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MEAT QUALITY TRAITS OF VIETNAMESE INDIGENOUS NOI CHICKEN AT 91 DAYS OLD

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Abstract: Indigenous chicken breeds have showed slower growth rate and yield lower meat production, compared to commercial broilers. However, their meat quality is valued by modern consumers. The present study aimed at analyzing the quality traits of breast meat samples of Noi broilers, one of the famous indigenous chicken breeds in Vietnam. A total of 355 breast fillet samples were collected to evaluate quality meat traits such as pH, surface color, drip loss, and cooking loss at different time points of 3, 24, and 48 hours after slaughtering as well as to analyze chemical compositions such as dry matter, crude protein and ether extract. As result, sex and cold-storage time significant affect some of quality traits of breast meat, whereas their interaction did not associate among the observed properties. After 3 hour-storage, the pH value was determined at 5.63, then decrease to 5.56 and 5.55 after 24 and 48 hours, respectively. The color values (L^*, a^*, and b^*) were in the normal range reported from previous studies. Meat samples of two sexes did not vary in the cooking loss and drip loss values, whereas it was significantly different due to cold-storage time. The ether extract content of the meat was found negatively correlated with the cooking loss. The higher dry matter content of breast meat resulted in the lower drip loss value after 3h cold-storage ($r=-0.12$, $P<0.05$). There is a negative relationship between L^* and a^*. The variation demonstrated in this study can be used in breeding schemes in order to improve meat quality of Noi chicken lines.

Key words: Noi chickens, breast meat, cold-storage, quality traits, correlation.

Introduction

Ingestion of healthy and nutritious food materials play a crucial role in maintaining the human health, as advised by doctors and nutritionists (*Farrell, 2010; Ahmad et al., 2018*). This concern has gained globally contributing to the raising awareness regarding the remarkable development of poultry production. Regarding nutritional aspects, poultry meat has been considered as “functional foods” of a well-balanced diet. It is well fit the current consumer preference for a meat type which is high in protein and low in saturated fatty acids. According to *Ahmad et al. (2018)*, the average value of the meat protein is about 22%, but it could range from high protein value of 34.5% in chicken breast to as low as 12.3% protein in duck meat. The amino acid score adjusted for protein digestibility, an indicator of protein quality, reveals that chicken meat has high efficiency of 69,79% compared to other meat sources including shrimp and turkey (52.58% and 63.49%, respectively) (*Barron-Hoyos et al., 2013*). In addition, chicken meat may also provide other bioactive substances with favorable effects on human health, such as conjugated linoleic acid, vitamins and antioxidants (*Petracci and Cavani, 2012*).

The growing consumption and consumer demands for chicken meat have resulted in pressure on intense selection processes in poultry production to enhanced animal growth rate, feed efficiency, size and quality of breast muscle as well as reduction in abdominal fatness (*Baracho et al., 2006*). The age at which poultry is slaughtered has been continually reducing halved to five weeks, while the yield of breast meat was significantly improved by 10% compared with poultry production 50 years ago (*Anthony, 1998; Havenstein, 2006*). Sensory characteristics and functional properties of poultry meat are critical not only for consumer’s initial selection but also for final product satisfaction and the most important quality attributes are appearance and texture. Major appearance quality issues are skin and meat colors while meat tenderness, juiciness and flavor are primarily associated with texture traits (*Fletcher, 2002; Ismail and Joo, 2017*). Quality traits of chicken meat along with nutritional compositions are dependent upon animal genetics, feeding source, rearing systems, handling and slaughter techniques (*Ahmad et al., 2018*). Interestingly, meat of indigenous chicken has been found to possess a unique taste, with tough muscles, whereas the meat of commercial broiler chicken obtains an over-tender characteristic (*Wattanachant, 2008; Assan, 2015*).

The meat quality properties of indigenous chickens have been widely researched. Korean native chicken contained higher percentage of protein but a lower fat and moisture contents than broilers (*Jayasena et al., 2013*). The color score of breast Korean chicken meat was also higher than that of silky fowl, an imported poultry breed from China owning special nutritive and medicinal values (*Choo et al., 2014*). For Leung Hang Khao (the Thai indigenous chicken), *Molee et al. (2018)* found a significant correlation between animal weight and cooking loss of breast meat. It was also found that the drip loss of the meat may be negatively affected when growth performance is improved. However, breast and thigh muscles of Thai chickens were higher in shear force value and collagen content, the cholesterol and triglyceride contents as well as n-3 fatty acid were also more favorable compared to those of broiler breeds and their crossbreds (*Jaturasitha et al., 2008*). *Raphulu et al. (2015)* obtained that the meat of Venda chickens (an indigenous breed in South Africa) containing less fat and more crude protein than the meat of commercial broilers. The available information might assure the opportunity to improve the production of native chicken. However, our knowledge of the quality variables of breast meat of indigenous Noi chickens in Vietnam is limited. It is also necessary to consider potential interactions between sex and cold-storage time on meat quality of Noi chickens. The objective of this study was to investigate the meat quality traits of Noi chickens, a famous indigenous breed originated in Vietnam in order to provide substantially data for commercial/industrial scale-up production.

Materials and Methods

Based on the previous experimental layout of *Do et al. (2019)* as well as continuing the research work of *Nguyen et al. (2020),* a total of 355 fillet samples of breast meat from 164 males and 191 female Noi chickens at 91 days old (weighed 1.43±0.29 kg/bird) were collected to evaluate their quality traits.

Generally, the samples were stored at 4°C after slaughtering to analyze (1) their chemical compositions such as dry matter (DM) and ether extract **(**EE, by using ANKOM XT15 Extractor, ANKOM Technology, USA) according to AOAC protocols (*AOAC, 2005*), followed by crude protein (CP, by using a DLK8 Fully Auto Digester and a UDK149 Automatic Kjeldahl Distillation Unit manufactured by VELP Scientifica, Italy) as guidance of Kjeldahl's method, (2) their quality traits such as pH value by using a pH meter (Hanna Instruments, HI 8314, Padova, Italy; *Cömert et al., 2016*), surface color (L^*, a^* and b^*) by using a CI60 colorimeter (Lovibond, UK; *C.I.E., 1978*), cooking loss (*Bertram et al., 2003*) and drip loss (*Guan et al., 2013*) at three different time points 3, 24 and 48 hours.

The differences between quality traits of breast meat data were analyzed with analysis of variance (ANOVA), the significance of each pair wise comparisons and Pearson's correlation coefficients of traits were estimated with Minitab 16 software. A probability value of less than 0.05 was considered to be significant. Mean ± standard deviation (SD) was used to measure all the parameters.

Results and Discussion

Chemical compositions

Nutritionally, chicken meat is a rich source of high value protein compared to vegetable proteins (*Soriano-Santos, 2010*). In addition, the low energy content with a high proportion of omega-3 polyunsaturated fatty acids, and other nutrients including zinc, iron, selenium, potassium, magnesium, sodium, vitamin A, B-complex vitamins and folic acid, places chicken meat as a healthy food, indicated for use in healthy diets, when compared to other meat sources (*Ahmad et al., 2018*). The chemical compositions of Noi chickens (average weight 1.43±0.29 kg/bird) are shown in Table 1.

Table 1. Difference of chemical compositions of breast meat

Traits	Sex				Overall
	Male (n = 164)	**Female** (n = 191)	**SEM**	**P**	
DM (%)	25.04 ± 1.05	25.20 ± 1.20	0.09	0.212	25.13 ± 1.14
EE (%)	0.53 ± 0.24	0.52 ± 0.21	0.02	0.705	0.53 ± 0.23
CP (%)	23.77 ± 1.21	23.93 ± 1.02	0.08	0.203	23.86 ± 1.11

In overall, the contents of DM, EE and CP of the breast muscle were 25.13%, 0.53%, and 23.86%, respectively. The results also indicated that there were no differences between sexes in relation to proximate compositions of DM, EE and CP (P>0.05). This observation is in agreement with *Bogosavljevic-Boskovic et al. (2010)*, who found no significant effects of rearing system and sex on dry matter and ash contents of breast muscle of Hybro G, a fast-growing broiler strain. In regards to indigenous chickens, *Pambuwa and Tanganyika (2017)* reported a non-significant difference between sexes found in proximate composition of Malawi indigenous chickens. *Jeon et al. (2010)* indicated that the protein content of breast meat in North Korean native chickens ranged from 24.13% to 24.63%, higher than the result of this study. Noi chicken muscle also contained less fat than Korean native chickens (0.53% and 1.31%, respectively). Bearded chickens, another indigenous chicken breed in the North of Vietnam, showed higher contents in dry matter (27.47-28.57%) and crude fat (0.54-0.91%) but lower in crude protein (19.36-20.25%) (*Nguyen et al., 2012*), as compared to the results of this study.

Meat quality traits

After slaughtering, postmortem glycolysis is activated and accumulation of lactic acid in the muscle is increased, which results in a pH decline (*Wideman et al., 2016*). A dramatic pH decline is associated with protein denaturation and negatively affects the meat quality, causing paleness, low water-holding capacity, and soft texture (*Petracci and Cavani, 2012*). Different traits of breast quality between sex, cold-storage time and their interaction as well as the descriptive statistics of these variables were shown in Table 2. In overall, there were significant effects (P<0.05) of sex and cold-storage time to some of quality traits of breast meat. However, regarding their interaction; there were no significant effects (P>0.05) for all the observed properties.

Table 2. Quality traits of breast meat at different time of measurement

Traits		**pH value**	**Lightness, L^***	**Redness, a^***	**Yellowness, b^***	**Cooking loss (%)**	**Drip loss (%)**
Sex effect							
Male		$5.61^a \pm 0.18$	57.40 ± 4.44	1.44 ± 1.51	$11.14^a \pm 3.05$	29.01 ± 8.40	2.08 ± 1.04
Female		$5.55^b \pm 0.14$	56.91 ± 4.33	1.48 ± 2.21	$12.64^b \pm 3.32$	28.69 ± 8.38	2.16 ± 1.10
Time effect							
3h		$5.63^a \pm 0.17$	57.44 ± 4.58	$1.11^a \pm 2.13$	$12.27^a \pm 3.18$	$25.52^a \pm 7.12$	$2.70^a \pm 1.09$
24h		$5.56^b \pm 0.16$	57.27 ± 4.46	$1.48^{ab} \pm 2.28$	$11.34^b \pm 3.38$	$30.54^b \pm 8.70$	$2.06^b \pm 0.91$
48h		$5.55^b \pm 0.15$	56.76 ± 4.09	$1.78^b \pm 2.58$	$12.06^a \pm 3.23$	$30.49^b \pm 8.26$	$1.61^c \pm 0.92$
Interaction effect							
Male	3h	5.65 ± 0.19	57.80 ± 4.43	1.10 ± 2.36	11.54 ± 3.12	25.91 ± 7.16	2.69 ± 1.02
	24h	5.60 ± 0.19	57.65 ± 4.50	1.43 ± 2.36	10.61 ± 3.08	30.64 ± 8.13	2.04 ± 0.96
	48h	5.58 ± 0.16	56.75 ± 4.34	1.78 ± 2.75	11.28 ± 2.90	30.49 ± 8.99	1.52 ± 0.79
Female	3h	5.61 ± 0.14	57.08 ± 4.69	1.12 ± 1.92	13.00 ± 3.09	25.14 ± 7.08	2.70 ± 1.16
	24h	5.53 ± 0.12	56.89 ± 4.41	1.54 ± 2.21	12.07 ± 3.49	30.43 ± 9.19	2.07 ± 0.87
	48h	5.52 ± 0.14	56.77 ± 3.87	1.78 ± 2.44	12.84 ± 3.32	30.49 ± 7.61	1.70 ± 1.01
SEM							
Sex		0.01	0.19	0.10	0.14	0.35	0.04
Time		0.01	0.23	0.12	0.17	0.43	0.05
Sex × Time		0.61	0.07	0.01	0.33	0.18	0.24
P-value							
Sex		0.000	0.070	0.762	0.000	0.512	0.228
Time		0.000	0.101	0.001	0.000	0.000	0.000
Sex × Time		0.326	0.422	0.945	0.973	0.805	0.481

$^{a\text{-}c}$ Superscripts on different means in a column within a factor differ significantly (p<0.05).

Regarding muscle pH, the ultimate-pH value of male chickens was higher ($p<0.05$) as compared to the females (5.61 *vs*. 5.55, respectively). After 3 hour-storage, the pH value was determined at 5.63, then decreased to 5.56 and 5.55 after 24 and 48 hours, respectively (Table 2). However, interaction was not observed between sex and cold-storage time for pH values. According to *Marcinkowska-Lesiak et al. (2016)*, the declining in pH values are probably due to the chances in glycogen content according preservative time. The findings are in line with other authors who found significant differences on the ultimate pH between different sexes of chickens (*Schneider et al., 2012; Khan et al., 2018*). Meat color is highly correlated to the amount of heme containing compounds such as myoglobin, haemoglobin, and cytochrome c. The breast muscle is almost entirely composed of white fibres which are low in myoglobin as compared to red fibres of the thigh/leg muscle. Therefore, chicken breast fillet generally appears to have a pink color, which is a desirable characteristic for the consumer (*Wideman et al., 2016*). Meat color is generally influenced by animal related factors, mainly genotype (*Barbosa-Filho et al., 2017*) and age (*Michalczuk et al., 2016*) of the birds. The color values of this study (L^*=56.75-67.80; a^*=1.10-1.78; b^*=10.61-13.00) were in the normal range reported from different broiler experiments (*Wideman et al., 2016*). Sex only affected b^* value of muscle color, whereas showed an independence relationship with the values of L^* and a^*. As shown in Table 1, the mean values of redness scoring (a^*) obtained greater standard deviations, probably indicating a high variation in the population of Noi chickens.

This result is consistent with the finding of *Khan et al. (2018)*, who reported that female Aseel chickens exhibited a higher yellowness (b^*) value than males. The results also confirmed that cold-storage time had an effects on meat color, a^* and b^*. The interaction between cold-storage time and sex do not affect breast muscle colors (L^*, a^* and b^*) in Noi chickens. Regarding the a^* value, it showed a reverse tendency which previously reported by *Suwattitanun and Wattanachant (2014)*, who stated that the redness of breast meat would be steadily decreased with storage. Within the local breeds, Korean local chickens have significantly lighter, darker red, and yellowish breast meat than that of silky fowl, which is assumed to be due to genetic difference (*Choo et al., 2014*). This finding was in agreement with that of *Jaturasitha et al. (2008)* who reported the similar color values in Thai native chickens. Comparing to commercial broilers, breast fillet of Noi chickens was lighter, yellower but less red than that of Cobb 500 (*Al-Marzooqi et al., 2019*).

Water holding capacity is defined as ability of the raw meat to retain its water during the application of external forces, such as transporting, processing and cooking. The water released can be described as cooking loss, drip loss, which is inversely related to water holding capacity (*Warner, 2017*). Meat samples of two sexes did not vary in the cooking loss and drip loss values ($P>0.05$), whereas it was significantly different due to cold-storage time ($P<0.05$). The interactions between the factors also have no influences (P>0.05) on the percentages of cooking loss and drip loss (Table 2). At 4ºC condition, the increasing storage time positively increased the cooking loss (25.52% to 30.54%) but reduced the drip loss (2.70% to 1.61%). The opposite effect of the storage time on drip loss was observed by other authors. *Suwattitanun and Wattanachant (2014)* found that longer storage time (under conditions of 0-4ºC and 12-15ºC) was induced greater drip loss. It was, additionally, confirmed that storage time had a negative effect on meat quality and caused greater drip loss regardless of the packaging methods (*Marcinkowska-Lesiak et al., 2016*).

Correlation between chemical compositions and other meat quality traits

The correlation coefficients among physicochemical parameters of breast meat are presented in Table 3. Regarding the chemical compositions, there is a positive correlation between dry matter content and ether extract (r=0.23, P<0.001) crude protein (r=0.20, P<0.001). Dry matter content of the breast muscle also correlated with the meat color b^* (r=0.13, P<0.05) and L^* but in different manner (r=-0.11, P<0.05). The ether extract content of the meat was found negatively correlated with the cooking loss percentage (r=-0.15, P<0.01). The higher breast meat DM content resulted in the lower drip loss value after 3h cold-storage (r=-0.12, P<0.05). According to former studies, there was an effect of surface pH on water holding capacity (*Baéza et al., 2012, Suwattitanun and Wattanachant, 2014; Marcinkowska-Lesiak et al., 2016*). However, that correlation was less obvious, as in the current study. At 48h post-mortem, the pH value also seems to have negative influence on the color of the meat, with higher pH values resulting in a lighter meat color (r=-0.18, P<0.001). At all investigation points, there was a negative relationship between L^* and a^*, determining that a^* values were higher in fillets showing lower L^* values. Similar to this study, *Kralik et al. (2014)* found a negative correlation between L^* and pH value as well as the negative correlation coefficient between L^* and a^*.

Table 3. Correlation coefficients (r) among meat quality traits at 3h – 48h post-mortem

Traits	DM	EE	CP	pH	L^*	a^*	b^*	CL	DL
3h post-mortem									
DM	**1.00**								
EE	0.23^{***}	**1.00**							
CP	0.20^{***}	0.09^{NS}	**1.00**						
pH	0.01^{NS}	0.01^{NS}	-0.02^{NS}	**1.00**					
L^*	-0.11^{*}	-0.06^{NS}	0.05^{NS}	-0.06^{NS}	**1.00**				
a^*	0.07^{NS}	0.002^{NS}	-0.01^{NS}	-0.03^{NS}	-0.15^{**}	**1.00**			
b^*	0.13^{*}	-0.02^{NS}	0.09^{NS}	-0.05^{NS}	-0.03^{NS}	0.43^{***}	**1.00**		
CL	-0.12^{*}	-0.15^{**}	0.05^{NS}	-0.11^{*}	0.08^{NS}	0.03^{NS}	0.11^{*}	**1.00**	
DL	-0.04^{NS}	0.01^{NS}	0.00^{NS}	0.002^{NS}	-0.13^{**}	0.14^{**}	0.06^{NS}	-0.01^{NS}	**1.00**
24h post-mortem									
DM	**1.00**								
EE	0.23^{***}	**1.00**							
CP	0.20^{***}	0.09^{NS}	**1.00**						
pH	-0.09^{NS}	0.00^{NS}	0.04^{NS}	**1.00**					
L^*	-0.13^{*}	0.04^{NS}	-0.08^{NS}	0.01^{NS}	**1.00**				
a^*	0.06^{NS}	0.03^{NS}	-0.03^{NS}	-0.07^{NS}	-0.28^{***}	**1.00**			
b^*	0.10^{NS}	0.13^{*}	0.04^{NS}	-0.05^{NS}	-0.05^{NS}	0.17^{***}	**1.00**		
CL	-0.04^{NS}	-0.10^{*}	-0.01^{NS}	0.02^{NS}	-0.01^{NS}	-0.03^{NS}	0.06^{NS}	**1.00**	
DL	-0.03^{NS}	-0.07^{NS}	-0.12^{*}	-0.02^{NS}	0.09^{NS}	0.004^{NS}	0.09^{NS}	0.07^{NS}	**1.00**
48h post-mortem									
DM	**1.00**								
EE	0.23^{***}	**1.00**							
CP	0.20^{***}	0.09^{NS}	**1.00**						
pH	-0.002^{NS}	-0.07^{NS}	0.12^{*}	**1.00**					
L^*	-0.17^{***}	0.03^{NS}	-0.09^{NS}	-0.18^{***}	**1.00**				
a^*	0.01^{NS}	0.004^{NS}	0.01^{NS}	0.01^{NS}	-0.31^{***}	**1.00**			
b^*	0.08^{NS}	0.06^{NS}	0.04^{NS}	-0.08^{NS}	-0.04^{NS}	0.09^{NS}	**1.00**		
CL	0.02^{NS}	-0.02^{NS}	0.02^{NS}	0.05^{NS}	-0.04^{NS}	0.01^{NS}	-0.002^{NS}	**1.00**	
DL	-0.09^{NS}	0.01^{NS}	-0.03^{NS}	0.01^{NS}	0.10^{*}	-0.02^{NS}	0.07^{NS}	-0.09^{NS}	**1.00**

CL= Cooking loss (%), DL= Drip loss (%), L^*= lightness, a^* = redness, b^* = yellowness.

*=significant at P<0.05, **=significant at P<0.01, ***=significant at P<0.001, NS= non-significant.

Conclusion

The chemical compositions of Noi chicken meat might fully meet the expectation of modern consumers. There were significant effects of sex and cold-storage time to some of quality traits of breast meat. It is also suggested that there are relationships among the variables of meat quality in Noi chickens although the interactions showed less significant effects. In conclusion, the variation in meat quality can be used in breeding schemes in order to improve meat quality of Noi chicken lines.

Osobine kvaliteta mesa vijetnamske autohtone rase živine Noi starosti 91 dan

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Rezime

Autohtone rase živine su pokazale sporiju stopu rasta i nižu proizvodnju mesa, u poređenju s komercijalnim brojlerima. Međutim, njihov kvalitet mesa je cenjen od strane savremenih potrošača. Ova studija imala je za cilj da analizira osobine kvaliteta uzoraka mesa grudi pilića rase Noi, jedne od poznatih autohtonih rasa živine u Vijetnamu. Ukupno je prikupljeno 355 uzoraka fileta grudi za procenu kvaliteta svojstava mesa kao što su pH, boja, kalo ceđenja i kalo kuvanja, u različitim vremenskim tačkama 3, 24 i 48 sati nakon klanja, kao i analiza hemijskog sastava, kao što su suva materija, sirovi protein i ekstrakt etra. Kao rezultat toga, pol pilića i vreme skladištenja na hladnom značajno utiču na neke osobine kvaliteta mesa grudi, dok njihova interakcija nije povezana sa posmatranim svojstvima. Posle skladištenja od 3 sata, pH vrednost je određena na 5,63, a zatim je pala na 5,56 i 5,55, posle 24 i 48 sati. Vrednosti boje (L *, a * i b *) bile su u normalnom rasponu koji je zabeležen u prethodnim studijama. Uzorci mesa od dva pola pilića nisu se razlikovali u vrednostima za kalo kuvanja i kalo ceđenja, dok se značajno razlikuju kao rezultat vremena skladištenja u hladnom. Sadržaj ekstrakta etra u mesu je u negativnoj korelaciji sa kalom kuvanja. Viši sadržaj suve materije u mesu grudi rezultirao je nižom vrednosti za kalo ceđenja nakon 3h skladištenja u hladnom (r = -0,12, P <0,05). Postoji negativan odnos između L * i a *. Varijacija koja je prikazana u ovoj studiji može se koristiti u šemama uzgoja u cilju poboljšanja kvaliteta mesa linija Noi pilića.

Ključne reči: Noi pilići, meso grudi, hladno skladištenje, osobine kvaliteta, korelacija.

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