

SERUM BIOCHEMICAL PROPERTIES OF VIETNAMESE INDIGENOUS NOI CHICKEN AT 56 DAYS OLD

Nguyen Tuyet Giang^{1,2,3}, Nguyen Duc Hien^{4,5}, Huynh Thi Phuong Loan⁴, Phan Thi Hong Phuc⁶, Nguyen Van Dai⁷, Takeshi Shimogiri⁸, Do Vo Anh Khoa^{3,6,9}

¹An Giang University, An Giang, Vietnam

²Vietnam National University Ho Chi Minh City, Vietnam

³Animal Husbandry Association of Vietnam, Vietnam

⁴Can Tho University, Vietnam

⁵Vemedim Corporation

⁶Thai Nguyen University of Agriculture and Forestry, Vietnam

⁷Mountainous Animal Husbandry Research and Development Center, National Institute of Animal Science, Vietnam

⁸Kagoshima University, Japan

⁹Southwest University of Science and Technology, China

Corresponding author: Do Vo Anh Khoa, dovoanhkhoa@tuaf.edu.vn

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Abstract: Serum profile is generally considered as comprehensive data which directly reflected animal health and their potential resistance to environmental, nutritional and pathological stress. The present study aimed to provide physiological reference values for selected biochemical parameters in Noi chickens, a famous Vietnamese native breed, at 56 days old. The collected blood samples of 355 Noi birds (164 males and 191 females) were used to evaluate biochemical serum profile. Glucose, total protein, albumin, globulin, albumin/globulin ratio, triglycerides, cholesterol, creatinine, and uric acid in the serum were measured. The variation in these values arising from different sexes was also investigated. The results indicated that there were no differences ($P>0.05$) in the assessed indices between male and female Noi chickens. In overall for the whole group, these values were obtained as 250.86 mg/dL, 7.34 g/dL, 3.40 g/dL, 3.94 g/dL, 1.75, 148.54 mg/dL, 190.86 mg/dL, 0.44 mg/dL, and 1.44 mg/dL, respectively. The relationship among the biochemical parameters showed relatively low coefficients ($r=0.79$ in maximum). The females obtained higher correlation coefficients between levels of total protein and glucose ($r=0.42$) as well as between total protein and globulin ($r=0.79$), compared to the males. It was concluded that the male and female chickens performed similar values of serum indices. The

contribution of this study might expand the knowledge on the biochemical profile and improved breeding strategies of Vietnamese indigenous Noi chickens.

Key words: Noi chickens, biochemical parameters, serum indices, correlation coefficients.

Introduction

Indigenous chickens are an important source of high quality protein, accounting for the majority of the local production of chicken meat as well as contributing to food security in the rural and peri-urban areas (Assan, 2015). Local population of Noi chickens which has been long-established in Vietnam, is known to be well-adapted to the harsh environment conditions (Quyen, 2008). The growth performances and some quantitative genetic traits of this breed were reported by various researchers. However, these traits are greatly influenced by sex, age and season (Giang et al., 2018; Giang et al., 2019; Khoa et al. 2019a,b). At the stage of 0-28 days old, Noi chick daily consumed 16.54 g of feed to gain a weight of 6.98 g /day, with the feed conversion ratio was 2.37. Their skeleton (wings and keel lengths) rapidly developed within the first week of life, followed by the development of muscle tissues (breast and thigh diameters) in the second week of age (Khoa et al., 2019a). At latter stage of age (28-84 days old), males and females of Noi chickens performed significant differences in feed intake, body weight, and some morphological dimensions, such as lengths of beak, thigh, shank, as well as diameters of breast and thigh (Khoa et al., 2019b). According to Giang et al. (2018, 2019), Noi chickens were adapted and grew well in both semi-intensive backyard and confined systems. After 14 weeks of age, the chickens weighed at 1,779 g/bird and gained around 17.82 g/day in the whole period. Males presented higher yield of carcass but there are no significant differences in carcass ratio as well as the proportion of other edible parts between males and females. At the stage of 0-28 days old, Noi chick daily consumed 16.54 g of feed to gain a weight of 6.98 g /day, with the feed conversion ratio was 2.37. Their skeleton (wings and keel lengths) rapidly developed within the first week of life, followed by the development of muscle tissues (breast and thigh diameters) in the second week of age (Khoa et al., 2019a).

Wide spread distribution of Noi chickens demonstrates a need to improve appropriate breeding approaches based on their morphological and physiological characteristics. Blood haematological and biochemical profile is generally considered as a comprehensive data and an ideal indicator of production and health status of many species. Changes in haematological and biochemical traits, in turn, directly reflected potential resistance of animal to environmental, nutritional and pathological stress (Chikumba et al., 2013; Shanmugam et al., 2017; Kongroi and

Likitdacharote, 2019). These indicators are different among bird genotypes, sex, age, nutrition, stocking density and other stress-creating factors (Pires *et al.*, 2007; Ibrahim *et al.*, 2012; Khawaja *et al.*, 2013; Attia *et al.*, 2017; Parveen *et al.*, 2017; Mosleh *et al.*, 2018). Although the reference ranges for avian haematological and biochemical profiles has been well published, mainly in commercial broilers and layers (Gyenis *et al.*, 2006; Tabeeh, 2016; Adeleyea *et al.*, 2018; Al-Rubae, 2018), there are still limited data on the biochemical profile of Vietnamese indigenous Noi chicken breed. This study, therefore, aimed at determining normal baseline values for some biochemical parameters in male and female Noi chickens at 56 days of age.

Materials and Methods

A total of 355 broilers (164 males and 191 females) of Noi breed were used in the study. The birds were raised at the Can Tho Center for Breeds of Seed, Livestock and Fish as previously described by Khoa *et al.* (2019a; 2019b). At the time point of 56 days old, approximately 3.0 mL blood specimens were taken from the brachial vein of each bird by using a syringe needle and gently mixed in a heparinized tube. The samples were, then, kept on ice in a cool container to avoid protein denaturation. All they were used to analyze serum biochemical properties such as glucose, total protein, albumin, globulin, triglycerides, cholesterol, creatinine, and uric acid within 2 hours after sampling by using the Biochemical Systems 3000 Evolution (Biomedical Systems International-BSI, Italia) with chemicals and kits of Erba Mannheim (Germany) according to theirs protocols and instructions at Veterinary Clinic, Can Tho University. The ratio of albumin to globulin (A/G) was calculated by dividing the concentration of albumin and globulin fractions.

Briefly, serum was separated by centrifuging at 900 rpm for 2 minutes and stored in the freezer at -20°C for further analysis. The serum was allowed to thaw under room temperatures before subsequent analyses.

The different biochemical parameters in male and female chickens were statistically analyzed using GLM procedures within Minitab 16 software. Data were expressed as means $\pm$ standard deviation ($\bar{x} \pm \text{SD}$) for each sex. The means were considered significant when the P-value were less than 0.05. Pearson's correlation coefficients (r) were used to evaluate the relationship among the biochemical parameters of Noi chickens.

Results and discussion

Biochemical Parameters

The concentration of different serum constituents is shown in Table 1. There were no differences ($P>0.05$) in glucose, total protein, albumin, globulin,

albumin/globulin ratio, triglycerides, cholesterol, creatinine, and uric acid and between male and female Noi chickens. In overall for the whole group, these values were obtained as 250.86 mg/dL, 7.34 g/dL, 3.40 g/dL, 3.94 g/dL, 1.75, 148.54 mg/dL, 190.86 mg/dL, 0.44 mg/dL, and 1.44 mg/dL, respectively. The main metabolite of animal metabolism is glucose, which is the primary energy substrate for animal activities, especially for the brain functions, is stored as glycogen in 1 - 5% in liver 1% in muscles (Fuller, 2004). In this study, sex did not affect the levels of serum glucose. However, the mean values for serum glucose was within the normal range as earlier reported by Dong *et al.* (2015) and Kalita *et al.* (2018). It also found that commercial broiler chickens had a significantly higher glucose content (253.28 mg/dL) than that of indigenous chickens (210.55 mg/dL) which might be due to the consumption of rich-grain diet (Kalita *et al.*, 2018).

Table 1. Difference of observed between genders

Traits					Overall
	Male (n = 164)	Female (n = 191)	SEM	P	
Glucose (mg/dL)	249.01 ± 45.23	252.49 ± 45.12	3.41	0.471	250.86 ± 45.14
Total protein (g/dL)	7.25 ± 1.54	7.41 ± 1.47	0.11	0.317	7.34 ± 1.50
Albumin (g/dL)	3.33 ± 1.28	3.46 ± 1.19	0.09	0.316	3.40 ± 1.23
Globulin (g/dL)	3.93 ± 1.72	3.95 ± 1.93	0.14	0.886	3.94 ± 1.84
A/G ratio	1.64 ± 3.42	1.85 ± 6.28	0.39	0.701	1.75 ± 5.11
Triglycerides (mg/dL)	148.34 ± 14.74	148.72 ± 14.48	1.10	0.805	148.54 ± 14.58
Cholesterol (mg/dL)	190.27 ± 45.14	191.39 ± 44.85	3.39	0.815	190.86 ± 44.93
Creatinine (mg/dL)	0.45 ± 0.10	0.44 ± 0.10	0.01	0.537	0.44 ± 0.10
Uric acid (mg/dL)	1.45 ± 0.49	1.43 ± 0.43	0.03	0.729	1.44 ± 0.46

A/G: Albumin/Globulin ratio.

Values bearing different superscripts within sex differed significantly ($P < 0.05$).

While the total protein is one of the criteria to identify the status of the animal body, serum protein that plays a key role in maintaining the osmotic pressure, is considered as an immediate alternative source of essential amino acids. Level of serum albumin also directly contributes to the process of tissue regeneration in the animal growth stage. The level of total protein found in Noi chickens (7.25-7.41 g/dL) is similar to that shown in five breeds of Nigerian indigenous chickens (6.43-7.93 g/dL) reported by Ibrahim *et al.* (2012) but higher than those shown in Ross 308 (3.2-3.4 g/dL) (Al-Rekabi *et al.*, 2018) and in local Saudi chickens during summer season (3.3-3.8 g/dL) (Albokhadaim, 2012). As shown in Table 1, the total protein of female Noi birds was comparable to males. The result is disagreeing with finding of Simaraks *et al.* (2004), who found that total protein of female Thai indigenous chickens was higher than that in males.

The total serum or plasma protein and its fractions can be extremely variable in avian species. Changes in the levels of the fractions depend on both internal and external, revealing the physiological role of total protein (Tóthová *et al.*, 2019). In term of quality, albumin is the most important protein in the serum or plasma and therefore, this is the favourable source of essential amino acids for the tissue synthesis to increase body mass, particularly during fattening (Filipović *et al.*, 2007; Tóthová *et al.*, 2019). The present study on Noi chickens revealed a relatively constant level of serum albumin between males and females ($P>0.05$), ranging from 3.33 to 3.46 g/dL (Table 1). According to Kalita *et al.* (2018), serum albumin might increase when the amount of protein exceeds the amount required for growth and maintenance. Globulin level has been used as indicator of immune responses and sources of antibody production (Tothova *et al.*, 2016). The similar values in serum globulin found in males and females suggest that both sexes have the similar health status at the age examined. The higher level of globulin concentration (3.94 g/dL) might confer higher capacity in disease resistance of indigenous Noi chickens compared to broiler in other studies (Dong *et al.*, 2015; Rasheed and Olusegun, 2017; Al-Rubaei, 2018). The changed proportion of albumin and globulin in the evaluated sex groups of Noi chickens was reflected in the changed A/G ratio with higher value was found in the females (1.85) compared to the males (1.64). However, the difference was not significant ($P>0.05$).

Lipid metabolites are strongly associated to energy metabolism. According to Attia *et al.* (2017), level of plasma cholesterol of slow-growing chickens was decreased by feeding restriction regime (85% and 70 % of the energy compared to the control diet). The concentration of serum triglycerides and cholesterol of Noi chickens was 148.54 mg/dL and 190.86 mg/dL, respectively, with no significant difference between sexes (Table 1), similar to the report in pheasant by Simaraks *et al.* (2004). However, these levels were higher than those in the indigenous Iran chickens (152.60-167.60 mg/dL) (Abdi-Hachesoo *et al.*, 2011). All chickens in this study were fed by the same diets which might result in the similar values of triglycerides and cholesterol in both sexes. Saklani *et al.* (2019), on contrary observed significant difference in male and female birds of native chicken of Himachal Pradesh.

Like urea, creatinine, a waste substance generated from the muscle metabolism, which range of normalcy is substantially maintained by kidney (Wyss and Kaddurah-Daouk, 2000). The interaction of sex on the serum creatinine is not significant ($P>0.05$) and in overall the creatinine of Noi chickens valued at 0.44 mg/dL (Table 1), suggesting a better utilization of protein in the diet. Different from mammals, in birds, uric acid, the main end-product of protein and purine metabolism, is excreted via faeces. It is relatively less toxic in comparison to ammonia and urea (Barsoum and El-Khatib, 2017). The results showed sex did not affect ($P>0.05$) the concentration of serum uric (1.45 mg/dL in males vs. 1.43 mg/dL in females). Contradictory result is found by Simaraks *et al.* (2004), who

found that sex may result in the increased concentration of serum uric in Thai indigenous birds. The disagreement with these previous studies may be due to difference in the genetic variation among breeds and ages of the broiler chickens used in the current experiment.

Table 2. Pearson's correlation coefficient (r) among the biochemical parameters of Noi chickens at 56 days of age

Traits	Glucose	Total protein	Album.	Globulin	A/G ratio	Triglycer.	Cholester.	Creatinine	Uric acid
<i>Male and female animals</i>									
Glucose	1.00	0.36***	-0.03 ^{NS}	0.34***	-0.16*	0.20**	-0.06 ^{NS}	0.02 ^{NS}	0.10 ^{NS}
Total protein	0.42***	1.00	0.26***	0.69***	-0.17*	0.39***	-0.02 ^{NS}	0.01 ^{NS}	0.24**
Albumin	-0.06 ^{NS}	-0.05 ^{NS}	1.00	-0.51***	0.52***	0.24**	0.12 ^{NS}	-0.04 ^{NS}	0.13 ^{NS}
Globulin	0.36***	0.79***	-0.65***	1.00	-0.54***	0.17*	-0.12 ^{NS}	0.04 ^{NS}	0.12 ^{NS}
A/G ratio	-0.14 ^{NS}	-0.24***	0.22**	-0.32***	1.00	0.01 ^{NS}	0.14 ^{NS}	-0.05 ^{NS}	0.03 ^{NS}
Triglycerides	0.27***	0.24***	0.09 ^{NS}	0.13 ^{NS}	-0.01 ^{NS}	1.00	0.05 ^{NS}	-0.16*	0.20**
Cholesterol	0.24***	0.13 ^{NS}	0.05 ^{NS}	0.06 ^{NS}	0.04 ^{NS}	0.23***	1.00	0.02 ^{NS}	0.04 ^{NS}
Creatinine	-0.10 ^{NS}	-0.18**	0.14*	-0.22**	0.05 ^{NS}	-0.20**	0.06 ^{NS}	1.00	-0.04 ^{NS}
Uric acid	0.32***	0.18**	-0.16*	0.23***	-0.02 ^{NS}	0.02**	0.08 ^{NS}	-0.08 ^{NS}	1.00
<i>Overall (male + female)</i>									
Glucose	1.00								
Total protein	0.39***	1.00							
Albumin	-0.04 ^{NS}	0.11*	1.00						
Globulin	0.35***	0.74***	-0.58***	1.00					
A/G ratio	-0.14**	-0.21***	0.30***	-0.37***	1.00				
Triglycerides	0.24***	0.31***	0.16**	0.14**	-0.001 ^{NS}	1.00			
Cholesterol	0.10 ^{NS}	0.06 ^{NS}	0.09 ^{NS}	-0.01 ^{NS}	0.07 ^{NS}	0.14**	1.00		
Creatinine	-0.05 ^{NS}	-0.09 ^{NS}	0.05 ^{NS}	-0.11*	0.02 ^{NS}	-0.18***	0.04 ^{NS}	1.00	
Uric acid	0.21***	0.21***	-0.01 ^{NS}	0.18***	-0.004 ^{NS}	0.20***	0.06 ^{NS}	-0.06 ^{NS}	1.00

A/G: Albumin/Globulin ratio.

Values bearing different superscripts within sex differed significantly ($P < 0.05$).

*=significant at $P < 0.05$, **=significant at $P < 0.01$, ***=significant at $P < 0.001$, ^{NS}= non-significant.

Male: above diagonal line break; Female: below the diagonal break.

Correlation of the biochemical parameters

The relationship among the biochemical parameters are presented in Table 2, showing relatively low coefficients (0.79 in maximum). Although sex was

unclear factor, female chickens obtained higher coefficients between levels of total protein and glucose ($r=0.42$, $P<0.001$) as well as between total protein and globulin ($r=0.79$, $P<0.001$), compared to the males. It also showed that Tables 2 also revealed the correlations among the serum characteristics in overall for both sexes. In this study, it was not noticed any significant relationships among the values of A/G ratio, cholesterol and creatinine. However, it is found that the serum globulin was possibly correlated to the total protein ($r=0.74$, $P<0.001$), rather than the albumin levels ($r=0.11$, $P<0.05$). There was a positive correlation between A:G ratio and albumin ($r=0.30$, $P<0.001$), demonstrating that the decrease in albumin is also related to decrease in A:G ratio. On the contrary, globulin was negative correlate to the A/G ratio ($r=-0.37$, $P<0.001$).

Conclusion

The results provide new information about selected biochemical parameters in clinically. The results suggested that sex of Noi chickens was not influence the metabolic values. Therefore, these biochemistry values could be used as additional information for evaluation of Noi chickens.

Biohemijska svojstva seruma vijetnamske autohtone rase živine Noi u uzrastu od 56 dana

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Rezime

Profil seruma se obično smatra sveobuhvatnom informacijom koja direktno odražava zdravstveno stanje životinja i njihovu potencijalnu otpornost na okruženje, prehrambene i patološke stresove. Ova studija imala je za cilj da pruži fiziološke referentne vrednosti za odabrane biohemijske parametre kod pilića Noi, poznate nativne rase iz Vijetnama, u uzrastu od 56 dana. Sakupljeni uzorci krvi 355 pilića Noi (164 muških i 191 ženskih grla) korišćeni su za procenu biohemijskog profila seruma. Izmereni su glukoza, ukupni protein, albumin, globulin, odnos albumina i globulina, trigliceridi, holesterol, kreatinin i mokraćna kiselina u serumu. Takođe je ispitivana varijacija u tim vrednostima kod različitih polova.

Rezultati su pokazali da nisu postojale razlike ($P > 0,05$) u procenjenim indeksima između muških i ženskih pilića Noi. Generalno, za celu grupu, dobijene su sledeće vrednosti: 250.86 mg/dL, 7.34 g/dL, 3.40 g/dL, 3.94 g/dL, 1.75, 148.54 mg/dL, 190.86 mg/dL, 0.44 mg/dL, i 1.44 mg/dL, respektivno. Odnos među biohemijskim parametrima pokazao je relativno niske koeficijente ($r = 0,79$ maksimalno). Ženska grla su imala veće koeficijente korelacije između nivoa ukupnog proteina i glukoze ($r = 0,42$), kao i između ukupnog proteina i globulina ($r = 0,79$), u poređenju sa muškim pilićima. Zaključeno je da su muški i ženski pilići imali slične vrednosti indeksa u serumu. Doprinos ove studije mogao bi proširiti znanje o biohemijskom profilu i poboljšati strategije uzgoja autohtonih vijetnamskih Noi pilića.

Ključne reči: Noi pilići, biohemijski parametri, indeksi seruma, koeficijenti korelacije.

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References

- ABDI-HACHESOO B., TALEBI A., ASRI-REZAEI S. (2011): Comparative study on blood profiles of indigenous and Ross-308 broiler breeders. *Global Veterinaria*, 7, 238-241.
- ADELEYEA O.O., OTAKOYAB I.O., FAFIOLUB A.O., ALABIB J.O., EGBEYALEA L.T., IDOWUB O.M.O. (2018): Serum chemistry and gut morphology of two strains of broiler chickens to varying interval of post hatch feeding. *Veterinary and Animal Science*, 5, 20-25.
- ALBOKHADAIM I. (2012): Hematological and some biochemical values of indigenous chickens in Al-Ahsa, Saudi Arabia during summer season. *Asian Journal of Poultry Science*, 6, 138-145.
- AL-REKABI M.M., ALI N.A., AL-DULAIMI I.H., AL-OBAIDI O.S., ALDULAIMI K.I., AL-ZIADI H.A. (2018): The effect of sex and slaughter age in some blood traits of broiler chicks Ross 308. *International Conference on Promotion of Scientific and Regional Cooperation on Food and Agricultural Sciences*, Iran.
- AL-RUBAEE M.A.M. (2018): The effect of sex and slaughter age in some blood traits in Ross 308 broilers. *International Journal of Biosciences*, 12, 362-366.

- ASSAN N. (2015): Genotype and sex influencing dressing percentage, carcass parameters and meat quality properties in indigenous chickens. *Scientific Journal of Biological Sciences*, 4, 43-52.
- ATTIA Y.A., ABD-ELHAMID A.E., MUSTAFA M., AL-HARTHI M.A., MUHAMMAD M. (2017): Response of slow-growing chickens to feed restriction and effects on growth performance, blood constituents and immune markers. *Revista Mexicana de Ciencias Pecuarias*, 8, 175-184.
- BARSOUM R., EL-KHATIB M. (2017): Uric acid and life on earth. *Journal of Advanced Research*, 8, 471-474.
- CHIKUMBA N., SWATSON H., CHIMONYO M. (2013): Haematological and serum biochemical responses of chickens to hydric stress. *Animal*, 7, 1517-1522.
- DONG J.Q., ZHANG H., JIANG X.F., WANG S.Z., DU Q., WANG Z.P., LENG L., CAO Z.P., LI Y.M., LUAN P., LI H. (2015): Comparison of serum biochemical parameters between two broiler chicken lines divergently selected for abdominal fat content. *Journal of Animal Science*, 93, 3278-3286.
- FILIPOVIĆ N., STOJEVIĆ Z., MILINKOVIĆ-TUR S., LJUBIĆ B.B., ZDELAR-TUK M. (2007): Changes in concentration and fractions of blood serum proteins of chickens during fattening. *Veterinarski Arhiv*, 77, 319-326.
- FULLER M.F. (2004): *The encyclopedia of farm animal nutrition*. Wallingford: CABI Publishing.
- GIANG N.T., HUONG D.P., CHI N.T.H. (2018): Phenotypic characteristics, growth performance and carcass traits of Noi chicken raised under semi-intensive backyard system. *Journal of Animal Science and Technology*, 93, 2-13 (in Vietnamese).
- GIANG N.T., VIET H.L.Q. (2019): Poultry production and economic efficiency of Noi chicken raised in confined system. *Vietnam Journal of Agriculture and Rural Development*, 2019, 199-205 (in Vietnamese).
- GYENIS J., SÜTŐ Z., ROMVÁRI R., HORN P. (2006): Tracking the development of serum biochemical parameters in two laying hen strains - a comparative study. *Archiv für Tierzucht*, 49, 593-606.
- IBRAHIM A.A., ALIYU J., WADA N.I., HASSAN A.M. (2012): Effect of sex and genotype on blood serum electrolytes and biochemical parameters of Nigerian indigenous chickens. *Iranian Journal of Applied Animal Science*, 2, 361-365.
- KALITA D.J., SULTANA R., ROY M.N., BHARALI K. (2018): Comparative study of certain biochemical profile of broiler and indigenous chicken of Assam. *Approaches in Poultry, Dairy and Veterinary Sciences*, 2, 175-177.
- KHAWAJA T., KHAN S.H., MUKHTAR N., PARVEEN A., FAREED G. (2013): Production performance, egg quality and biochemical parameters of three way crossbred chickens with reciprocal F1 crossbred chickens in sub-tropical environment. *Italian Journal of Animal Science*, 12, 127-132.
- KHOA D.V.A, NGUYEN N.T., TUOI N.T.H., SHIMOIGIGRI T., KAWABE K., OKAMOTO S., THUY N.T.D. (2019a): Some quantitative genetic traits in

Vietnamese indigenous Noi chicken from 0 to 28 days old. *Biotechnology in Animal Husbandry*, 35, 141-151.

KHOA D.V.A, TUOI N.T.H., THUY N.T.D., OKAMOTO S., KAWABE K., KHANG N.T.K, GIANG N.T., SHIMOGIGRI T. (2019b): Growth performance and morphology of in 28-84 day-old Vietnamese local Noi chicken. *Biotechnology in Animal Husbandry*, 35, 301-310.

KONGROI K., LIKITDACHAROTE B. (2019): The relationship of hematological values with Newcastle disease antibody in Thai indigenous chicken: strain Leung Hang Khao. *International Journal of Agricultural Technology*, 15, 309-318.

MOSLEH N., SHOMALI T., NEMATOLLAHI F., GHAHRAMANI Z., KHAFI M.S.A, NAMAZI F. (2018): Effect of different periods of chronic heat stress with or without vitamin C supplementation on bone and selected serum parameters of broiler chickens. *Avian Pathology*, 47, 197-205.

PARVEEN A., KHAN S.H., KHAWAJA T., IFTIKHAR N., KHAN S. (2017): Growth performance and haemato-biochemical parameters of different breeds of rural chickens. *Journal of World's Poultry Research*, 7, 114-122.

PIRES D.L., MALHEIROS E.B., BOLELI I.C. (2007): Influence of sex, age, and fasting on blood parameters and body, bursa, spleen and yolk sac weights of broiler chicks. *Brazilian Journal of Poultry Science*, 9, 233-240.

QUYEN N.V. (2008): Study on different ME and CP levels on growth and laying rate of Noi chicken in Mekong Delta. Doctoral thesis, Can Tho University (in Vietnamese).

RASHEED A.S., OLUSEGUN O.S. (2017): Influence of age and strain on haematological and blood biochemical indices in broiler chickens reared in derived Savanna environment of Nigeria. *American Journal of Biology and Life Sciences*, 5, 34-38.

SAKLANI S., SINGH G., VIJ R., SANKHYAN V. (2019): Biochemical parameters of native chicken of Himachal Pradesh, Dahlem Red and their crosses. *International Journal of Livestock Research*, 9, 127-132.

SHANMUGAM M., BHATTACHARYA T.K., REDDY M.R., RAO S.V.R., RAJKUMAR U. (2017): Sexual difference in chicken blood parameters during high ambient temperature. *Indian Journal of Poultry Science*, 52, 225-227.

SIMARAKS S., CHINRASRI O., AENGWANICH W. (2004): Hematological, electrolyte and serum biochemical values of the Thai indigenous chickens (*Gallus domesticus*) in northeastern, Thailand. *Songklanakarin Journal of Science and Technology*, 26, 425-430.

TABEEKH M.A.S.A. (2016): The effect of color light and stocking density on some biochemical traits of broilers and layers. *Research in Zoology*, 6, 21-28.

TOTHOVA C., NAGY O., KOVAC G. (2016): Serum proteins and their diagnostic utility in veterinary medicine: a review. *Veterinari Medicina*, 61, 475-496.

TÓTHOVÁ C., SESZTÁKOVÁ E., BIELIK B., NAGY O. (2019): Changes of total protein and protein fractions in broiler chickens during the fattening period. *Veterinary World*, 12, 598-604.

WYSS M., KADDURAH-DAOUK R. (2000): Creatine and creatinine metabolism. *Physiology Research*, 80, 1107-1213.

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