UDC 636.5.083.31
637.4.056
doi: 10.5937/AASer2458097S

Acta Agriculturae Serbica, 29 (58), 97–103, 2024

Publisher: Faculty of Agronomy Čačak

www.afc.kg.ac.rs

Comparative study of the production potential of indigenous poultry breeds of Banat Naked Neck and Svrljig Hen: Reproductive parameters and egg quality

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Received 29 August 2024; Accepted 20 September 2024

A B S T R A C T

In order to preserve indigenous and locally adapted breeds through development programs for sustainable egg and meat production, it is necessary to have more data on the potential of these breeds in different production conditions. Accordingly, the objective of the study was to determine and compare the reproductive potential, production performance and egg quality of two indigenous poultry breeds: the Banat Naked Neck (BNN) and the Svrljig Hen (SH), in improved growing conditions (nutrition, photoperiod and housing) in relation to the traditional rearing of these breeds. Four flocks for each breed were housed in floor pens in a closed facility during the winter months, and then in the vegetation season (April–September) they were kept in mobile cages in the pasture. The duration of the photoperiod in the facility was 15 hours, and in the pasture, they were exposed to the natural duration of daylight. The layers were fed *ad libitum* with balanced complete mixtures for layer-line hybrids and during the vegetation season supplemented with food found in the pasture around the mobile cage. The reproductive potential of BNN and SH hens was determined on the basis of the age of the hens at the beginning of laying, the age at the peak of laying and the number of eggs per housed hen. The egg hatching properties were examined based on the percentage of chicks hatching in relation to the number of laid and fertilized eggs. Data on the quality of table eggs were obtained by testing over eight-week periods during the entire laying period. Under the applied rearing, nutrition and photoperiod conditions, BNN hens achieved production in accordance with their genetic potential defined by the breed standard, while SH layers with 126.43 eggs/housed hen achieved production higher than the breed standard. The egg production of these two breeds of hens differed in the intensity and persistence of laying, which, in addition to a higher peak of laying, resulted in a higher production of egg/housed hen BNN (146.71) compared to SH. On the other hand, parameters of table egg quality, i.e., shell quality and egg albumen/yolk ratio, were significantly better in SH. Also, SH had a higher reproductive potential compared to BNN hens based on the percentage of fertilized and hatched eggs.

Keywords: poultry, indigenous breeds, egg, quality, hatchability

И З В О Д

За очување аутохтоних и локално прилагођених раса кроз програме развоја одрживе производње јаја и меса неопходно је располагати већим бројем података о потенцијалу ових раса у различитим условима производње. У складу са тим, постављени циљ рада је био утврђивање и компарација репродуктивног потенцијала, производње и квалитета јаја две аутохтоне расе кокоши: банатске голошијанке (БНН) и сврљишке кокоши (СХ), у побољшаним условима гајења (исхрана, фотопериод и смештај) у односу на традиционално гајење ових раса. Четири јата по раси су у току зимских месеци гајена у затвореном објекту у одвојеним боксевима, а након тога у сезони вегетације (април–септембар), у мобилним кавезима на пашњаку. Дужина фотопериода у објекту је била 15 сати, а на пашњаку су били изложени природној дужини светлосног дана. Исхрана кокоши је била по вољи избалансираним комплетним смешама за носиље и у периоду вегетације допуњена храном коју су налазиле на пашњаку у оквиру мобилног кавеза. Репродуктивни потенцијал кокоши БНН и СХ утврђен је на основу старости кокоши при проношењу, старости при достизању пика носивости и броја јаја по усељеној носиљи. Инкубациона својства јаја су испитана на основу процента извођења пилића у односу на број уложених и оплођених јаја. Подаци о квалитету јаја за конзум добијени су испитивањима у осмонедељним периодима током целог периода носивости. У примењеним условима гајења уз одговарајући менаџмент исхране и дужину фотопериода, кокоши БНН су остариле производњу сагласну свом генетском потенцијалу дефинисаном стандардом расе, док су носиље СХ са 126,43 јаја по усељеној носиљи остариле производњу већу од стандарда расе. Производња јаја ове две расе кокоши се разликовала у интензитету и перзистентности носивости, што је, поред вишег пика носивости, резултирало већом производњом јаја по усељеној носиљи БНН у односу на СХ. С друге стране, параметри квалитета јаја за конзум, односно квалитет љуске и однос беланце/жуманце су били значајно бољи код СХ. Такође, СХ су имале већи репродуктивни потенцијал у односу на кокоши БНН на основу процента оплођених и излежених јаја.

Кључне речи: живина, аутохтоне расе, јаје, квалитет, излеженост

1. Introduction

Intensive poultry farming, focusing on hybrids of one direction of production, eggs or meat, successfully meets the needs for animal proteins of the growing world population. On the other hand, highly selected and genetically improved hybrids are becoming more sensitive in terms of immune status and ability to adapt to suboptimal growing conditions (Song and King, 2015; Lukić et al., 2020). Also, ethical concerns about killing layer-line male chicks immediately after hatching are increasingly being expressed (Bessei, 2018; Giersberg and Kemper, 2018). Therefore, in world poultry industry, the focus is starting to shift to dual purpose hybrids and locally adapted, indigenous breeds, which at the same time play a significant role in preserving the genetic pool (Tudorache et al., 2022). These genotypes have poorer production performances, but they are much more resistant to diseases and parasites, they are better adapted to unfavorable climatic factors and also capable of producing on a less protein-rich diet (Rakonjac et al. 2017).

Banat Naked Neck (BNN) and Svrljig Hen (SH) are part of animal genetic resources and their preservation is part of the Biological Diversity Strategy of the Republic of Serbia (Strategija biološke raznovrsnosti Republike Srbije, 2011). Efforts to date in the direction of identification and characterization of indigenous breeds of poultry in Serbia have been modest, but have significantly contributed to global efforts to preserve animal genetic resources. The population size of these hens is threatened. According to FAO data (2022), the size of the Banat Naked Neck population is 1,000–2,000 birds and in a downward trend, and the Svrljig Hen is 300–500 birds. They are mainly grown in rural households, in small numbers, without significant expert supervision and control, which results in great variability in certain characteristics of the breed.

The Banat Naked Neck and the Svrljig Hen are dual purpose breeds, that is, for the production of meat and eggs. The Banat Naked Neck originates from the Transylvanian hen, which was originally bred in a pure breed, and then used to improve the characteristics of domestic hen populations. The production standards of the Banat Naked Neck breed indicate that it is a medium-maturing breed (reaches sexual maturity at 5–6 months of age), lays 120–150 eggs in the first year of production, has a pronounced maternal instinct, but also gives good quality meat (Milošević et al., 2013). Data on the origin and creation of the Svrljig Hen are much scarcer. It originates from the primitive domestic chicken, the so-called "pogrmuša" ("hedgehogs"), and the Svrljig Hen was considered to be its strain (Mitrović, 1996), while today's populations of the Svrljig Hen are created by unplanned crossing with other imported breeds, such as Australorp and Langshan, among others. Phenotypic confirmation of the origin of today's population of Svrljig Hen is in larger body dimensions and better production characteristics. The standard of the breed is the production of 100–120 eggs per year with a pronounced laying instinct (GOP/Main Breeding Program of indigenous poultry breeds of the RS, 2019).

Given that these breeds are locally adapted, with significant adaptive abilities to modest rearing conditions, it is desirable to base their conservation programs on the self-sustainability of growing through traditional meat and egg production. The idea to implement the preservation of these breeds through sustainable production development programs is not new, but it has never been realized to a significant extent in Serbia. To implement such a program, it is necessary to have more data on the potential of today's locally adapted breeds in different production conditions.

In this sense, the objective of the study was to determine and compare the reproductive potential, production performance and egg quality of Banat Naked Neck and Svrljig hens in improved rearing conditions in terms of nutrition, photoperiod and housing relative to the traditional rearing of these breeds.

2. Materials and methods

2.1. Design, birds and management

The reproductive characteristics of BNN and SH hens were examined in the first year of the production on a total of 88 hens. The initial laying and start of the trial took place in the fall. Four (4) flocks (4 replicate groups) were formed per breed with a gender ratio of 10:1, and were housed in floor pens in a well-ventilated closed facility during the winter months, and then in the vegetation season (April–September) they were reared in mobile cages in the pasture. The pens in the facility, as well as the mobile cages in the pasture, were equipped with an adequate number of round waterers and feeders, perches and nests. The flocks were provided with a photoperiod duration of 15 hours in the facility, whereas in the pasture they were exposed to the natural duration of daylight, which ranged from 15.5 to 12.5 hours in the examined period. The chickens were fed ad libitum balanced maize/soybean-based complete mixtures for layers, with 16% CP and 11.6% MJ ME, and during the vegetation season they were supplemented with feed they found in the pasture around the mobile cage.

2.2. Methods

The reproductive potential of Banat Naked Neck and Svrljig hens was determined based on the age of the hens at the beginning of laying, the age at reaching the peak of egg production and the daily recording of the number of eggs laid during the entire period of laying in the first year. The egg hatching properties were examined during 5 repeated incubation processes. All laid eggs were set in the incubator machine (MG576 Jupiter, FIEM, Italy) on a weekly basis. The number of unfertilized eggs was recorded on the 18^{th} day by candling, and the other egg hatching parameters were calculated based on the number of hatched chicks. Data on the quality of eggs for consumption (table eggs) were obtained by testing over eight-week periods during the entire laying period on samples of 15 eggs per breed. The eggs were sampled in the morning and the initial quality of the eggs was examined based on the following parameters: egg weight, egg shape index (short-axis to long-axis length ratio, using a special device B.V. Apparatenfabriek van Doorn, Holland), egg shell color

(by scoring system on a scale from 1(white shell) to 5 (dark brown shell)), egg shell weight (without drying the shell), albumen height (tripod micrometer, AMES, USA), yolk color (according to Roche Yolk Color Fan), yolk weight, shell deformation (using a load of 500 g on the equatorial part of the egg by the special device Marius, Holland), shell thickness was measured on shell fragments sampled from the equatorial circumference (SOMET, USA), egg breaking force was determined according to Pavlovski and Vitorović (1996), a spring of 15 kg and a movement speed of 70 mm/min were used. The weight of the egg white was calculated based on the difference between the weight of the egg, the weight of the shell and the weight of the yolk.

Haugh units were calculated according to the following formula:

$$HU = 100\log (H + 7.57 - 1.7M^{0.37}) \quad (1)$$

where H = albumen height, mm; M = egg weight, g.

2.3. Statistical Data Processing

The obtained results were processed with the statistical software package STATISTICA, version 8 (StatSoft Inc., Tulsa, OK, USA), using the Factorial ANOVA procedure. The significance of the differences was assessed at the probability level of $p \leq 0.05$ by LSD post hoc test.

3. Results

Egg production of the indigenous breeds Banat Naked Neck (BNN) and Svrljig Hen (SH) started in fall (September–October), which was in accordance with the seasonal nature of the production of local breeds that were hatched in spring. In our study, these breeds were reared in a closed facility during the winter, where they were provided with a photoperiod duration of 15 hours. BNN hens reached sexual maturity and began egg production at 23 weeks of age. Compared to them, SHs laid earlier (19 weeks of age), but the graph (Fig. 1) shows a faster increase in egg production of BNN hens, which also reached a higher peak of egg production (0.61 egg/hen/day) compared to SHs, whose peak of egg production was 0.56 egg/hen/day. Thanks to the higher laying intensity of BNN hens, the difference compared to SH of 4 weeks at the start of laying was reduced to 2 weeks when reaching the peak of laying. Both breeds of chickens reached one peak in the winter season and one (significantly lower) peak in the summer season when reared on pasture.

Summarized for the entire laying period in the first year of exploitation, there were no statistically significant differences ($P > 0.05$) in egg/hen/day production between the BNN and SH breeds (Table 1). Total eggs/housed hen production of BNN hens was within the breed standard (120–160 eggs), and in SH it was slightly above the production standard for this breed (100–120 eggs) (MBP of indigenous poultry breeds of RS, 2019).

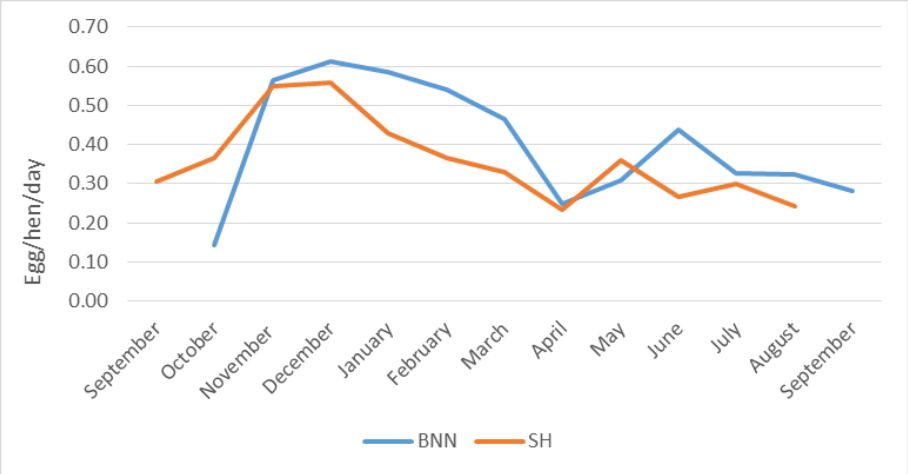

Figure 1. Egg/hen/day production of Banat Naked Neck and Svrljig Hen in the course of first laying cycle

Table 1.
Egg production of Banat Naked Neck and Svrljig Hen

	Banat Naked Neck (BNN)	Svrljig Hen (SH)
Laying period, day	365	365
Age at the beginning of laying, weeks	23	19
Age at peak production, weeks	33	31
Rate of lay at peak, %	64	55
Total eggs/housed hen	146.71	126.43
Egg/hen/day	0.403^{ns}	0.359 ^{ns}

ns – non-significance ($P > 0.05$)

The egg hatching properties of BNN and SH breeds shown in Table 2 indicate that there were no statistical differences in the percentage of fertilized eggs, nor in the percentage of hatching in relation to the fertilized eggs. The larger number of eggs laid by BNN hens gave a significantly lower percentage of hatched chicks in relation to the total eggs of this breed. Thanks to a higher percentage of fertilized eggs, as well as a higher percentage of hatched chicks, our SHs showed a higher reproductive potential compared to BNN hens.

Table 2.
The egg hatching properties of BNN and SH breeds

Breed/Properties	Banat Naked Neck	Svrljig Hen	p-value
	Mean ± SD	Mean ± SD	
Fertilized eggs, %	71.02 ± 7.26	77.32 ± 7.09	0.203
Hatching of chicks from total eggs, %	47.93 ± 17.57	67.33 ± 4.70	**0.044**
Hatching of chicks from eggs fertilized, %	74.80 ± 17.63	87.80 ± 11.23	0.201

The average values of table egg quality parameters for the entire period of laying of BNN and SH hens are shown in Table 3. Very uniform values of egg weight, egg shape index and egg shell color of BNN and SH hens were determined. Statistically significant differences were found for shell quality traits. SH eggs had less shell deformation, greater mass and shell thickness, which ultimately resulted in higher shell strength, expressed by breaking force. SH eggs, compared to BNN eggs, showed slightly better internal quality of eggs, without statistical confirmation of differences. Differences were confirmed in the ratio of egg albumen and yolks between these two breeds of hens, as a result of a higher yolk weight in SH (18.26 g) compared to BNN eggs (17.62 g). Differences were noted in the presence of blood and flesh stains in the eggs of these breeds, which, although present in a small number of eggs (16.67% –BNN; 15% – SH), were present in BNN eggs at the beginning of the laying period and in SH eggs at the end of the study period of laying capacity.

Table 3.
Egg quality of Banat Naked Neck and Svrljig Hen

Breed/Parameter	Banat Naked Neck	Svrljig Hen	p-value
	Mean ± SD	Mean ± SD	
Egg weight, g	52.61 ± 5.21	53.00 ± 6.36	0.613
Shape index	74.30 ± 2.42	74.60 ± 2.52	0.374
Shell color, point	1.75 ± 0.60	1.82 ± 0.50	0.385
Shell deformation, 0.001mm	29.77 ± 6.76	25.30 ± 4.63	**<0.001**
Shell weight, g	6.41 ± 0.76	6.64 ± 0.87	**0.042**
Shell thickness, 0.01 mm	28.37 ± 3.05	30.12 ± 2.95	**<0.001**
Shell Breaking force, kg	2.08 ± 0.46	2.25 ± 0.44	**0.005**
Albumen height, 0.1mm	54.44 ± 16.14	55.83 ± 12.59	0.467
Yolk Color, Roche	12.90 ± 1.76	12.75 ± 1.04	0.448
Egg albumen/yolk ratio	1.65 ± 0.36	1.56 ± 0.24	**0.017**
Haugh units	72.01 ± 14.36	74.45 ± 10.25	0.139

4. Discussion

The significant distribution of different local breeds of naked neck hens, especially on the African continent, was certainly influenced by the adaptability of these breeds to high temperatures associated with the gene for naked neck (Bobo Athes, 2008; Fathi et al., 2013). Naked neck hens are part of genetic resources in Indonesia (Kostaman and Sopiyana, 2016). In our region, naked neck hens are present in Romania (the original Transylvanian chicken), Hungary and Serbia (Bobo Athes, 2008; Lan Phuong et al., 2014; Supić et al., 1997). The phylogenetic analysis of mitochondrial DNA indicates the origin of the BNN maternal line from the Indian subcontinent (Vekić et al., 2022). Unlike them, it cannot be claimed with certainty that SH is a cross-border breed, although hens with very similar external characteristics (Black Shumen) are reared on the territory of Bulgaria (Teneva et al., 2015). The difference in the number of studies and the availability of data for the BNN and SH breeds resulted from the aforementioned facts about the number of populations and their territorial distribution.

In this comparative study, BNN hens started laying eggs at 23 weeks, which is earlier compared to the data on this breed cited by Milošević et al. (2013). Egg production was at the level of the breed standard, but the average egg weight was slightly lower than the stated standard (55–60 g). Despite the fact that both indigenous breeds (BNN and SH) are of the dual-purpose, the age of hens at sexual maturity, the dynamics of laying, and the peak and persistence of laying indicated key differences in egg production between these two breeds. Difference was also shown in the response to improved rearing conditions (photoperiod, nutrition, housing), whereby SH had a slightly higher egg production compared to the breed standard, while such a response was absent in BNN

hens. The beginning of egg production took place during the fall, when the duration of the daylight is shortened, which would certainly affect the productivity of these breeds in natural environment conditions. By prolonging the daylight hours, the peak of laying capacity was reached in the winter months (November–December), which is not typical for local breeds and the seasonal nature of production. Lan Phuong et al. (2014) recorded the lowest egg production of local Hungarian breeds in the period December–February and the highest in the period March–May, as a result of the natural duration of the daylight hours. In addition, they noticed that their naked neck hens produced fewer eggs during the winter compared to other local breeds, which they attributed to the greater sensitivity of this breed to low temperatures. The negative effect of low temperatures on the laying capacity rate of BNN hens was not recorded in our study. On the contrary, BNN hens achieved higher egg production in the winter months compared to SH. Fathi et al. (2019) concluded that rearing naked neck hen genotypes in the temperature range of 22.2 –16.7°C did not affect the laying capacity. The achieved production of their white naked neck hens in the first cycle of production ranged from 0.306 to 0.319 egg/hen/day, depending on the year of the study.

Feeding hens ad libitum with standard complete mixtures for layers was carried out in order to exclude nutrition as a limiting factor in the expression of the productive potential of these breeds. It is known that breeds of the combined type of production have higher nutritional needs compared to laying hens, which are additionally increased in rearing conditions that ensure greater locomotor activity of hens (Rakonjac et al., 2021). Constantly available food caused a large amount of food wastage, which is the reason why food consumption is not shown in the research results.

The BNN and SH breeds have a pronounced maternal instinct, which makes them suitable for the natural rearing of chicks. However, in order to achieve better results in egg production, by avoiding the phase when hens lie on eggs and stop laying, but also in order to produce high-quality one-day-old chicks, by providing controlled incubation conditions, we decided to use an incubator machine in the study. The incubation results obtained in this study were worse than the literature reports for BNN and SH, which are few. Mitrović et al. (2011), in the study of the incubation value of eggs of indigenous breeds reared by several breeders, reported that the hatchability of chicks from the number of eggs introduced was 80.0% for BNN and 78.02% for SH. Depending on the age of the BNN flock, Supić et al. (1997) found that the percentage of hatching from the number of eggs laid ranged from 63.16 to 82.22. The genetic potential and standard of the BNN breed, according to Milošević et al. (2013), are significantly higher than our results, that is, 90–95% for egg fertilization, and 85–90% for hatchability of chicks in relation to fertilized eggs. Given that we are talking about small populations of hens, the possibility of adequate selection of roosters is questionable, which was certainly reflected in the percentage of fertilized eggs in our study. In addition to the parents, environmental factors are also responsible for the vitality of the embryo and the ability to hatch; in extensive rearing conditions they are not strictly defined and controlled.

BNN and SH eggs, in addition to uniform average weight, had a similar shape index (74) and shell color (<2 points), i.e., quality characteristics that are similar for local, indigenous breeds (Pavlovski et al., 2012) which are not subject to more intensive selection improvement. Differences between breeds have been established for shell quality properties, which can influence the breeders' decision to breed a particular breed. Shell quality affects the economic profitability of producers due to egg losses caused by poor shell quality. Fathi et al. (2019) linked shell quality and firmness to naked neck gene homozygosity. However, in our study, SH had better shell quality. The obtained results confirmed our previous results (Škrbić et al., 2020), when we studied the quality of BNN and SH eggs in a pasture system of rearing and hens at the age of 53–57 weeks. Mitrović et al. (2011) reported a higher average egg weight for the BNN and SH breeds (61.27 g and 57.67 g) compared to our study, which indicates high genetic variability within the population of these hens. In relation to the egg quality of hybrid layers, which was initially better, the determined correlation coefficients of egg quality and age of hens showed that the decrease in the egg quality of indigenous breeds with the age of layers was significantly minor (Škrbić et al., 2011). The mentioned results are in accordance with the rearing method and exploitation (use) of local, indigenous breeds, which are not limited to one production cycle. Škrbić et al. (2021) confirmed the satisfactory quality of BNN eggs in the second production cycle as well. Đermanović et al. (2018) reported that the average weight and shape index of BNN eggs in the first and second production cycles were 54.29 g and 59.56 g, and 74.83 and 75.40, respectively. In addition to the initial quality of eggs, the viability of eggs during storage is also important for consumers. By comparing the egg quality of BNN and ISA Brown layers under the same storage conditions over a period of four weeks, Škrbić et al. (2023) determined more moderate processes of loss of freshness in eggs of BNN hens compared to eggs of ISA Brown layers. The loss of egg weight during the storage of BNN eggs was 2.66% and in ISA Brown layers – 4.24%, which could be related to the difference in the proportions of structural parts, primarily yolk and egg white. The higher proportion of yolk in the eggs of BNN hens is responsible for the higher content of fat and dry matter compared to Lohmann Brown eggs (Stanišić et al., 2015). In the same study, eggs of BNN hens had significantly more SFA and less PUFA, while the proportion of total n-3 fatty acids did not differ. By comparing the proportion of yolk and albumen in an egg, we found that differences also exist between the eggs of indigenous breeds of hens. The obtained results also imply differences in chemical composition, which should be confirmed by future research.

5. Conclusions

Both indigenous breeds of hens, BNN and SH, in the applied rearing conditions with proper nutrition management and daylight duration, achieved production in accordance with their genetic potential defined by the breed standard and demonstrated the possibility of exceeding it in the case of SH. The egg production of these two breeds of hens differed in the intensity and persistence of laying, which, in addition to the higher peak of laying, resulted in higher egg

production of BNN compared to SH. The differences in the reproductive traits of BNN and SH in our and other studies point to large genetic variability, primarily in BNN, which enables work on its genetic improvement in the future. Data for SH are significantly scarcer, which is not surprising given the size of the population and the endangered status of the breed. In order to include these breeds of hens in the systems of non-conventional production of table eggs, research should be focused on the chemical and nutritional composition of eggs, as well as on the viability of SH eggs during storage, which would complete scientific knowledge about the potential of these indigenous breeds in the production of table eggs.

Acknowledgments

This study was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, based on the Agreement on the realization and financing of scientific research work of SRO No. 451-03-66/2024-03/200022, No. 451-03-66/2024-14/200088, and No. 451-03-66/2024-14/200045.

Declaration of competing interests

The authors declare that they have no conflict of interest.

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