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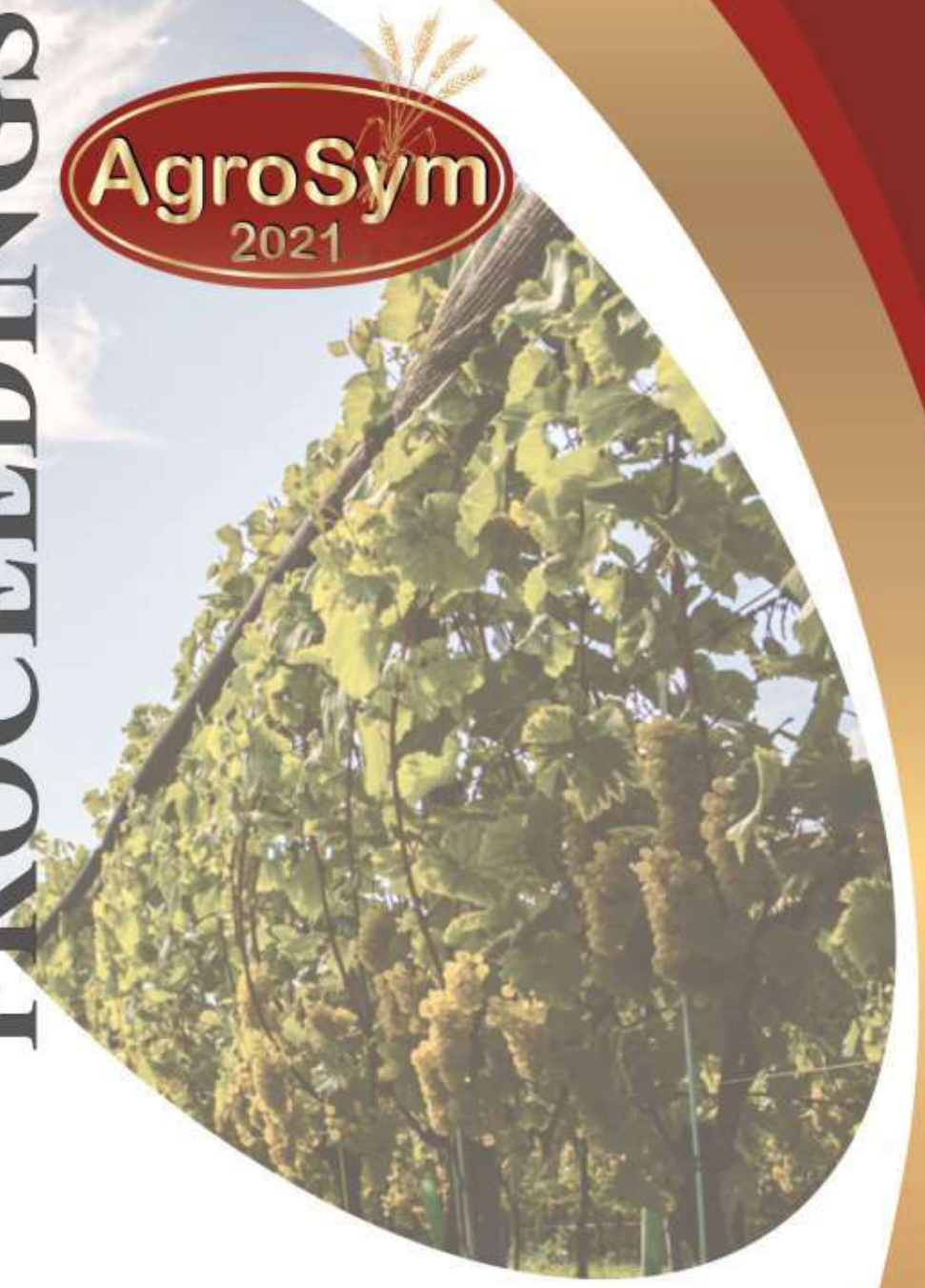

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DETERMINATION OF EXTERNAL, INTERNAL AND EGGSHELL QUALITY PARAMETERS

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Abstract

Eggs of class "L" produced of Isa Brown genotype were used for the research needs. The research aimed to determine the external (length, width, shape index and mass of eggs), internal (proportion of main parts of eggs, albumen height, Haugh units and yolk color) and eggshell quality parameters (purity, thickness and strength). The eggshell strength was determined by applying the direct method of puncture, using a specially constructed measuring and acquisition device. The results of the research showed that the average egg length was 58.33 mm, width 45.17 mm, and shape index 77.44. Of the average egg mass (65.79 g), the albumen proportion was 59.87%, yolk 27.33% and eggshell 12.90%. Albumen height ranged from a minimum of 4.42 mm to a maximum of 6.76 mm, with a coefficient of variation of 16.90%. Accordingly, values of the Haugh units ranged from 60.2 to 80.2 and the coefficient of variation of 10.96%. The average yolk color was 13 Roche. The purity of the eggshell was rated 4.44. The eggshell quality of the tested eggs was quite uniform because the average puncture force of the eggshell was 25.88 N, with a coefficient of variation of 4.20% and an average thickness of 0.40 mm. Knowledge of the values of external, internal and properties of eggshell quality can be used in a selection of laying hens hybrids with increased eggshell strength, as well as for cage construction, design of egg collection equipment and design of egg packaging.

Keywords: *hen eggs, egg quality, eggshell puncture force.*

Introduction

The cage rearing system is the dominant way of rearing of laying hens all over the world, and this situation probably will continue for a long time. The reason for this is because the rearing of hens in the cage is the most economical way of production, and it provides that the price of eggs is low and that product be accessible to all segments of the population (Rakonjac et al., 2017). In Serbia, more than 90% of eggs for consumption are produced in this - industrial way, in closed facilities with automatic feeding and watering systems, with control of all ambient conditions and the use of artificial lighting and ventilation.

In recent years, great attention has been paid to the quality and health safety of eggs, as one of the most important foodstuffs. In addition to the chemical composition of eggs and their external and internal quality properties, a special attention is paid to the quality of the eggshell, which can be crucial for success in hen eggs production. Thus Coucke et al. (1999) state that 6-8% of produced eggs break up before it comes to use, which makes financial losses of millions of dollars. A large percentage of this damage is caused by the inadequate quality of the shell because eggs cracks during manipulation.

The research aimed to determine the external (length, width, shape index and mass of eggs), internal (proportion of main parts of eggs, albumen height, Haugh units and yolk color) and eggshell quality parameters (purity, thickness and strength). In addition, the research aims to test a device that was constructed for the experiment, for determining the stress of the eggshell by direct puncture method.

Material and Methods

A total of 30 "L" class eggs (produced of 63 weeks old Isa Brown hens on the "Grbović" farm in the vicinity of Čačak) were used in this research. These eggs (one day old) were evaluated for external (length, width, shape index and egg mass), internal (proportion of main parts of eggs, albumen height, Haugh units and yolk color) and eggshell quality properties (purity, thickness and strength).

The shape index was calculated by formula according to the research of Panda (1996):

$$Shape\ index\ (\%) = egg\ width\ /\ egg\ length\ *\ 100$$

Haugh units were calculated according to the following formula (Haugh, 1937):

$$HU = 100 * log\ (h - 1.7w^{0.37} + 7.6)$$

where h = albumen height, mm, w = egg weight, g.

The yolk color was determined by comparison with the color on the "Roche-Yolk Color Fan 1969" range, classified by the intensity of color shades on a scale from 1 to 15. The length and width of eggs and eggshell thickness were measured by Fowler Pro-max electronic caliper with an accuracy of 0.01 mm. The mass of whole eggs and main parts of eggs were measured using an analytical balance Kern EMS 3000-2 with an accuracy of 0.01 g. The purity of the eggshell was visually assessed from 1 (very dirty) to 5 (completely clean).

A special measuring and acquisition device was constructed to determine the eggshell strength using the direct puncture method. The device for measuring the eggshell stress by determining the puncture force of eggshell was constructed in the Laboratory for Mechatronics of the Faculty of Technical Sciences and the Faculty of Agronomy in Čačak. A detailed description of the measuring acquisition device for measuring the mechanical properties of the puncture force of cracking and breaking of rapeseed fruits was given by Božić et al. (2014) and Koprivica et al. (2021). The procedure for determining stress of the eggshell is performed in such a way that the egg is placed on a support plate in a horizontal position (along the length) perpendicular to the direction of the force. With a 2 mm diameter probe, the eggshell puncture is performed on the equatorial part of the egg. At the moment of eggshell puncture, the minimum puncture force expressed in N is registered and represents the maximum of the eggshell strength. The device registers and displays data on measured values of the eggshell puncture force in Excel table and graphic. The tabular report provides data on eggshell puncture forces, as well as basic statistical data (minimum, maximum, mean, coefficient of variation, standard deviation).

Results and Discussion

Egg quality was determined based on obtained values of 4 external, 3 internal and 3 properties of eggshell quality. The properties of the external quality of eggs are shown in Table 1.

Table 1. External quality of eggs

Egg properties	Mean	St. Dev.	CV in %	Min.	Max.
Length (mm)	58.33	1.05	1.79	56.65	59.72
Width (mm)	45.17	1.06	2.34	43.96	46.94
Shape index (%)	77.44	3.91	5.01	74.63	81.04
Mass (g)	65.79	3.01	4.57	62.89	70.79

The average length of eggs was 58.33 mm and width 45.17 mm, so the shape index was 77.44%. Based on the shape index and mass index, the eggs are graded and packaging is designed. The shape index is important from an economic point of view because, with an irregular shape, the cracking of eggs during collection, packaging and transport is much higher. The results for shape index is in agreement with the results published by Kralik et al. (2013), Ahammed et al. (2014), Dikmen et al. (2017), Rakonjac et al. (2018) and Turker and Alkan (2019), and greatest than the value it states by Nedomova et al. (2009). The mass is the main indicator of egg quality and it ranged from 62.89 g to 70.79 g, with an average of 65.78 g, so the eggs were classified in the "L" class (large eggs). These values are following the technological norm for Isa Brown laying hens in the later stages of the production cycle (Isa Brown Management Guide, 2018), and the results determined by Đukić-Stojčić et al. (2009) and Rakonjac et al. (2017).

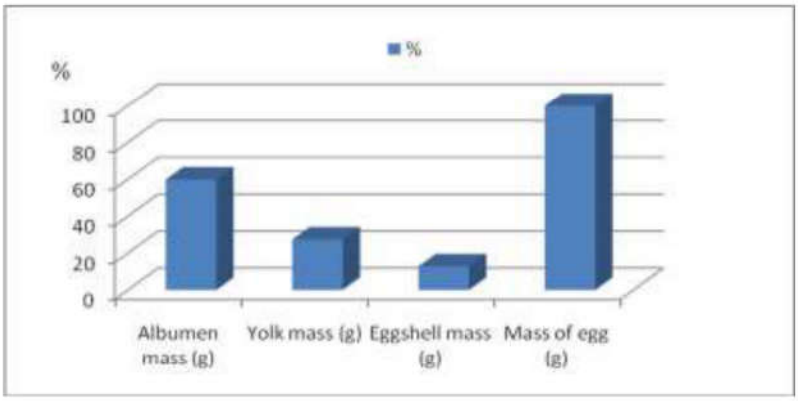

Figure 1. The average share of basic parts of egg

The proportion of the main parts of eggs is shown in Figure 1. The obtained values are in accordance with the results given by Rakita et al. (2016), Rakonjac et al. (2017) and Keta and Tumova (2018). Internal egg quality parameters are presented in Table 2.

Table 2. The internal quality of eggs

Egg properties	Mean	St. Dev.	CV in %	Min.	Max.
Albumen height (mm)	5.57	0.94	16.90	4.42	6.76
The Haugh units	70.77	7.76	10.96	60.2	80.2
Yolk color (Roche)	13.00	0.87	6.66	12	14

The values of albumen height ranged from a minimum of 4.42 mm to a maximum of 6.76 mm, with a coefficient of variation of 16.90%. Accordingly, the values of the Haugh units varied from 60.2 to 80.2 and with a coefficient of variation of 10.96%. Similar results for the same hybrid and approximately the same age of the hens were also determined by Minelli et al. (2007) and Rakonjac et al. (2018), who state that the hen's age is one of the main factors that affecting the value of these parameters.
The yolk color depends on a large number of factors, primarily on genotype (Kucukyilmaz et al., 2012), age of the laying hens (Škrbić et al., 2011) and nutrition (Mugnai et al., 2009). The average value of the yolk color in this study was 13 Roche, which is similar to the results published by Perić et al. (2016), and significantly higher than the results reported by Kralik et al. (2013) and Rakonjac et al. (2018). Eggshell quality parameters are presented in Table 3.

Table 3. The quality of eggshell

Properties of eggshell	Mean	St. Dev.	CV in %	Min.	Max.
Purity eggshell (points)	4.44	0.73	16.35	3.0	5.0
Eggshell thickness (mm)	0.40	0.02	6.16	0.37	0.45
Puncture force (N)	25.88	1.09	4.20	23.41	26.46

For eggs to be sold, the eggshell must be clean, without visible cracks. On average, the purity of the eggshell was rated 4.44. The quality of the eggshell is determined by the thickness and eggshell strength. The strength of the eggshell is the ability of the eggshell to resist the action of external forces that would break it. The eggshell strength values obtained by the direct puncture method represent the stress force to load the eggshell to the limit when it is punctured or cracked. The quality of the tested eggs was uniform because the average puncture force of the eggshell was 25.88 N, and varied from 23.41 N to 26.46 N. These values of eggshell strength measured by puncture force are in agreement or approximate with the results published by Krawczyk (2009), Ahammed et al. (2014) and Turker and Alkan (2019), and less than measured values by Hunt et al. (1977), Voisey et al. (1979), Hamilton and Thompson (1986) and Rakonjac et al. (2019). Inconsistency of the obtained results for values of eggshell puncture force presented in the research with the results of other authors can be explained by using different genotypes, different rearing and feeding conditions, different ages of laying hen, but also by using different methods to determine values of this parameter.
The average eggshell thickness with membranes on the equatorial part of the egg was 0.40 mm with a coefficient of variation of 6.16%. These values are in agreement with the values presented by Ahammed et al. (2014), Dikmen et al. (2017) and Keta and Tumova (2018).

Conclusion

The most important parameters for determining the quality of egg are external, internal and eggshell quality properties. Knowing the value of these parameters is of great importance for both egg producers and consumers, as well as for science and practice. Only by knowing the mentioned properties, it is possible to create new or improve existing hybrids of laying hens by the selection, which are characterized by a better external and internal quality of eggs and

eggshell strength increased. The obtained values of some parameters are important for cage construction, design of collection equipment and design of egg packaging.
The research shows that the device for measuring egg strength by eggshell puncture method is simple, light construction, easy to use, non-invasive, efficient, reliable in work, and the obtained results of puncture force are precise, concrete and comparable with the results of other authors. The constructed device for measuring the strength of eggs and the method of puncture eggshell have application not only in laboratories of scientific institutions but also in practice on farms.

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