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# Effects of Different Proportions of Sorghum (*Sorghum vulgare*) and Methionine Additions in the Rations on Laying Performance and Egg Quality Properties in Hens

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**Abstract:** The effects of substitution of maize with different proportional additions of sorghum and methionine to laying hen rations on egg production and some egg quality properties were investigated in this study. Fifty five week old Lohman laying hens (n = 168) were used. Ration compositions included 49% maize (Control = C), 30% sorghum (Medium Sorghum = MS), MS + 0.2% methionine, MS + 0.4% methionine, 40% sorghum (High Sorghum = HS), HS + 0.2% methionine and HS + 0.4% methionine. The research was carried out in 6 repeated stages. Groups fed sorghum-containing feed showed negative weight gain and reduced egg production (p<0.01). Addition of 0.4% methionine to the ration caused further negative effects on egg production. While the ratio of broken eggs was similar in the Control and MS groups, the other groups had higher egg breakage than the control group (p<0.05). In Control, MS and MS + 0.2% methionine groups, feed consumption and feed benefits were similar, while the other groups were significantly different from Control and MS groups in these aspects (p<0.01). The rations did not affect egg weights, but egg shell quality was determined as the best in the MS+0.2% methionine group and the worst in MS + 0.4% methionine group (p<0.01). The eggshell thickness was the highest in Control and MS + 0.2% methionine groups and the lowest in MS + 0.4% methionine and HS + 0.2% methionine (p<0.05). In summary, sorghum addition to the ration negatively affected the laying performance of the animals and 0.4% methionine further increased this negative effect. Thus, it was determined that the high tannin sorghum content of laying hen rations should not exceed 30%.

**Key words:** *Sorghum vulgare*, methionine, laying hens, egg

## INTRODUCTION

Sorghum is a commonly raised plant, secondary to maize and wheat and it has a good feed composition in terms of nutritional substances. In addition, it needs less water than maize to grow and can be raised in hotter climate conditions, which are important advantages. Brown and white sorghums are raised throughout the world. Brown sorghum includes various proportions of tannin while white sorghum has none of these anti-nutritional substances. The tannin ratios depend on the type and hybrids of sorghum, which can change according to the region it is raised and its glume portion (Pond *et al*., 1995; NRC, 1996).

Animals have different sensitivities towards feed substances containing tannins, which depends on their ability to denature tannins with digestive enzymes. (Begovic *et al*., 1978). The negative effects of tannins in feed substances can be eliminated by soaking, boiling (Mitaru *et al*., 1983; Teeter *et al*., 1986), adding sodium bicarbonate (Banda-Nyirenda and Vohra, 1990) or sulfur-containing amino acids (Armstrong *et al*., 1973; Imik *et al*., 1974; Hagerman and Butler, 1981; Jacob *et al*., 1996; Mitarru *et al*., 1983; Teeter *et al*., 1986). The animals with most resistance to tannins are goats and the most sensitive ones are avian species (Begovic *et al*., 1978).

Previous reports have revealed that tannins in sorghum negatively affect the nutrient performance of animals and the digestibility of feeds (Ebadi *et al*., 2005; Elkin *et al*., 1990, 2002; Imik *et al*., 2008; Jacob *et al*., 1996; Nelson *et al*., 1975 Nyachoti *et al*. 1997; Sell *et al*., 1983). Condensed tannins limit activities of some enzymes and microorganisms by forming complexes with nutrients and prevent their dissolution in the digestion system (Ebadi *et al*., 2005; Lizardo *et al*., 1995; Mansoori and Acamovic, 2007; Mcsweeney *et al*., 2001; Mehansho *et al*., 1987; Nelson *et al*., 1975). However, some reports have indicated that sorghum containing only low or intermediate levels of tannin does not negatively influence the performance of animals (Armstrong *et al*., 1974; Hulan and Proudfoot., 1982; Imik *et al*., 2006; Nyachoti *et al*., 1996).

Proportions of up to 20% sorghum added to the poultry rations exhibited appropriate results in previous studies (Imik *et al*., 2006, 2007). This study was aimed to determine the effects of substitution of maize with higher proportions of sorghum and of sorghum plus methionine to laying hen rations on laying performance and egg quality.

## MATERIALS AND METHODS

Fifty five weeks of ages Lohman laying hens (n = 168) were used in this study carried out during 13 weeks in the poultry science unit of Ataturk University. The research was conducted with 6 replications per treatment. Four hens were placed together into cages with dimensions of 50×46×46 cm. The hens were divided into 7 groups according to the 7 different experimental rations used in the study, as shown in Table 1. Animals were fed every day at 8:30 am. Water and feed were supplied *ad libitum* during the study.

Raw protein values of the feeds were determined by the dry matter AOAC method (1990), raw cellulose according to Van Soest and Robertson (1985) and ME, Ca, P, lysine and linoleic acid through calculations. The tannin content of sorghum used in experimental rations was determined using Folin-Denis solutions (AOAC, 1990). Feed consumption and egg fertility were measured daily, egg weights were measured weekly and body weights were determined at the beginning, middle and end of the study.

To determine the egg quality, 12 eggs were selected randomly from each group in the 12th week of the study. Specific gravity of eggs was assessed by using the following formula according to Archimedes method (Hempe *et al*., 1988).

$$\text{Specific gravity} = \frac{\text{Weight in air (g)}}{\text{Weight in air (g)} - \text{Weight in water (g)}}$$

Eggs were first measured with a compass to obtain short and long diameters at a 0.001 sensitivity, to determine the shape indexes. The eggs were then broken and left to stand for 5 min, then heights of egg yolk and albumen and the short and long diameters of albumen and the yolk diameter were measured with a compass. Egg yolks were separated from albumen and their weights were recorded. Shells of broken eggs were washed under the lightly running tap water and albumen residue was cleaned and dried. Then they were weighed with the aim of determining their weights and membrane proportion. Shell thicknesses at the equator, the obtuse and the sharp ends of the egg were measured with a compass. The data pertaining to these parameters were input into the following formulas to yield the final values.

Table 1: Research groups, rations given to groups and nutritional components of rations

| | | Methiyonine (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Sorghum 30% | | | Sorghum 40% | | |
| | Control | 0 | 0.2 | 0.4 | 0 | 0.2 | 0.4 |
| Corn | 49 | 28.79 | 28.85 | 28.95 | 18.7 | 18.7 | 18.8 |
| Sorgum | - | 30 | 30 | 30 | 40 | 40 | 40 |
| Sunflowers meal | 10.1 | 9 | 9 | 9 | 9 | 9 | 9 |
| Wheat | 8.65 | - | - | - | - | - | - |
| Soybean meal | 14.23 | 13.9 | 13.9 | 13.9 | 14 | 14 | 13.6 |
| Vegetable fat | 1.4 | 1.6 | 1.6 | 1.6 | 1.85 | 1.85 | 1.85 |
| Full fat soybean | 5 | 5.1 | 4.9 | 4.6 | 5 | 4.8 | 4.9 |
| Fish meal | 0.5 | 0.62 | 0.55 | 0.55 | 0.3 | 0.3 | 0.3 |
| Dicalcium-P | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 |
| limestone | 9.32 | 9.19 | 9.2 | 9.2 | 9.3 | 9.3 | 9.3 |
| salt | 0.3 | 0.3 | 0.3 | 0.3 | 0.35 | 0.35 | 0.35 |
| Vitamin-mineral premix | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Dl-Methionine | 0 | 0 | 0.2 | 0.4 | 0 | 0.2 | 0.4 |
| **Nutritional levels of basal diet** | | | | | | | |
| Crude protein (%) | 17 | 17 | 17 | 17 | 17 | 17 | 17 |
| ME (kcal $kg^{-1}$) | 2696 | 2709 | 2710 | 2711 | 2706 | 2707 | 2712 |
| Ca (%) | 3.96 | 3.96 | 3.95 | 3.99 | 3.95 | 3.94 | 3.94 |
| P (%) | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Lysine (%) | 0.79 | 0.76 | 0.75 | 0.74 | 0.76 | 0.73 | 0.72 |
| Linoleik asit (%) | 2.09 | 2.13 | 2.11 | 2.09 | 2.15 | 2.13 | 2.14 |

[2]Dicalcium-P = dicalcium phoshate (Ca, 24%; P, 17%). Per kg vitamin-mineral premix provides 8000 IU vitamin A, 1000 IU cholecalciferol, 15 mg á-tocopheryl acetate, 3 mg menadione, 5 mg riboflavin, 40 mg niacin, 2 mg thiamin, 0.6 mg folic acid, 15 μg vitamin $B_{12}$, 70 mg Mn, 50 mg Zn, 30 mg Fe, 5 mg Cu, and 0.3 mg Se. [3]ME = Metabolizable Energy; CP = Crude Protein

$$\text{Shape index: } \frac{\text{Short diameter}}{\text{Long diameter}} \times 100$$

$$\text{Yolk index: } \frac{\text{Yolk height}}{\text{Yolk diameter}} \times 100$$

$$\text{Albumen index: } \frac{\text{Albumen height}}{\left(\frac{\text{Long diameter of albumen} + \text{short diameter}}{2}\right)} \times 100$$

$$\text{Shell thickness: } \left(\frac{\text{(Sharp end + equator + obtuse end)}}{3}\right)$$

$$\text{Shell membrane thickness: } \left(\frac{\text{(Sharp end + equator + obtuse end)}}{3}\right)$$

Haugh unit: $100 \times \log(\text{Albumen height} + 7.57 - 1.7 \times \text{egg weight}^{0.37})$ (Nesheim *et al*., 1979).

Differences in the data were examined by analysis of variance and the differences between groups were determined with the Duncan's Multiple Range Test. Statistical analyses were made using the SPSS.10.01 software program (SPSS, 1996).

Table 2: Effects of experimental rations on parameters of egg laying performance (n = 168)

| | Initial BW (kg) | Final BW (kg) | Chage BW (%) | Egg production (%) | Defective egg (%) | Egg weight (g) | FI (g) | FCR (kg) |
|---|---|---|---|---|---|---|---|---|
| Control | 1.65 | $1.79^{a}$ | $7.83^{a}$ | $87.87^{a}$ | $0.57^{a}$ | 67.67 | $110.53^{a}$ | $1.64^{a}$ |
| MS | 1.63 | $1.47^{bc}$ | $-10.46^{b}$ | $75.38^{b}$ | $1.74^{ab}$ | 66.66 | $109.37^{a}$ | $1.64^{a}$ |
| MS+0.2% | 1.73 | $1.62^{ab}$ | $-7.03^{b}$ | $75.40^{b}$ | $2.67^{b}$ | 68.39 | $106.26^{ab}$ | $1.56^{ab}$ |
| MS+04% | 1.66 | $1.54^{bc}$ | $-7.61^{b}$ | $63.70^{c}$ | $3.76^{b}$ | 67.67 | $101.89^{bc}$ | $1.52^{b}$ |
| HS | 1.65 | $1.45^{bc}$ | $-12.20^{b}$ | $60.78^{c}$ | $2.22^{b}$ | 66.65 | $102.07^{bc}$ | $1.54^{b}$ |
| HS+0.2% | 1.73 | $1.48^{bc}$ | $-14.23^{b}$ | $61.67^{c}$ | $3.13^{b}$ | 66.24 | $101.19^{bc}$ | $1.54^{b}$ |
| HS+0.4% | 1.66 | $1.34^{c}$ | $-19.17^{b}$ | $55.42^{d}$ | $4.60^{b}$ | 68.87 | $99.24^{c}$ | $1.52^{b}$ |
| SEM | 0.03 | 0.07 | 3.55 | 1.40 | 0.56 | 0.84 | 1.77 | 0.03 |
| probability< | 0.34 | 0.01 | 0.001 | 0.000 | 0.05 | 0.61 | 0.000 | 0.002 |

MS = Medium Sorghum (30%); HS = High Sorghum (40%); [2]BW = Body Weight; FI = Feed Intake (daily average); FCR = Feed Conversion Ratio (kg feed consumed/kg egg produced)

Table 3: Effect of experimental rations on egg quality parameters (n = 84)

| | Parameter | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Experimental diets | Shape index (%) | Shell weight | Shell thickness | Yolk weight | White index | Yolk index | Haugh unite | Specific gravity |
| Control | 74.90 | $6.53^{ab}$ | $0.34^{a}$ | $17.56^{ab}$ | 1.81 | 38.41 | 74.64 | 1.08 |
| MS | 75.73 | $5.84^{bc}$ | $0.29^{ab}$ | $17.34^{b}$ | 1.90 | 38.11 | 76.59 | 1.07 |
| MS+0.2% | 73.89 | $6.88^{a}$ | $0.34^{a}$ | $18.95^{a}$ | 1.70 | 39.23 | 71.88 | 1.08 |
| MS+0.4 | 71.89 | $5.64^{c}$ | $0.26^{b}$ | $18.49^{ab}$ | 1.88 | 38.21 | 75.96 | 1.07 |
| HS | 73.12 | $5.80^{bc}$ | $0.31^{ab}$ | $18.43^{ab}$ | 1.81 | 37.19 | 74.52 | 1.07 |
| HS+0.2% | 72.00 | $5.84^{bc}$ | $0.27^{b}$ | $17.53^{ab}$ | 1.80 | 37.92 | 74.10 | 1.07 |
| HS+0.4% | 74.10 | $6.02^{bc}$ | $0.28^{ab}$ | $19.05^{a}$ | 1.89 | 40.32 | 75.83 | 1.07 |
| SEM | 0.97 | 0.22 | 0.02 | 0.44 | 0.10 | 0.88 | 2.14 | 0.00 |
| Probability< | 0.25 | 0.004 | 0.02 | 0.05 | 0.84 | 0.37 | 0.8 | 0.10 |

MS = Medium Sorghum (30%); HS = High Sorghum (40%)

## RESULTS

The tannin content of the sorghum used in this study was determined to be 0.67%. Laying performance values of the experimental groups are presented in Table 2. The live weight changes of all groups given sorghum and methionine dropped significantly compared to the control group ($p<0.001$). Egg production for all groups fed sorghum dropped significantly compared to the control group ($p<0.001$). The addition of 0.4% methionine to the ration resulted in further negative effects on egg production. While broken egg ratios were similar in control and MS groups, broken egg ratios in MS + 0.2%, MS + 0.4%, HS, HS + 0.2% and HS + 0.4% groups were significantly higher than in the control group ($p<0.05$). Feed consumption in the MS + 0.4%, HS, HS + 0.2% and HS + 0.4% groups were lower than control and MS groups ($p<0.001$) but benefits from feed were higher ($p<0.01$).

In this study, while there were no deaths in the control group during the research, deaths in MS, MS + 0.2%, MS + 0.4%, HS, HS + 0.2% and HS + 0.4% groups were 2.38, 1.19, 3.57, 2.98, 1.79 and 5.95%, respectively.

These findings, including the effect of sorghum on egg quality, are presented in Table 3. The shells were thickest in the MS+0.2% group and thinnest in the MS+0.4% group ($p<0.01$). No significant differences in shell weight were observed in the MS, MS+0.4%, HS, HS+0.2% and HS+0.4% groups, but it was highest in Control and MS groups and lowest in the MS+0.4% group ($p<0.5$). No significant difference was seen between control, MS, MS+0.2%, HS, HS+0.4% and MS, MS+0.4%, HS, HS+0.4% groups. Egg yolk weight was highest in the MS+0.2% and HS+0.4% groups and lowest in the MS group ($p<0.05$).

The effects of experimental rations on the shape index, albumen index, yolk index, Haugh unit and specific gravity were not found to be significant.

## DISCUSSION

Condensed tannins negatively influence the energy and mineral metabolism by forming complexes with feed components and these do not dissolve in the digestion system. This results in limitations of nutrients and limited activities of enzymes and microorganisms in the digestive tract (Ebadi *et al*., 2005; Imik *et al*., 2008; Lizardo *et al*., 1995; Mansoori and Acamovic, 2007; Mcsweeney *et al*., 2001; Mehansho *et al*., 1987; Nelson *et al*., 1975).

Elkin *et al*. (2002) reported that maize increased daily live weight gains by 60.2 g in broilers and that, for groups fed different varieties of sorghum at quantities of 25-40 g, feed consumptions of 246, 187 and 228 g resulted in feed benefits of 4.10, 5.17 and 7.57 g, respectively. Other studies have reported similar results (Armonious *et al*., 1973; Armstrong *et al*., 1973; Elkin *et al*., 1990; Jacob *et al*., 1996; Mitaru *et al*., 1983). The substitution of maize with sorghum containing high ratios of tannins (0.67%) in this study negatively affected performance values of hens in aspects such as final BW, changes in BW, egg production, defective eggs, feed intake and FCR.

The reasons for the performance drop in laying hens were due to the high tannin from the sorghum included in the ration. Thus, a higher tannin ratio led to a lower egg production and a lower feed intake.

In contrast to findings in the present report, sorghum did not negatively influence performance of animals in other studies (Hulan and Proudfoot, 1982; Imik *et al*., 2006; Nyachoti *et al*., 1996). Some possible reasons for this can be due to the use of different animal breeds in this research, the laying capacities of the hens and the different tannin ratios of different sorghum varieties.

Since tannins are highly sensitivity against proteins, provision of essential amino acids is a primary detoxification process. It is thought that these amino acids bind tannins and improve the performance of the animals by allowing better digestion of the foodstuffs (Armstrong *et al*., 1973; Imik *et al*., 2007; Sell and Rogler, 1984; Teeter *et al*., 1986). Some studies showed that while amino acid additions to basal rations had positive effects on performance, further addition had no positive effects on laying functions (Bunchasak and Silapasorn, 2005; Loughmiller *et al*., 1998; Narváez-Solarte *et al*., 2005; Rosell and Zimmerman, 1985; Tsiagber *et al*., 1982).

Some researchers Elkin *et al*. (1990), Imik *et al*. (2007) and Sell and Rogler (1984) have pointed out that addition of nutrients such as methionine, choline, glutamate and lysine eliminated the negative effects of tannins and improved animal performance. In the current study, 0.2% methionine addition to MS significantly improved the feed benefit, as has been reported in other previous studies (Armstrong *et al*., 1973; Sell and Rogler, 1984). Methionine and choline added to poultry rations counteracted the negative effect of tannin in the ration within certain proportions. However, they were unable to counteract tannic acid added to the same rations and production performance of the animals was negatively affected (Armonious *et al*., 1973; Armstrong *et al*., 1973).

Animals can tolerate, in limited ratio, some amino acids such as methionine, arginine and lysine in excess of that needed for normal metabolism (Buttery and D'mello, 1994). In addition, methionine digestion limits the metabolism of some other amino acids (Benevenga, 1974; Harter and Baker, 1978; Simth and Austic, 1978). Amino acid imbalances are well known to negatively affect performances of animals (Buttery and Mello, 1994; Loughmiller *et al*., 1998; Rosell and Zimmerman, 1985).

In this study, while deaths were not seen in the control group fed maize rations during the research, deaths were seen in the groups given sorghum, concomitant with the drops in live weight gains. Addition of 0.2% methionine to the MS ration decreased the death ratio from 2.38-1.19% and in the HS ration from 2.98-1.79%. In contrast, addition of 0.4% methionine increased the death ratios to 3.57% in MS and to 5.95% in HS.

Tannins from sorghum also have negative effects on the digestion of vitamins and minerals that are needed for formation of shells and for general metabolism (Al-Mamary *et al*., 2001; Imik *et al*., 2006; Mcsweeney *et al*., 2001). Neither the 22% sorghum containing low ratios of tannin (0.26%) nor the addition of methionine to this sorghum ration fed to laying hens at their peak laying period affected egg quality properties, although, they did decrease shell thickness and contents of lysine, choline and sulfur in layers in significant ratio. The lysine content of the yolks was decreased but the yolk color was increased. Bunchasak and Silapasorn (2005) pointed out that 0.26, 0.30, 0.38, 0.44% ratios of methionine addition to a basal ration involving 14% raw protein had negative effects on egg shell weights and thicknesses, proportional to the increasing ratios of methionine. In some studies (Bunchasak and Silapasorn, 2005; Imik *et al*., 2006), different rations and ovulation periods can be considered as reasons for the different findings.

## CONCLUSION

In this study, provision of 30 and 40% ratios of high tannin (0.67%) sorghum, instead of maize, in the rations of laying hens decreased egg production of the animals significantly. Addition of 0.20% methionine to the sorghum rations did not negatively affect other parameters including benefits from feed, shell weight and thickness and live weight loss. However, increasing the methionine level to 0.4% created an imbalance and significantly reduced functions of production. Thus, high tannin sorghum should not make up more than 30% of the ration of laying hens.

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