significant correlations among sensory attributes of chicken breast meat observed. Positive and weak correlation was observed between aroma and tenderness. Overall acceptability correlated positively and very weakly with taste and tenderness. Regarding the other relationships, there were not found any significant correlations. In addition, it has been shown that taste was the only attribute correlated negatively with juiciness.

Table 3 Pearson correlation coefficients among sensory attributes.

Variables	Aroma	Taste	Juiciness	Tenderness	Acceptability
Aroma	1				
Taste	0.083	1			
Juiciness	0.102	-0.081	1		
Tenderness	0.221*	0.066	0.062	1	
Acceptability	0.076	0.19*	0.12	0.151*	1

Note: *significant correlation ($p \leq 0.05$).

Table 4 Loadings (coefficients of correlation between variable and PCs).

Variables	PC1	PC2	PC3	PC4	PC5
Aroma	0.60	-0.23	-0.49	-0.48	0.34
Taste	0.42	0.72	0.09	-0.36	-0.40
Juiciness	0.33	-0.68	0.51	-0.25	-0.33
Tenderness	0.64	-0.13	-0.39	0.57	-0.32
Acceptability	0.61	0.21	0.55	0.26	0.46

Table 5 Squared cosines of the attributes.

	PC1	PC2	PC3	PC4	PC5
Aroma	0.36*	0.05	0.24	0.23	0.12
Taste	0.18	0.52*	0.01	0.13	0.16
Juiciness	0.11	0.46*	0.26*	0.06	0.11
Tenderness	0.41*	0.02	0.15	0.32	0.10
Acceptability	0.37*	0.05	0.30	0.07	0.21

Note: Values with asterisk correspond for each variable to the factor for which the squared cosine is the largest.

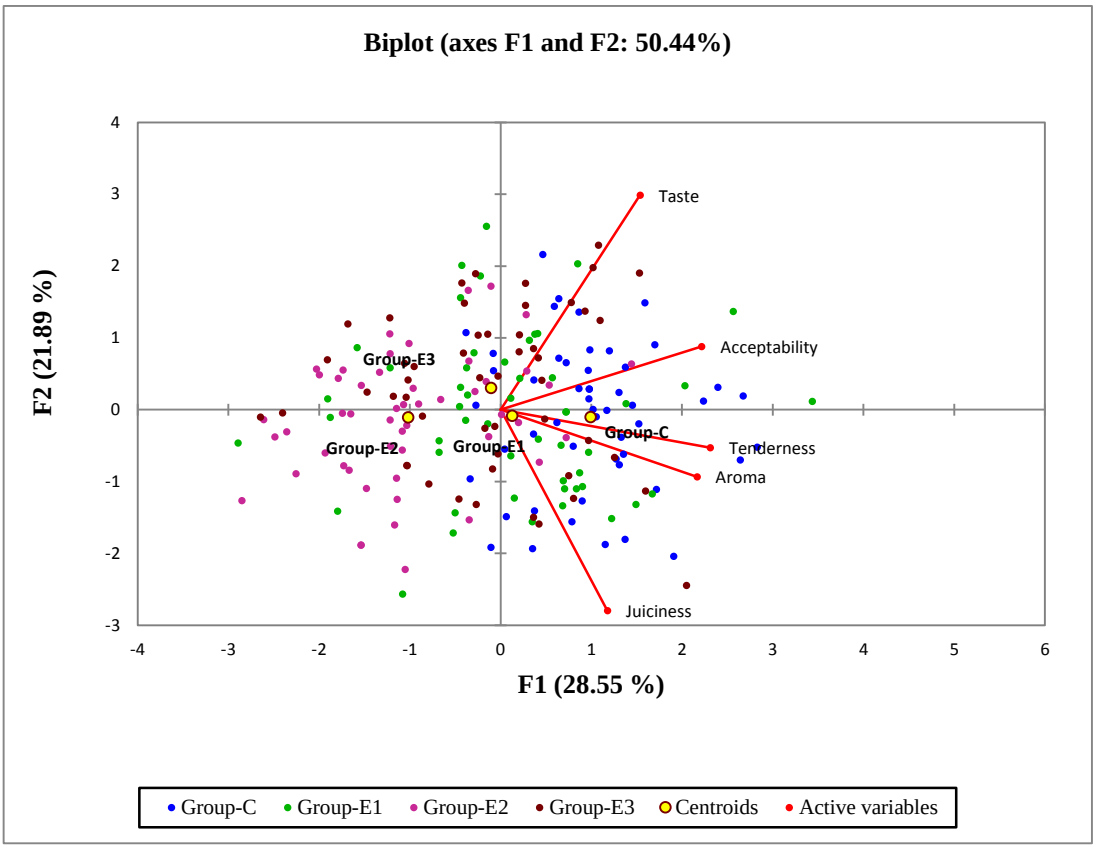

Figure 1 Plot of PC1 and PC2 showing obsevations (groups) of breast chicken meast and positions in terms of vectors of variables.

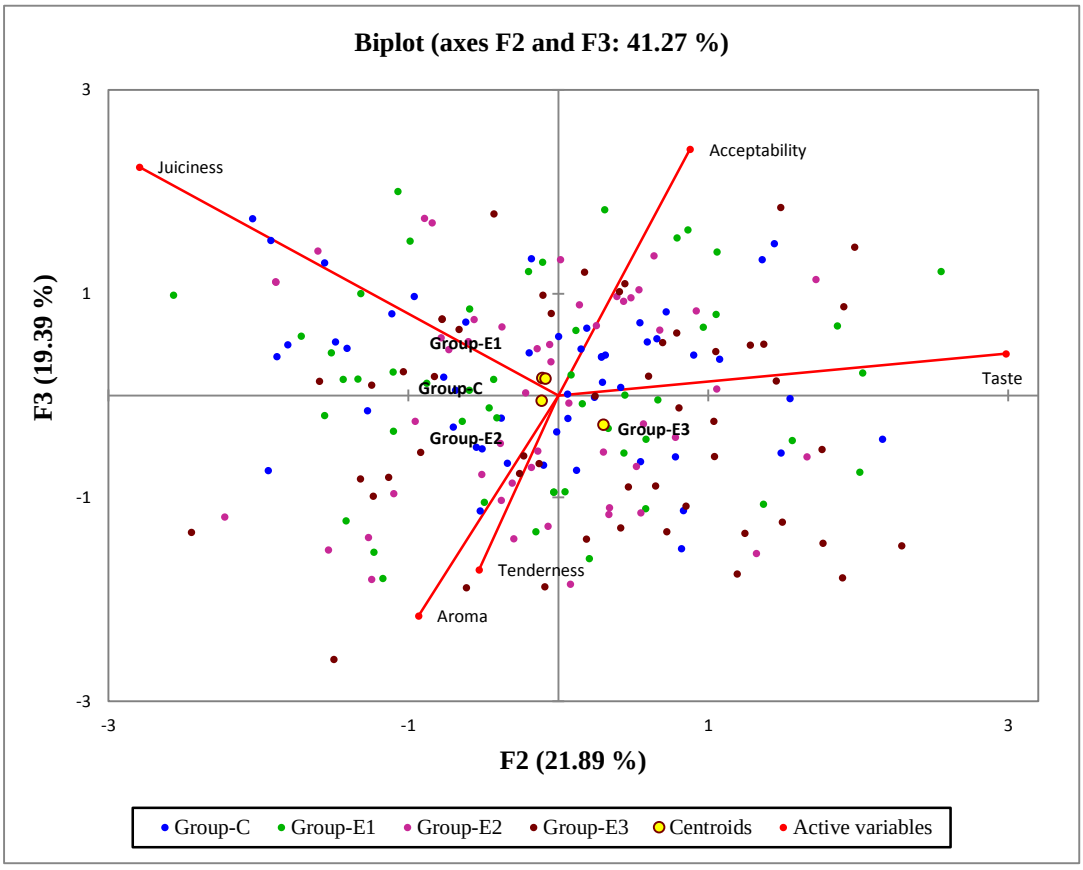

Figure 2 Plot of PC2 and PC3 showing obsevations (groups) of breast chicken meast and positions in terms of vectors of variables.

Regarding the factor loadings (Table 4) and squared cosines (Table 5), the PC1 was the most defined by tenderness, acceptability, and aroma. The most important for PC2 was taste and juiciness. In addition to juiciness attribute, it seemed to be the most characterised by PC2 and PC3, since there were the the highest values of squared cosines.

The first 3 significant PC were chosen for result plotting and interpretation (Figures 1 and 2). There is noticeable from PC1 and PC2 plot that C group is the most separated from E2 group, suggesting that groups E1 and E3 are entirely similar in terms of aroma, tenderness, and overall acceptability attributes.

As shown on PC2 and PC3 plot, evolution of breast muscle juiciness in control group resembled to those in E1 and E2 groups, but, on the contrary, evidently differed from that in E3 group. The finding is also in accordance with data obtained by ANOVA. As far as the differences in taste attribute are concerned, the positions of the groups coincided with the ANOVA results.

CONCLUSION

The results obtained in the present study demonstrated that supplements investigated in experiment (bee pollen, propolis, and probiotic) had rather undesirable impact on sensory quality of chicken breast muscle. Propolis-supplemented group of chickens has been shown as the least acceptable in sensory evaluation, whereas the control group received the highest raking scores for each sensory attribute. Sensory panel was not able to distinguish clearly between the samples supplemented with bee pollen and probiotic according to their sensory attributes. Furthermore, PCA results indicated clear separation of the groups in the most of sensory attributes. Further studies on supplementation of these additives regarding the sensory quality of chicken meat may be, however, recommended.

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