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RESEARCH ARTICLE

A comparative study on the susceptibility of different Algerian native chick phenotypes and Cobb 500 broiler strain to coccidiosis

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ABSTRACT

The purpose of this study was to evaluate the susceptibility to coccidiosis in three Algerian indigenous chicken phenotypes (normal feathered, crested head and naked neck) and one commercial strain Cobb 500. A total of 112 chicks were used in this evaluation. The chicks were done with a 20-fold dose (6×10^4 sporulated *Eimeria spp* oocysts) of a live attenuated coccidiosis vaccine. At 28 days of age, clear differences were observed between genotypes in the effects of challenge on mortality due to coccidiosis from day 1 to 7 post-inoculation. The commercial strain Cobb 500 had the highest mortality (28.5%), while the naked neck chicks showed no mortality at post-inoculation. The lesion scores and the oocyst load were also considerably higher ($p < 0.05$) in the Cobb 500 strain as compared to indigenous genotypes. The naked neck birds had the highest oocyst counts ($p < 0.05$) compared to their crested head and normally-feathered counterparts. However, there were no differences ($p > 0.05$) in terms of intestinal lesion score among the indigenous genotypes. Furthermore, the severity of bloody diarrhea was milder in naked neck birds than in the other genetic groups. These findings indicate that the naked neck genotype is associated with remarkable and better tolerance to coccidial infection compared to other genotypes. However, further studies should be conducted to investigate the potential utilization of naked neck birds in poultry breeding programs aimed at controlling the effects of the disease.

Keywords: coccidiosis, native chicken, major gene, resistance

INTRODUCTION

Coccidiosis is the most severe and economically important disease all over the world in the avian industry (Arabkhazaeli *et al*., 2013). This enteric disease is caused by *Eimeriaspp* (Abbas *et al.*, 2017). Exotic and domestic chickens are considered susceptible to seven species of *Eimeria* with *Eimeria maxima* being one of the prevalent causes of coccidiosis in poultry production (Boulton *et al.*, 2018). Coccidiosis mainly affects young birds between 3 and 8 weeks of age, when the immune system is immature (Fatoba and Adeleke, 2018). The extensive damage to the intestinal epithelium caused by *Eimeria* has various clinical features such as decreased feed conversion rates, poor weight gain, reduced welfare, bloody feces, and high mortality (Abbas *et al.*, 2017)resulting in enormous economic losses which have been estimated more than $3 billion per year worldwide (Chapman, 2014). Currently, the strategy to control coccidiosis relies on chemoprophylaxis and anticoccidial feed additives. However, it has been found that long-term use of anticoccidials has led to the emergence of drug resistant strains (Xie *et al.*, 2020). Moreover, there are some concerns about drug residues in poultry meat that threaten food security and health (Tang *et al.*, 2018).

Increasing genetic resistance to coccidiosis represents a promising complementary control strategy (Mpenda *et al.*, 2019). The native African chicken is a potential candidate chicken population for the selection of resistant chicken to viral infections in a changing environment attributed to climate changes (Mpenda *et al.*, 2019). Some major genes such as the naked neck and frizzled feather are believed to confer not only adaptability to hot ambient temperatures, but also, be resistant to diseases and greatly enhance immune status (Abou-Emera et al., 2017;Dahloum *et al.*, 2018). However, even though several studies on the performance of the native birds in Algeria have been reported (Zouaoui *et al.*, 2023) there is a dearth of literature available on their genetic variability for resistance to diseases. Therefore, this preliminary study was set up to measure susceptibility to coccidiosis in three local Algerian chicken phenotypes to reduce the cost of the disease and increase the profitability of chicken farmers.

MATERIAL AND METHODS

Animals and experimental design

The study was carried out at the Research Farm of Abdelhamid Ibn Badis, University of Mostaganem, Algeria. A total of 112 one-day-old chicks consisting of 84 Algerian local chicks of three phenotypes (28 naked neck, 28 crested head, and 28 normally feathered), and 28 *Cobb 500* broiler chicks were used in the current study. One-day-old chicks of each genetic group were separated into groups of seven birds with three replications for the challenged birds, and one group of seven birds remained as uninfected control. According to Soutter *et al.* (2020), a minimum of five birds per treatment group is required for the evaluation of differences between lesion scores due to variability in coccidiosis response. Each group was housed in a separate cage (1m x 0.5m), and birds were kept at identical stocking density (7 birds/0.5 m2). The cages had their floor covered with clean wood shavings until 28 days of age. The cages were equipped with a hand-filled round feeder, and two nipple drinkers were supplied with drinking water. All groups were housed in similar conditions within hen houses, according to the recommendations of the Technical Institute of Livestock of Baba Ali (ITELV, Algeria). The ambient temperature was maintained at 32°C for the first two weeks of the experiment and was gradually reduced to 24°C by 21 day of age, after which no heat was provided. Light was supplied continuously throughout the experiment. The control groups were kept in an isolated enclosure to prevent accidental exposure to contamination according to Akanbi and Taiwo (2020). The birds had ad libitum access to a commercial diet from arrival until the end of the experiment. A starter diet was given from hatch to 8 days (2850 kcal/kg; 21% CP), a grower diet from 9 to 20 days (2900 kcal/kg; 19.5 % CP), and a finisher diet from 21 to 28 days (2950 kcal/kg; 18% CP). The diets used did not contain coccidiostats. Prior to the commencement of the experiment, fecal samples from all chicks in each group were examined to confirm the absence of coccidian oocysts. *Eimeria* oocysts in each fecal sample were detected through coprological flotation technique, employing a saturated sodium chloride (NaCl) solution as the flotation medium. The experiment lasted for a duration of 28 days.

Coccidiosis challenge

At 21 day of age, all the experimental groups, except the control groups were challenged *per os* with a 20-fold dose of Paracox-8, equivalent to 6×10^4 sporulated oocysts of *Eimeria acervulina*, *Eimeria maxima*, *Eimeria mitis*, *Eimeria brunetti*, *Eimeria praecox*, *Eimeria necatrix*, and *Eimeria tenella*. The control groups were given 1 ml of Hanks Balanced Salt Solution (HBSS). After the coccidiosis infestation, mortality was recorded daily for each challenge group. From day 5 to 7 post-infection, samples of chicken feces were collected daily and taken to the laboratory for calculation of the number of oocysts per gram of feces (OPG). The collected samples were cleaned of litter, thoroughly homogenized, and analyzed for *Eimeria* oocysts according to the modified method described by Conway and McKenzie (2007), using a McMaster counting chamber and a microscope. Briefly, a suspension was prepared by mixing 10% (w/v) of collected feces with a saturated solution of sodium chloride (aqueous NaCl). The samples were shaken, and 1 ml of the suspension was diluted with 9 ml of a saturated NaCl solution. A specific volum of the suspension was then placed in the McMaster chamber, and light microscopy was used to count the Eimeria oocysts under 10× magnification. Triplicate counts were performed for each sample. Daily observation of the presence or absence of blood in feces was carried out for each infected group from days 3 to 7 inclusive.On day 7 post-inoculation (28 days old),three birds from each challenge group were humanely killed by cervical dislocation to evaluate the lesion score on different segments of the small intestine and ceca based on macroscopic visible lesions caused by *Eimeria*. The lesions included petechial hemorrhages, bloody fecal contents, thickening of the cecal wall, and mucoid discharge. Depending on the severity of the lesions, a score of 0 (no lesions), 1 (mild lesions), 2 (moderate lesions), 3 (severe lesions), or 4 (numerous severe lesions)was determined for each bird as proposed by Johnson and Reid (1970).

Statistical analysis

Comparisons of the mean values of oocyst production and lesion score were performed by one-way analysis of variance using the GLM procedure of SPSS (v.20) followed by a post-hoc analysis using Tukey's t-test. The Chi-Square test was processed to analyze differences in survavibility rate values between the different genotypes. Statistical significance was established to be $P< 0.05$.

RESULTS AND DISCUSSION

Mortality

The most common diseases that cause considerable losses in poultry production in Algeria according to several investigations are Colibacillosis, Mycoplasmosis, Salmonellosis, Newcastle (local name, Ettaoun), Gumburo, infectious bronchitis, and Coccidiosis (Halbouche *et al*., 2009; Debbou-Iouknane *et al*., 2018). However, genetic research into parasitic infections of chickens is lagging behind that of viral and bacterial diseases. According to Mathis *et al*. (1984) mortality rate which is the selection trait in most coccidial selection programs is correlated with resistance to coccidiosis. In the current study, mortality due to experimental *Eimeria* coccidiosis was low (9.5%) in both normal feathered and crested head birds, while the highest mortality rate (28.5%) was observed in Cobb 500 broiler chicks (Table 1). However, no deaths occurred in the naked neck and the non infected groups. The present results are in line with what was reported by Dakpogan *et al.* (2012) who observed that the naked neck chicks seemed to have better survivability (100%) than silky feathered (90%) and frizzle feathered (70%) phenotypes, while normal feathered and dwarf chicks had the lowest survival rate (60%). In another study, Pinard-van der Laan et al. (2009) found a high mortality rate of 26% in *Eimeria* challenged White Leghorn broiler chicks and no mortality in the Egyptian Fayoumi birds.

Oocyst shedding

The three indigenous genotypes had nearly similar body weights at 3 weeks of age, ranging from 71.4 g to 74.25 g, while the Cobb 500 strain has significantly ($P<0.05$) the highest body weight of 237 g as compared to the three local genotypes. As shown in table 1, significant differences

($p<0.05$) between genotypes for the oocyst shedding were observed. The commercial Cobb 500 birds had higher mean fecal oocyst counts (960.4×10^3) followed by the crested head (366.5×10^3) and normally feathered chicks (305.3×10^3) while the naked neck birds showed the lowest oocyst output (3.25×10^3). However, no oocysts hedding was observed in the unchallenged groups throughout the post-inoculation period. The findings of the current study are in conformity with those reported in Ethiopia by Gari *et al.* (2008) where the overall oocyst count in the native chickens was much lower than that in the exotic Rhode Island Red strain. Similarly, Ayssiwede *et al.* (2011) found that the oocyst production was significantly lower in Senegal free-range chicks in comparison with Cobb 500 and Hyline W-36 broiler chicks. Ojimelukwe *et al.* (2018) reported that Marshal broiler chicks inoculated orally with approximately 23×10^4 *Eimeria spp* sporulated oocysts produced on average 1023×10^3 oocysts per gram of feces from day 5 to day 7 post-inoculation. In Nigeria, Adenaike *et al.* (2016) observed a higher fecal oocyst output in normal-feathered chickens compared to the naked neck and frizzled counterparts, although genotype had no significant effect on this parameter. In another study, Dakpogan *et al.* (2012) recorded the fewest oocyst count in naked neck chicks compared to silky, frizzled, and normal-feathered chicks. Furthermore, it has been demonstrated that prolonged storage of *E. tenella* oocysts has a considerable impact on the peak point and pattern of oocyst count (Cha et al., 2018). In the current study, there was no oocyst production in the uninfected control groups throughout the experimental period as the chicks were not infected with *Eimeria* oocysts.

Lesion scores

The mean value of the intestinal lesion score ranged from 0.80 ± 0.10 to 2.82 ± 0.12. The highest lesion score was noticed in Cobb 500 chicks. Most broiler chicks (82%) showed lesion scores of 3.0, whereas indigenous chicks had more frequent (81% on average) lesion scores of 1.0. However, there were no significant differences between the indigenous phenotypes for this parameter. The findings of the current study are in agreement with those of Ayssiwede *et al.* (2011) who reported the highest mean values of lesion scores in commercial strains Cobb 500 and Hy-line W-36 (1.44 ± 0.50 and 1.20 ± 0.40, respectively), and the lowest score in Senegal native chicks (0.83 ± 0.38). Similarly, Thakur *et al.* (2016) studied the genetic differences in susceptibility due to coccidial challenge in five commercial lines and Kadaknath breeds of chicken. They found a lesion score up to 4.0 in Cobb strain and Caribro-91. In naked neck and Hubbard it ranged from 1.0 to 3.0 while Kadaknath and Jabalpur dual colored breeds exhibited more resistance to coccidia with the lowest lesion score ranging from 1.0 to 2.0. In another study, Qaid *et al.* (2021) found a higher mean lesion score of 2.6 in the commercial Ross 308 broiler chickens challenged with 10^4 *E. Tenella* sporulated oocysts. However, Zulpo *et al.* (2007) found that all commercial Cobb broiler chicks infected with 2×10^4 sporulated oocysts of *E. tenella*, *E. maxima*, and *E. acervulina* had a mean lesion score less than 2.0. Soutter *et al.* (2021) found no significant variation in lesion scores between Lohmann Brown, Hy-line Silver Brown, and Hy-line Brown layers infected with different challenge doses of *E.tenella* sporulated oocysts (250,4.000, 8.000, or 12.000). In this study, although there were no significant differences ($p>0.05$) among the native genetic groups, the naked neck birds showed less severe lesions in comparison with their normally-feathered and crested head counterparts. Dakpogan *et al.* (2012) found that the naked neck and frizzle feathered birds had significantly the lowest average lesion scores (1.00 ± 0.5 and 1.2 ± 0.3, respectively) compared to dwarf birds counterparts (2.5 ± 0.4) while the silky feather and normal-feathered phenotypes showed intermediate values (1.4 ± 0.5 and 1.5 ± 0.4, respectively). The favorable effect of some major genes against susceptibility to coccidiosis has also been demonstrated by Adenaike *et al.* (2016) who stated the frizzled and naked neck phenotypes have clear-cut potential to resist the disease with an average lesion score of 1.0 ± 0.32 and 1.58 ± 0.53, respectively, compared to normal-feathered birds (2.50 ± 0.93). Jatau *et al.* (2012) studied the preponderance of the *Eimeria* in Zaria (Northwestern Nigeria), they found that 31% of the naturally infected broilers were moderately and severely infected with coccidia, while only 8% of the infected local chickens had low grade and severe infections.

Blood in feces

Except for the naked neck birds, where blood in feces was recorded from post-inoculation days 4 to 5, bloody diarrhea was observed in all infected experimental birds from post-challenge days 4 to 6 (Table 2). However, bloody diarrhea (melena) did not occur in the uninfected control groups throughout the experimental period. Divergent results were reported by Ngongeh *et al.* (2017) who observed that the infected Nigerian indigenous chickens passed bloody diarrhea for 6 days from day 8 to 14. According to Kaingu *et al.* (2017) post-infection days 5 and 6 are the most important days in the life cycle of *E. tenella*. In this study, the severity of bloody diarrhea was milder in the naked neck chicks than in the normal feathered and crested-head genotypes, while the commercial birds were associated with more severe bloody diarrhea. However, the present findings are in contrast with those of Ngongeh *et al.* (2017) who reported that Nigerian native chickens revealed more severe clinical signs in comparison with exotic ones. These differences might be attributed to different factors including breed, sex, and age of birds, the *Eimeria* strain and the dose of cocci challenge used.

Table 1. Survival rate (%), means **(**Standard errors) for oocyst output per gram fresh feces (OPG) and lesion score (LES), and distribution of LES (%) for each genetic group.

	Phenotype			
Parameter	NF	NN	CH	Cobb500
Survivability (%)	90.5[b]	100.0[a]	90.5[b]	71.5[c]
OPG[1]	305.3 [b] (4.1)	3.24 [a] (0.12)	366.5 [c] (11. 7)	960.4 [d] (9.7)
LES[2]	1.00 [b] (0.11)	0.80 [a] (0.10)	1.21[b] (0.11)	2.82 [c] (0.12)
LES (%)				
0	0	20	7	0
1	100	80	64	0
2	0	0	29	18
3	0	0	0	82
4	0	0	0	0

[a–d] Values within lines with no common superscript indicate significant differences ($p < 0.05$) between genotypes. [1]10^3 Oocyst per gram of feces. [2]LES: Lesion score measured at 7 days post-inoculation. SE= Standard Error; NF: Normal-feathered; NN: Naked neck; CH: Crested head.

Table 2. Bloody diarrhea degree.

Group	Days post-infection				
	3 day	4 day	5 day	6 day	7 day
Normal-feathered	-	+	++	+	-
Naked neck	-	+	+	-	-
Crested head	-	+	++	+	-
Cobb 500	-	++	+++	++	-

- normal, + mild, ++ moderate, +++ severe

CONCLUSION

The present study is the first to evaluate the genetic variabilty in the response of Algerian native chickens to experimental *Eimeria* induced coccidiosis. These results demonstrate that the naked neck genotype appeares to be associated with better tolerance to coccidiosis compared to other genetic groups. However, further investigations are needed to fully exploit the advantage of the naked neck gene, especially in hot climates, and to identify other genotypes that may exhibit resistance to coccidiosis among Algerian indigenous chickens with the goal of reducing disease-related damage and ultimately contributing to increased productivity and family farm income.

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REFERENCES

1. Abbas, A., Iqbal, Z., Abbas, RZ., Khan, MK. and Khan, JA. (2017). Immunomodulatory activity of Pinusradiata extract against coccidiosis in broiler chicken. Pakistan Veterinary Journal, 37(2): 145-149
2. Abou-Emera, O.K., Ali, U., Galal, A., El-Safty, S., Abdel-Hameid, E.F. and Fathi M.M. (2017). Evaluation of GeneticDiversity of Naked Neck and Frizzle Genotypes Based on Microsatellite Markers. International Journal of Poultry Science, 16: 118-124. doi: 10.3923/ijps.2017.118.124.
3. Adenaike, A.S., Mabunmi, A.O., Takeet, M.I., Adenaike, O.D., Ikeobi, C.O. (2016). Genetic differences in the body weight and haematological traits of Nigerian indigenous chickens infected with Eimeria tenella. Tropical Animal Health and Production. 48(7):1443-1447. doi: 10.1007/s11250-016-1114-6.
4. Akanbi, O.B. and Taiwo, V.O. (2020). The effect of a Local isolate and Houghton strain of *Eimeria tenella* on clinical and growth parameters following challenge in chickens vaccinated with IMMUCOX® and LIVACOX® vaccines. Journal of Parasitic Diseases, 44, 395–402. doi: 10.1007/s12639-020-01202-y.
5. Arabkhazaeli, F., Modrisanei, M., Nabian, S., Mansoori, B., Madani, A. (2013). Evaluating the resistance of *Eimeria spp*. Field isolates to anticoccidial drugs using three different indices. Iranian journal of parasitology, 8, 234-241.
6. Ayssiwede, S.B., Dieng, A., Houinato, M.R.B., Chrysostome, C.A.A.M., Issay Missohou A. (2011). Étude comparée de la sensibilité de différentes souches de poules à la coccidiose aviaire. Revue de Médecine Vétérinaire, 162, 138-142.
7. Boulton, K., Nolan, M.J., Wu Z, et al. (2018). Phenotypic and genetic variation in the response of chickens to *Eimeria tenella* induced coccidiosis. Genetics Selection Evolution, 50, 1-12. doi: 10.1186/s12711-018-0433-7.
8. Cha, J. O., Zhao, J., Yang, M. S., Kim, W. I., Cho, H. S., Lim, C. W., & Kim, B. (2018). Oocyst-Shedding Patterns of Three Eimeria Species in Chickens and Shedding Pattern Variation Depending on the Storage Period of Eimeria tenella Oocysts. The Journal of parasitology, 104 (1), 18–22. doi.org/10.1645/16-132
9. Chapman, H.D. (2014). Milestones in avian coccidiosis research: A review. Poultry Science, 93 (3), 501-511. doı: 10.3382/ps.2013-03634
10. Conway, D.P and Mckenzie, M.E. (2007). Poultry coccidiosis: diagnostic and testing procedures. *Blackwell Publishing Professional, Ames, Iowa, United States.*
11. Dahloum, L., Yakubu, A, and Halbouche, M. (2018). Effects of housing system and plumage colour on egg quality characteristics of indigenous naked-neck chickens. Livestock Research for Rural Development. *Volume 30*.
12. Dakpogan, H. B., Salifoua, S., Murielb, N., Gbangbotche, A. (2012). Comparative sensitivity of different phenotypes of free-ranges chicks to Eimeria tenella coccidiosis in Benin. Journal of Animal and Plant Sciences, 14, 1978–1984.
13. Debbou-Iouknane N, Benbarek H, Ayad A. (2018). Prevalence and aetiology of coccidiosis in broiler chickens in Bejaia province, Algeria, Onderstepoort. Journal of Veterinary Research, 85, 1-6. doi: 10.4102/ojvr.v85i1.1590.
14. Fatoba, A. J. and Adeleke, M.A. (2018) Diagnosis and control of chicken coccidiosis: a recent update. *Journal of Parasitic Disease*, 42, 483–493. doi10.1007/s12639-018-1048-1.
15. Gari, G., Tilahun, G and Dorchies, Ph. (2008). Study on poultry coccidiosis in Tiyo district, Arsi Zone, Ethiopia. International Journal of Poultry Science, 7, 251-256. doi:10.3923/ijps.2008.251.256
16. Halbouche, M., Dahloum, L. Mouats, A. Didi, M. Ghali, S. Boudjenah W. and Fellahi A. (2009). Phenotypic inventory of local poultry populations in northwestern Algeria, morphological characterization of animals and eggs. (Inventaire phénotypique des populations avicoles locales dans le nord-ouest algérien, caractérisation morphologique des animaux et des œufs). In Proceedings of the 1st national Conference on local poultry genetic resources, 23 et 24 June 2009, Mostaganem, Algeria
17. Jatau, I.D., Sulaiman, N.H., Musa, I.W., Lawal, A.I. Okubanjo, O.O., Isah I. and Magaji, Y. (2012). Prevalence of coccidia infection and preponderance Eimeria species in free range indigenous and intensively managed exotic chickens during hot-wet season, in Zaria, Nigeria. Asian Journal of Poultry Science, 6, 79-88. doi:10.3923/ajpsaj.2012.79.88.
18. Johnson, J. and Reid, W.M. (1970). Anticoccidial drugs: Lesion scoring techniques in battery and floor pen experiments with chickens. Experimental Parasitology, 28, 30–36. doi:10.1016/0014-4894(70)90063-9.

19. Kaingu, F., Liu, D., Wang, L. et al. (2017). Anticoccidial effects of Aloe secundifloraleafextract against Eimeriatenella in broiler chicken. Tropical Animal Health and Production, 49, 823–828. doi: 10.1007/s11250-017-1267-y.
20. Mathis, G.F., Washburn, K.W. & L.R. McDougald (1984). Genetic variability of resistance to Eimeria acervulina and E. tenella in chickens. Theoretical and Applied Genetics, 68, 385–389. doi: 10.1007/BF00254803.
21. F.N. Mpenda, M.A. Schilling, Z. Campbell, E.B. Mngumi, J. Buza. (2019). The genetic diversity of local african chickens: A potential for selection of chickens resistant to viral infections. Journal of Applied Poultry Research, 28, 1-12. doi: 10.3382/japr/pfy063.
22. Ngongeh, A.L., Onyeabor, A., Nzenwata, E., & Samson, G. K. (2017). Comparative Response of the Nigerian Indigenous and Broiler Chickens to a Field Caecal Isolate of Eimeria Oocysts. Journal of Pathogens, 2017, 1-9. doi:10.1155/2017/2674078.
23. Ojimelukwe, A.E, Emedhem, D.E, Agu, G.O, Nduka, F.O, Abah, A.E . (2018). Populations of Eimeria tenella express resistance to commonly used anticoccidial drugs in southern Nigeria. International Journal of Veterinary Science and Medicine, 6, 192-200. doi: 10.1016/j.ijvsm.2018.06.003.
24. Pinard-van der Laan, M. H., Bed'hom, B., Coville, J. L., Pitel, F., Feve, K., Leroux, S., et al. (2009). Microsatellite mapping of QTLs affecting resistance to coccidiosis (Eimeria tenella) in a Fayoumi × White Leghorn cross. BMC Genomics, 10, 1-13. doi: 10.1186/1471-2164-10-31.
25. Qaid, M. M., Al-Mufarrej, S. I., Azzam, M. M., Al-Garadi, M. A., Albaadani, H. H., Alhidary, I. A., &Aljumaah, R. S. (2021). Anti-Coccidial Effect of RumexNervosus Leaf Powder on Broiler Chickens Infected with Eimeria Tenella Oocyst. Animals, 11, 167. doi: 10.3390/ani11010167.
26. Soutter, F., Werling, D., Kim, S., Pastor-Fernández, I., Marugán-Hernández, V., Tomley, FM, and Blake, DP. (2021). Impact of Eimeria tenella oocyst dose on parasite replication, lesion score and cytokine transcription in the caeca in three breeds of commercial layer chickens. Frontiers in veterinary science, 8, 640041. doi: 10.3389/fvets.2021.640041.
27. Soutter, F., Werling D., Tomley F.M, and Blake, D.P. (2020). Poultry Coccidiosis: Design and Interpretation of Vaccine Studies. Frontiers in veterinary science, 7, 1-12. doi: 10.3389/fvets.2020.00101.
28. Tang, X., Liu, X., Yin, G., Suo, J., Tao, G., Zhang, S, and Suo, X. (2018). A Novel Vaccine Delivery Model of the Apicomplexan Eimeria tenella Expressing Eimeria maxima Antigen Protects Chickens against Infection of the Two Parasites. Frontiers in Immunology, 8, 1982-1994. doi: 10.3389/fimmu.2017.01982.
29. Thakur, A., Malik, D.S., Kaswan, S. and Saini A. L. (2016). Effect of floor space allowances on growth, coccidiosis and economics of Beetal kids under stall feeding. Indian Journal of Small Ruminants, 22, 264-266. doi: 10.5958/0973-9718.2016.00043.X.
30. Xie, Y., Huang, B., Xu, L., Zhao, Q., Zhu, S., Zhao, H., Dong, H., & Han, H. (2020). Comparative Transcriptome Analyses of Drug-sensitive and Drug-resistant Strains of Eimeria tenella by RNA-sequencing. Journal of Eukaryotic Microbiology, 67, 406-416. doi: 10.1111/jeu.12790.
31. Zouaoui, K., Dahloum, L., Halbouche, M., Soltani, F., Homrani, A. and Yakubu, A. (2023). Rural chicken flocks in the northwest of Algeria: their husbandry, performance indices, and marketing. Journal of Animal and Plant Sciences, 33 (1), 11-24. doi: 10.36899/JAPS.2023.1.0589.
32. Zulpo, D. L., Peretti, J., Mortean Ono, L., Longhi, E., Oliveira, M. R., Gomes Guimarães, I., Arlington Headley, S., da Silva Guimarães Junior, J., & Garcia, J. L. (2007). Pathogenicity and histopathological observations of commercial broiler chicks experimentally infected with isolates of Eimeria tenella, E. acervulina and E. maxima. Semina: Ciências Agrárias, 28, 97–104.