KNOWLEDGE – International Journal
Vol. 20.5
Bansko, December, 2017

STUDY OF THE MAJOR PHYSICAL AND CHEMICAL PROPERTIES OF GUINEA-FOWL (*NUMIDA MELEAGRIS*) MEAT DEPENDING ON THE DURATION OF THE FATTENING PERIOD pH AND COLOUR OF MEAT

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Abstract: A study was carried out on the pH values and colour characteristics of meat from a local population of guinea-fowls (*Numida meleagris*), fattened to different ages (16, 20, and 24 weeks). It was established that the instrumentally obtained mean values of the pH indicator, reported for the breast meat in the time interval from 25 min. to 24 hours post mortem, ranged within 6.09 to 6.75, whereas for the thigh meat they were in the range of 6.36 to 7.29. It was found that at the 25th minute, as well as at the 24th hour post mortem, the indicator did not depend on the age and sex of the birds.
The mean values of *L** (colour luminosity) of the thigh meat for the three fattening periods were 39.59 (male guinea-fowls) and 40.07 (female birds), respectively, recorded at the 4th hour. When the meat was stored and the indicator was measured after 24 hours, the colour luminosity ranged from 40.65 to 42.34 in the males and 41.53 to 43.38 in the females. In the breast meat of the experimental male guinea-fowls the colour luminosity (*L**) was 45.69 vs. 45.49 for the females at the 4th hour. At the 24th hour there was a statistically insignificant increase of the value both in the males (47.52) and in the females (47.64). Colour luminosity (*L**) of the guinea-fowl breast and thigh meat was not sex-dependent.
The instrumentally obtained value of the red colour component α^* in all the studied samples of breast muscle at the 4th hour was 15.94 (15.65 in the males and 16.23 in the females). The results obtained did not show significant differences at the 24th hour. Male birds have α^* (red colour component) of 15.29 and females – 15.78. In the thigh muscle the measured mean values of the red colour component α^* were 16.13 at the 4th hour (16.09 in the males and 16.18 in the females) and 15.72 (15,76 in the males and 15.67 in the females) at the 24th hour.
The yellow colour component *b** in the breast muscle varied from 8,44 to 11,78 at the 4th hour and from 8,78 to 12,86 at the 24th hour (for both sexes taken together). The mean values in the thigh muscle were 4,74 at the 4th hour and 4,47 at the 24th hour, respectively.
The following values were established when calculating the colour saturation (C*) of the meat from male and female guinea-fowls: 17,44 – 20,22 for the breast muscle and 15,31 – 17,40 for the thigh muscle at the 24th hour. The highest pigment saturation in the two studied muscle samples was established at 16-week old guinea-fowls (in the breast muscle at the 24th hour and in the thigh muscle at the 4th hour post mortem).
The calculated colour difference (ΔE *) in the time interval from 4th to 24th hour after slaughtering the fowls (from the three groups) varied from 2,09 to 3,56 in the breast muscles and from 2,44 to 3,28 in the thigh muscle for both sexes.
Keywords: guinea-fowl meat, colour characteristics, pH-value.

INTRODUCTION

Poultry meat production is steadily increasing worldwide, due to its dietary and nutritional characteristics. Last but not least, its universal use in the diet of people from different religions is also important.
The production of guinea-fowl meat is a relatively affordable as an additional business activity for a large number of small farmers, especially taking into account that those birds are resistant to a number of diseases, which cause huge losses in poultry farming (**Bolotnikov and Konopatov, 1993; Reuter et al., 2006**). That has greatly increased the interest of many West European countries such as France, Italy, Belgium and others to continuously increase the number of birds raised on the farm. A few years ago the annual consumption of guinea-fowl meat per capita exceeded 0.6 kg (**Audran X., Gain Report FR 5080 – France**).
The production of meat with a good taste and better dietary qualities increased the interest in rearing that poultry species in our country, as well as in carrying out breeding activities. Guinea-fowls are currently reared mainly in hunting farms and by amateur poultry breeders, ignoring the increase in their productivity (Kabakchiev et al., 2014).

Taking into account the inadequate research in our country on that poultry species and its productivity, as well as the scarce studies of the physical and chemical qualities of guinea-fowl meat, we set the aim to investigate the pH values and colour characteristics of meat from a local population of guinea-fowls fattened to different ages.

MATERIAL AND METHODS

The experimental work of the present study was carried out at the poultry farm of the Training and Experimental Site of the Agricultural University – Plovdiv with three groups of 20 little guinea-fowls each, of a local population of pearl-gray colour of the plumage (equal number of each sex), fed on forages prepared following the recipes of **Todorov et al.** (2016).

At the end of each fattening period (16, 20 and 24 weeks), 4 male and 4 female birds were selected, their weight being close to the average weight in the group.

Determining the pH indicator and the colour characteristics of the meat was carried out at the University of Food Technologies – Plovdiv. Standard parts of the skinned carcass were used according to AOAC (1990).

The muscle pH values were determined between 20 and 30 minutes after slaughter (pH1), at the 4th (pH4) and 24th hour (pH24) post mortem, using Hanna HI 99121 portable pH meter, equipped with a glass electrode and an electrode for temperature measurement. Measurement was performed at a depth of 1 cm at the middle of one-third part of each studied muscle.

The colour characteristics of the meat were determined spectrophotometrically by Minolta Chroma meter, CR 410, Osaka, Japan, in the CIE-$L^*a^*b^*$ system (CIE, 1978), reporting: L^*– colour brightness, a^* – the red colour component and b^* – the yellow colour component. The analysis was performed at five replications on non-overlapping zones. The instrumentally obtained data were used to calculate the values of the colourfulness C by the formula $C = \sqrt{a^{*2} + b^{*2}}$, the colour saturation h by the formula $h = \tan^{-1}(b^*/a^*)$, as well as the colour difference ΔE by the formula $\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$.

RESULTS AND DISCUSSION

It is known that poultry meat is characterized by high pH values. **Genchev et al.** (2010) mentioned that for most agricultural poultry species, the pH value is close to neutral (pH 7,0) immediately after slaughter, and decreases during *rigor mortis* (6,02-6,41). According to other researchers, the technological meat qualities are complemented by its structural and mechanical properties, water-holding capacity and colour characteristics (**Owens et al.**, 2000; **Van Laack et al**., 2000; **Barbut et al.**, 2000; **Qiao et al**., 2001, **Lonergan et al.**, 2003, **Fraqueza et al.**, 2006. Although most of the authors mentioned that pH24 has the strongest effect on the colour characteristics of meat, **Le Bihan-Duval et al.** (2008) supposed that some of the parameters of that characteristic are also influenced by other factors unrelated to pH values.

Changes in the colour of poultry meat depend to a large extent on the primary production factors (the breed, age and nutritional status), conditions and methods of slaughter, as well as storage (**Berri, 2000**).

The results of the analysis for establishing the physical and chemical pH-value and the colour characteristics of the meat were presented in Tables 1, 2 and 3.

Table 1 shows the pH values of breast and thigh guinea-fowl muscles, measured between the 20th and 30th minute (pH1), at the 4th hour (pH4) and at the 24th hour (pH24), depending on sex, on the fattening period duration and the average data.

The mean pH values of the breast muscle, reported in the period 25th min. – 24th hour were 6,32 in the male birds and 6,41 in the females. The mean pH values for the same time interval in the thigh muscle were 6,73 in the males and 6,84 in the female guinea-fowls.

The lowest pH values were established in 24-week old male birds in the breast muscle, measured at 24th hour post mortem (pH24) – 6,02 and the highest – in 16-week old guinea fowls at the 25th minute in the females – 6,80. The values measured in the thigh muscle were from 6,27 (24-week old male birds at pH24) to 7,53 (20-week old males, the pH values measured after the 20th minute).

The results obtained showed that the pH values in the breast and thigh muscles, both at the 25th minute and at the 24th hour post mortem, did not show a tendency of dependence either on the age of slaughter or on the sex of the birds. The same was confirmed by **Kokoszyński et al.** (2011) at two different ages and in both sexes in the breast and thigh muscles. They reported the pH value of 6,10 in the breast meat in male birds and 5,90 in female guinea-fowls at 13 weeks of age. The pH values established by them in the thigh muscle were slightly higher – 6,50 in males and 6,30 in females. The results reported for the 16-week old birds almost did not show any change. In both sexes the values in the breast muscle were pH 6,10 and in the thigh muscle the values were 6,40 in the males and 6,50 in the females.

Aisha Elfaki M. et al. (2012) obtained similar results. They carried out their experiment with 5 groups of guinea-fowls up to 7 weeks of age, fed on forages of different levels of protein and energy – pH 5,94 to 6,12; **Pudyszak et al.** (2005) two hours after slaughter – pH6,10-6,40 and **Baéza et al.** (2001) – 6,16-6,45 pH values in the breast muscles.

Table1. pH-values in guinea-fowl meat

Muscle		16 weeks of age			20 weeks of age			24 weeks of age		
		pH 25th minute	pH 4th hour	pH 24th hour	pH 25th minute	pH 4th hour	pH 24th hour	pH 25th minute	pH 4th hour	pH 24th hour
BREAST	Males	6,70±0,10	6,23±0,08	6,09±0,06	6,51±0,15	6,38±0,07	6,12±0,15	6,63±0,17	6,21±0,03	6,02±0,05
	Females	6,80±0,15	6,39±0,10	6,14±0,03	6,75±0,15	6,33±0,13	6,24±0,14	6,61±0,18	6,24±0,08	6,15±0,09
	Average	6,75±0,09	6,31±0,07	6,12±0,03	6,63±0,11	6,36±0,07	6,18±0,10	6,62±0,12	6,22±0,04	6,09±0,05
THIGH	Males	7,01±0,14	6,72±0,10	6,48±0,12	7,19±0,09	6,74±0,05	6,42±0,15	7,05±0,26	6,71±0,15	6,27±0,26
	Females	7,03±0,15	6,68±0,10	6,38±0,13	7,26±0,14	6,83±0,02	6,63±0,05	7,53±0,16	6,80±0,12	6,45±0,08
	Average	7,02±0,09	6,70±0,07	6,43±0,08	7,22±0,08	6,78±0,03	6,52±0,08	7,29±0,17	6,76±0,09	6,36±0,13

The colour characteristics of meat are much more important in the evaluation of its quality (Tabl. 3 and 4). The values of *L** (colour brightness) are an important criterion for assessing the technological meat qualities. It could be seen that colour brightness of both the breast and the thigh muscles of the guinea-fowls was not influenced by sex.

The mean values of *L** (colour brightness) of the thigh muscle were 39,59 for male guinea-fowls and 40,07 for the females, ranging from 37,92 to 41,09 (both sexes taken together), reported at the 4th hour of measurement. After storage and measurement at 24th hour, the values ranged from 40,65 to 42,34 in males and from 41,53 to 43,38 in female guinea-fowls. The average values of colour brightness of male breast meat were 45,69 vs. 45,49 of the females at the 4th hour. At the 24th hour there was a statistically insignificant increase: 47,52 in males and 47,64 in females. The result obtained in the present study was confirmed by **Wojtysiak and Poltowicz** (2006), the most intense changes being in the first 24 hours (**Qiao et al**., 2001; **Petracci et al**., 2004). It is known from literature that during that period a number of processes occur leading to weakening of the hydrophilic properties of the proteins, whereby part of the water passes from the muscle fiber into the intracellular space in the *rigor mortis* phase. Contractions in that phase lead to a strong adhesion of the muscle protein structures, whereby water is released in the intracellular space. As a result, there are prerequisites for greater light scattering, which increases the values of *L** (brightness).

In the three age groups of both sexes, as well as in both muscle types, the *L** values (colour brightness) in the study slightly increased at the 24th hour. Only the differences in the breast muscle of 20-week old birds and in the thigh muscle of 24-week old birds of both sexes ($p < 0.05$) were statistically significant.

Close to our *L** (colour brightness) values were also obtained by **Kokoszyński et al**. (2011). Higher values (52,27 to 59,22) were announced by **Aisha Elfaki M. et al.** (2012). Our results are between the values established by **Ribarski and Genchev** (2013) for *L** (colour brightness) at the 24th hour in the two quail breeds studied by them, i.e. between 41,30 and 58,80. Similar values for colour brightness (43,12-46,66) were obtained by **Kuźniacka et al.** (2007) for pheasant meat.

The instrumentally obtained mean values for the red colour component *a** of the studied local guinea-fowl population in all the breast muscle samples at the 4th hour were 15,94 (15,65 in the male birds and 16,23 in the females). The results obtained by us did not show significant differences at the 24th hour. Male experimental birds had *a** (red colour component) of 15,29 and female guinea-fowls – 15,78. In the thigh muscle the average data of the red colour component *a** at the 4th hour were 16,13 (males – 16,09, females – 16,18) and at the 24th hour – 15,72 (males – 15,76, females – 15,67). Statistically significant differences in the red component *a** were not established by sex and age, as well as between the 4th and 24th hour.

The variation range of *a** (red colour component) in the studied guinea-fowls showed higher values than those published by **Aisha Elfaki M. et al.** (2012) and similar to those of **Kokoszyński et al**. (2011). Significantly lower

values of the red colour component α* were established in turkeys, varying from 4,90 to 5,50 (**Fraqueza et al.,** 2006). The significant differences in the colour of the breast meat between guinea-fowls and turkeys are due to differences in morphological structure of the muscles. The rich in myosin dark muscle fibers of the breast meat of the guinea-fowl give more strongly saturated colour of the red spectrum, whereas in turkeys, this muscle is totally built of myosine-poor light muscle fibers (**Riegel et al.**, 2003).

The yellow colour component *b** in the breast muscle showed a variation of 8,44 to 11,78 at the 4th and from 8,78 to 12,86 at the 24th hour, respectively. The mean values in the thigh muscle at 4th hour were 4,74 and the 24th hour – 4,47. The values of the yellow component *b** in the breast muscle showed a statistically significant decrease in the 16-week old birds compared to the older fowls of both sexes at the 4th hour and at the 24th hour (Table 2).

The mean value of the yellow colour component *b** obtained in the present study was higher compared to that of **Kokoszyński et al**. (2011) for both sexes and at the two studied time intervals for measuring the samples (4th and 24th hour). Similar to our results were also reported by **Chiericato et al.** (2001): red colour component *α** of 10,10-10,70; yellow colour component b* – 3 ,99 and 4,39, while **Aisha Elfaki M. et al.** (2012) announced higher values of *b** (yellow colour component), i.e. from 15,81 to 17,56.

Pigment saturation of the muscles in the red and yellow spectrum gives the guinea-fowl meat of a good colour saturation (C*). The mean C* values were within the range of 17,44 to 20,22 in the breast muscle and 15,31 to 17,40 in the thigh muscle at the 24th hour. Summarizing the results of the red component *a** and the yellow component b* and calculating the colour saturation (C*), it could be concluded that pigment saturation was the highest in 16-week old muscle (in the breast muscle at the 24th hour and in the thigh muscle at the 4th hour post mortem). During the first 24 hours of meat storage, colour saturation (breast muscle) increased slightly in 16- and 24-week old guinea-fowls (both male and female), while in those fattened until the 20th week of age, it decreased in both sexes. By calculating the colour saturation (C*) in the thigh muscle, a slight decrease was established (4th hour compared to 24th hour) in male and female guinea-fowls fattened to the three studied ages.

The summarized results for *L**, *a** and *b** characteristics and the calculation of the colour difference (*ΔE**) in the time interval of 4th until 24th hour post mortem, gave the grounds to conclude that in both muscle types the variation was almost the same. The values in the breast muscle ranged within 2,09 to 3,56 and in the thigh muscle from 2,44 to 3,28, respectively, for both sexes.

Table 2. Colour characteristics of the breast muscle

Characteristics	16 weeks of age		20 weeks of age		24 weeks of age	
	Male	Female	Male	Female	Male	Female
*L**4 – colour brightness	45,18±1,04	47,12±0,55^{a}	45,61±0,61^{b1}	44,23±0,45^{ab1}	46,28±0,30	45,11±1,03
*a**4 – red colour component	15,15±0,32	15,95±0,53	15,54±0,18^{b1}	16,33±0,44	16,25±0,33	16,42±0,42
*b**4 – yellow colour component	10,50±0,83^{a}	11,78±0,93^{a}	8,44±0,67	8,78±0,41^{a}	8,39±0,43^{a}	9,50±0,99
C4 – colourfulness	18,46±0,65	19,9±0,49	17,72±0,37	18,55±0,50	18,31±0,21	19,01±0,82
h°4 – colour saturation	34,56±1,86^{a}	36,36±2,70^{a}	28,40±1,92	28,25±1,05^{a}	27,36±1,58^{a}	29,81±2,12
*L**4 – colour brightness	47,69±0,37	48,43±0,53^{a}	47,59±0,37^{b1}	46,61±0,38^{ab1}	47,28±0,84	47,87±0,87
*a**4 – red colour component	14,86±0,43	15,53±0,60	14,79±0,14^{b1}	15,66±0,51	16,23±1,11	16,16±0,44
*b**4 – yellow colour component	11,68±0,86	12,86±0,82^{a}	9,19±0,64	8,78±0,71^{a}	8,95±0,35	10,78±1,25
C4 – colourfulness	18,94±0,71	20,22±0,52^{a}	17,44±0,38	17,98±0,64^{a}	18,59±0,83	19,51±0,87

h°4 – colour saturation	38,00±1,94[a]	39,57±2,44[a]	31,76±1,78	29,21±1,90[a]	29,20±2,47[a]	33,38±3,03
ΔE* – colour difference	3,08±0,91	2,32±0,29	2,37±0,45	2,09±0,48	2,61±0,08	3,56±0,40

* Colour differences are statistically significant at p <0.05, as follows: a-a – colour by age of fattening; b-b – Muscle colour within 16 weeks of age between the 4th and 24th hour post mortem; b1-b1 – Muscle colour within 20 weeks of age between the 4th and 24th hour; b2-b2 – Muscle colour within 24 weeks of age between the 4th and 24th hour; c-c – Muscle colour by sex of the birds at the same age.

Table 3. Colour characteristics of the thigh muscle

Characteristics	16 weeks of age		20 weeks of age		24 weeks of age	
	Male	Female	Male		Male	Female
*L**4 – colour brightness	39,96±0,77[a]	41,09±1,22	40,88±0,80[a]	40,04±0,85	37,92±0,12[ab1]	39,07±0,76[b1]
*a**4 – red colour component	16,15±0,33	15,86±0,30	15,78±0,55	16,62±0,43	16,33±0,47	16,06±0,55
*b**4 – yellow colour component	6,27±0,54[a]	6,58±1,86	3,78±0,60[a]	4,47±0,45	3,52±0,39[a]	3,81±0,60
C4 – colourfulness	17,34±0,48	17,4±0,93	16,25±0,64	17,23±0,47	16,72±0,50	16,52±0,68
h°4 – colour saturation	21,11±1,36[a]	21,74±5,27	13,3±1,83[a]	15,02±1,33	12,17±1,21[a]	13,14±1,56
*L**4 – colour brightness	41,22±0,34	43,38±1,35	42,34±0,84	41,79±1,04	40,65±1,10[b1]	41,53±0,41[b1]
*a**4 – red colour component	16,34±0,28	15,57±0,34	14,56±1,03	15,56±0,40	16,37±0,52	15,89±0,24
*b**4 – yellow colour component	4,75±0,49	5,36±1,98	4,69±0,61	5,61±0,59[a]	3,51±0,80	2,91±0,38[a]
C4 – colourfulness	17,05±0,17	16,78±0,73	15,31±1,13	16,55±0,57	16,79±0,61	16,17±0,31
h°4 – colour saturation	16,26±1,81	18,24±6,34	17,73±1,41	19,69±1,47[a]	11,88±2,56	10,33±1,18[a]
ΔE* – colour difference	2,68±0,60	2,44±0,52	3,28±0,80	2,71±0,57	2,54±0,45	2,93±0,42

* Colour differences are statistically significant at p <0.05, as follows: a-a – colour by age of fattening; b-b – Muscle colour within 16 weeks of age between the 4th and 24th hour post mortem; b1-b1 – Muscle colour within 20 weeks of age between the 4th and 24th hour; b2-b2 – Muscle colour within 24 weeks of age between the 4th and 24th hour; c-c – Muscle colour by sex of the birds at the same age.

CONCLUSION

The results obtained show that the pH values in the breast and thigh muscles both at the 25th minute and at the 24th hour post mortem were not influenced either by the age of the slaughtered birds or by their sex.

On the basis of the instrumental analysis, it could be concluded that the values of L*, a* and b* coordinates of the breast and thigh muscles of the guinea-fowls within the interval 4th to 24th hour post mortem were not affected by sex of the birds.

Summarizing the results obtained of the red colour component a* and the yellow colour component b* and calculating the colour saturation (C*) gave the grounds to conclude that the pigment saturation was the highest in both studied muscle types at the guinea-fowl age of 16 weeks.

Statistical significance was not established in colour difference (ΔE*) in the time interval of the 4th until the 24th hour post mortem in both muscle types (breast and thigh muscle) and both sexes (males and females).

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