Original paper

# THE EFFECT OF RAW SOYBEANS IN MIXTURES FOR LAYING HENS ON EGG QUALITY AND EGG SHELL QUALITY

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**Abstract**

The study was conducted on hens at the age of 49 - 57 weeks to identify opportunities for replacing, with raw grain, thermally processed soybean Lana variety with a reduced level and Lydia variety with a standard level of trypsin inhibitor. The effect of using different levels of participation of both varieties of raw soybean in mixtures for layers on egg quality and eggshell quality was examined. The research was conducted according to the principle of two-factorial experiment (2 varieties x 4 levels of participation of raw soybeans). The average values of properties of the external and internal egg quality were under statistically significant influence of the level of participation of raw soybean in the mixture. Share of 8 % of raw soybeans of both varieties in diets for layers influenced significantly lower eggshape index, albumen height and Haugh's unit in relation to the mixture with a lower level of participation of raw soybeans. Yolk color and eggshell firmness were not significantly influenced by the studied factors.

**Key words:** *egg quality, egg shell quality, laying hens, soybean, trypsin inhibitor*

## Introduction

Various methods of thermal treatment increase the nutritional value of soybean but result in the consumption of large amounts of energy and thus increase the cost of food. Through plant breeding, varieties with reduced content of specific anti-nutritive substances have been created. As a result of the domestic soybean breeding program focused on a reduced trypsin inhibitor (TI) activity, in our conditions, a Lana variety was created with lower TI than standard varieties.

Trypsin inhibitors reduce the utilization of soy protein and are the main antinutritive factor in raw soybean that prevents the utilization of nutrients which this feed is rich in (Zhang et al., 1993). In addition to the TI, lectins are present in the soybean as important antinutritive substances (Douglas et al., 1999).

Comparing the nutritional value of soy with lower TI in the experiments conducted on chickens (Han et al., 1991), layer hens (Zhang et al., 1991) and pigs and chickens (Palacios et al., 2004), better product results have been determined when compared with standard soybean. Cook et al. (1988), in a study on pigs, have found that the negative effects of the use of raw soybeans decreased with the age of the animal. Latshaw and Clayton (1976), found that the increase of the share of thermally unprocessed soybeans in diets for laying

hens diet gradually reduces egg laying capacity and egg weight. Senkoylu et al. (2005) and Koci et al. (1997) established no significant differences in production performance between laying hens fed diets with different levels of participation of full-fat soybean.

The aim of this study was to investigate the effects of replacing a portion of heat-treated soybean of Lydia standard variety and Lana variety with reduced TI, with raw grain of both varieties in the diet for laying hens, on egg quality and egg shell quality.

## Material and methods

The study was conducted at the experimental farm of the Institute of Animal Husbandry in Zemun using light line hybrid hens Isa Brown. The mixtures for laying hens contained two local varieties of soybean, heat-treated and untreated, or raw, Lana variety with reduced trypsin inhibitor and Lydia standard variety (Table 1). Effect of different levels of raw soybeans in diets on egg quality and egg shell quality was determined by two factorial experiment 2 x 4 (2 varieties x 4 levels of participation of raw grain in the mixture) with a total of 8 treatments (a total of 512 monitored birds).

**Table 1.** *Level of trypsin inhibitor in soybean*

| Treatment | Raw soybean | | Heat-treated soybean | |
|---|---|---|---|---|
| Variety | Lana | Lydia | Lana | Lydia |
| TI (mg/g) | 17.71 | 36.74 | 4.38 | 14.03 |

The experiment was conducted on hens aged 49 - 57 weeks. In the preparation of the diet the recommendations for the studied hybrid were used. Raw material composition of the mixture was the same with adjustment for soybean variety and the relationship between heat-treated and raw grain to achieve the objective of the research. Participation of heat-treated soybean of both varieties was 8 % in the mixture and it was included in the two control treatments (K). In trial groups, (I) 6 % of 8 % of whole soybeans contained in the mixture was heat-treated and 2 % was raw soybean. In the group (II) 4 % of heat treated and 4 % of raw soybean was added to the mixture. In the group (III) diet included only 8 % of the raw soybeans. Ingredients of mixtures and chemical composition are given in Table 2.

Random samples of 15 eggs were taken from each treatment over a period of 7 days during the experiment and the quality of eggs and egg shell was investigated. The quality of the eggs was studied on fresh eggs, immediately after collection, and thus the resulting score on the initial quality of table eggs was obtained.

Egg quality traits were divided on the properties of the external and internal egg quality. Determination of the external quality of eggs included egg mass and egg shape index. The following internal properties of egg quality were determined: albumen height, yolk color and Haugh's unit obtained as a logarithmic function of egg mass and height of thick egg white.

Eggshell quality included the determination of the following characteristics: egg shell mass, shell thickness and shell deformation and breaking force were determined according to the method stated by (Pavlovski and Vitorović, 1996).

**Table 2.** *Ingredients and chemical composition of mixtures–diet for layer hens during the experiment (%)*

| Feeds | Groups (Treatments) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Lana | | | | Lydia | | | |
| | K | I | II | III | K | I | II | III |
| Heat-treated (extruded) soybean | 8 | 6 | 4 | 0 | 8 | 6 | 4 | 0 |
| Raw soybean | 0 | 2 | 4 | 8 | 0 | 2 | 4 | 8 |
| Corn | 59 | 59 | 59 | 59 | 59 | 59 | 59 | 59 |
| Soybean meal | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Sunflower meal | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Livestock lime granules | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Livestock lime, powder | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Monocalcium phosphate | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Salt | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Mikozel | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Premix | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Σ (%) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Chemical composition | | | | | | | | |
| ME, MJ/kg | 11.84 | 11.78 | 11.76 | 11.70 | 11.84 | 11.78 | 11.76 | 11.70 |
| Crude protein | 15.3 | 15.6 | 15.8 | 15.4 | 15.9 | 15.4 | 15.3 | 15.1 |
| Crude fat | 5.12 | 5.11 | 5.16 | 5.14 | 4.99 | 4.99 | 4.93 | 4.91 |
| Crude fibre | 4.87 | 4.64 | 4.51 | 4.40 | 4.18 | 4.33 | 4.25 | 4.35 |
| Ash | 12.40 | 12.75 | 12.43 | 12.9 | 13.10 | 12.50 | 13.04 | 13.14 |
| Calcium | 3.53 | 3.97 | 3.72 | 3.66 | 3.69 | 4.01 | 3.65 | 3.87 |
| Total phosphorus | 0.65 | 0.58 | 0.60 | 0.63 | 0.62 | 0.57 | 0.59 | 0.60 |
| Sodium | 0.19 | 0.19 | 0.18 | 0.16 | 0.21 | 0.17 | 0.16 | 0.19 |

The software package STATISTICA, version 12 (Stat Soft Inc.) was used for statistical analyses. The level of statistical significance of differences between the groups was determined by Tukey-test.

## Results and discussion

Average values of egg quality traits obtained during the study are shown in Table 3. In the study, no statistical significance for the mass of eggs depending on diet containing different soybean varieties was observed. Statistical analysis of the level of participation of raw soybeans in mixtures indicated that the differences between the groups were statistically significant ($p<0.01$). With the increase in the share of raw soybeans in mixtures the egg mass gradually decreased. The highest average value of egg mass was found in layers in Lydia-K group (64.80 g) and the lowest in layers in Lydia-III group (62.61 g). The differences in egg mass between the groups were not influenced by the interactive effects of the studied factors. Perez-Maldonado et al. (2000), in the diet for laying hens from 29-48th weeks of age, which included raw soybeans with a lower TI levels, obtained the results showing higher egg mass (63.1 g) compared to the raw standard variety of soybean (62.1 g).

Feeding hens diets containing different soybean varieties during the test did not cause significant changes in egg shape index. A significant ($p<0.05$) influence of the level of raw soybean in diet on the egg shape index was observed. The highest average shape index was measured in eggs of laying hens fed with 2 % raw soybeans (77.74 %), while the use of 8

% of raw soybean influenced the expression of the smallest values of this parameter (77.22 %). Analysis of the interaction of two tested factors indicated very significant differences ($p<0.01$) between the groups. The lowest average values of the shape index during the study form (indicating more oval egg shape) were found in eggs of hens from Lydia-III group while the highest mean egg shape index (the most elongated eggs) were determined in eggs of hens from Lana-I group. Established values of egg shape index (from 76.61 % to 77.82 %) showed the value of this indicator in range of desired values for this property and in accordance with the data obtained by (Mašić and Pavlovski, 1994).

**Table 3.** *Egg quality properties*

| Factor | Variety | Level of raw soybean, % | Parameters | Egg quality properties | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Egg mass(g) | Shape index | Albumen height(0,1mm) | Haugh units | Yolk colour |
| Variety | Lana | | x | 63.30 | 77.39 | 81.47 | 88.20 | 12.01 |
| | | | Sd | 5.05 | 2.15 | 15.49 | 9.28 | 0.72 |
| | Lydia | | x | 63.60 | 77.42 | 80.71 | 87.79 | 12.00 |
| | | | Sd | 5.30 | 2.29 | 14.58 | 8.78 | 0.74 |
| Level of raw soybean, % | | 0% | x | $64.48^{x}$ | $77.27^{b}$ | $82.50^{x}$ | $88.55^{x}$ | 11.92 |
| | | | Sd | 4.94 | 2.32 | 14.96 | 8.57 | 0.73 |
| | | 2% | x | $63.28^{y}$ | $77.74^{a}$ | $81.88^{x}$ | $88.83^{x}$ | 12.09 |
| | | | Sd | 4.79 | 2.31 | 14.68 | 8.69 | 0.73 |
| | | 4% | x | $63.13^{y}$ | $77.39^{ab}$ | $81.72^{x}$ | $88.30^{x}$ | 12.03 |
| | | | Sd | 5.44 | 2.15 | 15.27 | 8.84 | 0.77 |
| | | 8% | x | $62.89^{y}$ | $77.22^{b}$ | $78.25^{y}$ | $86.29^{y}$ | 11.99 |
| | | | Sd | 5.39 | 2.07 | 14.96 | 9.81 | 0.68 |
| Variety x Level | Lana | 0% (K) | x | 64.20 | $77.27^{xy}$ | 83.92 | 89.36 | 12.01 |
| | | | Sd | 4.56 | 2.26 | 14.71 | 8.27 | 0.72 |
| | | 2% (I) | x | 63.10 | $77.88^{x}$ | 81.52 | 88.44 | 12.09 |
| | | | Sd | 4.55 | 2.26 | 16.10 | 9.71 | 0.70 |
| | | 4% (II) | x | 62.70 | $76.98^{y}$ | 80.96 | 87.97 | 11.95 |
| | | | Sd | 5.57 | 2.02 | 15.01 | 8.90 | 0.80 |
| | | 8%(III) | x | 63.20 | $77.47^{xy}$ | 79.48 | 87.02 | 12.01 |
| | | | Sd | 5.39 | 1.98 | 15.94 | 10.08 | 0.64 |
| | Lydia | 0% (K) | x | 64.80 | $77.28^{xy}$ | 81.09 | 87.74 | 11.84 |
| | | | Sd | 5.29 | 2.38 | 15.13 | 8.81 | 0.74 |
| | | 2% (I) | x | 63.50 | $77.61^{xy}$ | 82.24 | 89.23 | 12.08 |
| | | | Sd | 5.01 | 2.37 | 13.17 | 7.55 | 0.76 |
| | | 4% (II) | x | 63.52 | $77.82^{x}$ | 82.48 | 88.64 | 12.10 |
| | | | Sd | 5.30 | 2.21 | 15.54 | 8.80 | 0.73 |
| | | 8%(III) | x | 62.61 | $76.97^{y}$ | 77.01 | 85.55 | 11.98 |
| | | | Sd | 5.41 | 2.14 | 13.87 | 9.51 | 0.72 |
| Two-factorial variance analysis (p value) | | | | | | | | |
| Variety | | | | 0.303 | 0.836 | 0.385 | 0.441 | 0.755 |
| Level of raw soybean | | | | 0.001 | 0.026 | 0.003 | 0.003 | 0.056 |
| Variety x Level | | | | 0.422 | 0.002 | 0.194 | 0.201 | 0.053 |

*x-y, The values in each column without common superscript are significantly different at the level of 1%
*a-b, The values in each column without common superscript are significantly different at the level of 5%

The initial quality of the eggs is important for maintaining the qualities for the direct consumer. Under the influence of different varieties there were no statistically significant differences in the height of egg white. It has been found that the level of 8 % of participation of raw soybean in diet affected significantly lower ($p<0.01$) egg white heights as compared to the other groups. Interaction effect of the studied factors showed no statistically significant differences between groups. Realized average height ranged from (77.01) in the Lydia-III group to (83.92) in the Lydia-K group, which indicated a good initial egg quality but also a great variability of these properties both in groups and within groups. Mašić and Pavlovski (1994), reported that the height of egg white has the greatest variability among internal egg quality traits. Senkoylu et al. (2005), reported that the height of egg white among groups of hens fed diets containing different amounts of full-fat soy is not significantly different.

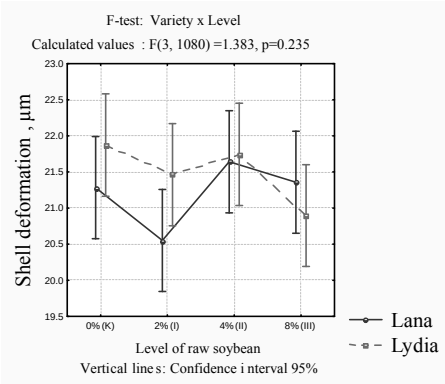
Haugh units featured less variability in relation to the height of egg whites since for an objective assessment of the internal quality of eggs the HU are more appropriate indicator. There was no significant effect of variety on the value of Haugh unit, but it was determined that the level of participation of raw soybean of 8 % in mixtures affect significantly lower ($p<0.01$) values compared to the other groups. In the analysis of the interactive influence of both factors no statistical significance was observed. The average value of Haugh units during the experiment ranged from (85.55) in the Lydia-III group to (89.36) in the group of Lana-K. Senkoylu et al. (2005), reported lower values of the Haugh units (81.8 to 84.2) in comparison to the results obtained in our study.

Soybean varieties and the level of participation of raw soybeans in mixtures, as well as the interaction effect of the studied factors had no statistically significant effect on the intensity of the color of egg yolks in the present research. The average value of the egg yolk color ranged from (11.84) in the Lydia-K group to (12.10) Roshe points in the Lydia-II group. Considering that the mixtures used did not differ in the share of nutrients that can affect the yolk color the average value of this indicator of egg quality was consistent across groups. Jokić et al. (2004), reported that the color of egg yolk may be affected by the increasing participation of xanthophyll- and pigment-rich nutrients that control this feature.

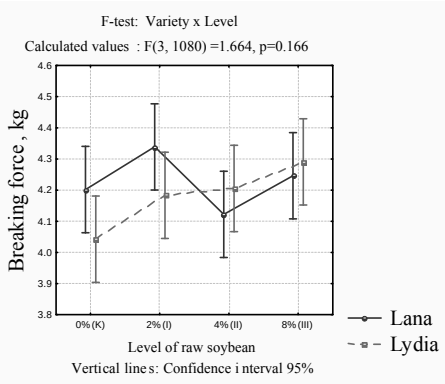
In graphs 1, 2, 3 and 4 the characteristics of eggshell quality are shown. Poor quality eggshell may have a significant economic impact on lowering the value of eggs. The eggshell is the protection of the internal contents of eggs from mechanical damage and contamination. The results indicate that there was no significant effect of soybean varieties and levels of participation of raw soybeans and their interaction effects on indicators of shell strength, deformation, breaking force, mass and shell thickness.

Eggshell deformation is a parameter which indirectly indicates the strength of eggshell. It represents a value that expresses the deflection of eggshell under a pressure of 500 g in the equatorial part of the egg. Lower values of this parameter of the eggshell quality indicate its greater resistance to pressure, or to a potentially tougher/firmer eggshell. The average values of the parameter (Graph 1) in the course of experiment ranged from 20.55 μm in the Lana-I group to 21.87μm in the Lydia-K group. The breaking force indicates a minimum force necessary (expressed in kg) which leads to the breaking of the eggshell. This is a direct indicator of the eggshell strength/firmness. The mean value of this indicator (Graph 2) of eggshell quality ranged from (4.04 kg) in Lydia-K group to (4.34 kg) in Lana-I group. The average value of the eggshell mass (Graph 3) in the study varied from (8.62 g) in Lydia-III group to (8.90 g) in the Lydia-K group, and the average value of the thickness of the shell (Graph 4) varied from (32.49) in the Lydia-K and Lydia-II groups to (33.02) in

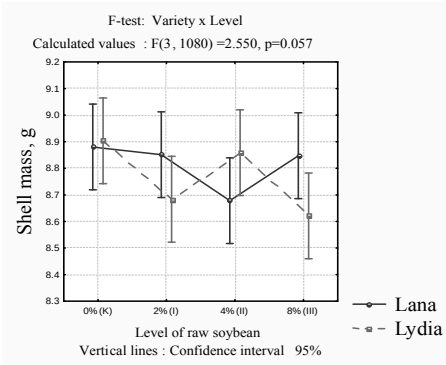
Lydia-III group. Senkoylu et al. (2005), observed no significant differences in egg shell thickness (0.294 mm to 0.298 mm) with a gradual increase in the share of full-fat soybeans in mixtures for laying hens.



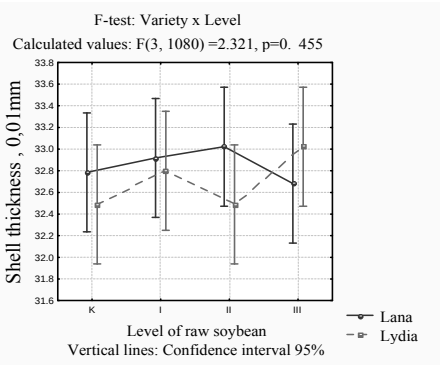

**Graph 1.** *Average shell deformation, µm*




**Graph 2.** *Average breaking force, kg*




**Graph 3.** *Average shell mass, g*




**Graph 4.** *Average shell thickness, 0.01mm*

## Conclusion

Average property values of external and internal egg quality were under the statistically significant influence of the level of participation of raw grain in the mixture. Share of 8% of raw soybean of both varieties in diets for laying hens influenced significantly lower egg mass value, egg shape index, albumen height and Haugh's unit.

Indicators of the strength of egg shell: shell deformation, breaking force, mass, and egg shell thickness were not significantly influenced by the studied factors or under the influence of their interaction effects.

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