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Effect of Tomato Waste Meal Diets on Egg Fertility, Hatchability, Embryonic Mortality, Chick's Quality and Economic Assessment of White Leghorn Layers

Research Article

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ABSTRACT

The experiment was conducted at poultry unit, Haramaya University, Haramaya, Ethiopia to determine the effects of tomato waste meal supplementation on egg fertility, hatchability, embryonic mortality, chick's quality and economic analysis of white leghorn chickens. In this experiment, 180 white leghorn layers along with 30 males (41 weeks old age and average body weight of 1.44 kg) were allocated into five experimental groups *viz.*, basal diet + 0.0% tomato waste meal (TWM0), basal diet + 6.5% TWM (TWM6.5), basal diet + 13.0% TWM (TWM13), basal diet + 19.5% TWM (TWM19.5), and basal diet + 26.0% TWM (TWM26) with three replications and each replication have 12 layers and two males. During the experimental period, egg fertility, hatchability, embryo mortality, chick quality and economic analysis were collected and analyzed. The results showed that inclusion of tomato waste meal was non-significantly affected the egg fertility and hatchability. However, chick's quality significantly (P<0.001) was superior observed in TWM 19.5 (95.3%) as compared to TWM13 (95.00%), TWM6.5 (91.7%), TWM0 (89.7%) and TWM26 (86%) by visual score method. But chick quality on the basis of chick's weight and length recorded non-significant. The results obtained from economic assessment analysis indicated that inclusion of TWM improved the economics of egg performance which is attributed to the high cost of maize. Thus, TWM inclusion improved egg fertility, hatchability, chick's quality and profitability. In conclusion, TWM can be used as an alternative feedstuff for laying hens along with maize at inclusion levels up to 19.50 percent without any negative impact on egg fertility, chick's quality, embryonic mortality and economic analysis. Therefore, inclusion of TWM in white leghorn diets at up to 19.5 percent is recommended from 41 weeks to 72 weeks of age.

KEY WORDS chick quality, economic assessment, embryonic mortality, feed intake, fertility.

INTRODUCTION

Chickens are raised in many parts of the globe, regardless of climate, traditions, or living standards, and there are no religious prohibitions against eating eggs or chicken meat, as there are for pig meat (Tadelle, 2003). Chickens provide an instant supply of meat and revenue for the poor majority of people in rural regions when money is required for a family emergency (Ekue *et al.* 2002). It makes a considerable contribution to human well-being and helps to ensure food security (Gondwe, 2004) notably in terms of providing individuals with animal protein. The daily animal protein consumption per capita in most developing nations is below the FAO's recommended level (FAO, 2008). Particularly in Ethiopia, yearly chicken meat and egg consumption per capita is projected to be close to 0.12 and 0.14 kilogram, respectively, on a national level (Lalisa, 2010). Poultry production, as compared to other livestock species, is the quickest way to fill the gap in animal protein shortfall since it has short generation intervals, strong environmental tolerance, and requires a small agricultural infrastructure (Gulilat *et al.* 2018). However, availability, quality and cost of feed ingredients are the major constraints to poultry production regardless of the system of production and geographical location (Etalem, 2006). The rivalry for feeds between humans and poultry, such as maize, sorghum, soybeans, and groundnuts, is another expression of the feed challenge (Samsami *et al.* 2021).

Tomato is one of the most widely grown vegetables in the world, according to Rossini *et al.* (2013), both for direct consumption and for the creation of tomato derivatives. Tomato output has been gradually expanding worldwide, with total yearly production rising from 129 million tons in 2005 to 163 million tons in 2013 (FAO, 2008). Tomato is a tremendous source of vitamins A, C and potassium and as well as superior sources of α-tocopherol (Seid *et al.* 2021) and bioactive compounds *e.g.,* amino and fatty acids, carotenoids and polyphenols (Jalalinasab *et al.* 2014). The dried tomato waste sampled contained 42.1 gm/kg ash, 524.4 g/kg crude fiber, 21.9 g/kg fat, and 176.2 g/kg protein (Jalalinasab *et al.* 2014). Both fresh and processed tomato possesses a high nutritional value, due to its content of vitamins, folates, carotenoids and phenolic compounds (Savatovic *et al.* 2010). Tomato pomace skins and seeds are commonly dried in the shade or sunshine before being fed to animals (Poore *et al.* 2008). Thus, tomato waste meal is a possible feedstuff for poultry in several nations. As a result, the current study was able to determine the impact of various levels of tomato waste meal inclusion on fertility, hatchability, embryonic mortality, chick quality, and economic evaluation of white leghorn layers ration.

MATERIALS AND METHODS

Description of the experimental site and location

The experiment was conducted at Poultry Farm, Haramaya University, Dire Dawa, Ethiopia during 2017-2018. The university was located in East at about 515 km away from Addis Ababa on 42˚ 3´ E longitude, 9˚ 26´ N latitude and an altitude of 1980 m above sea level. The mean annual rainfall of the area is 780 mm and the average minimum and maximum temperature are 8 ˚C and 24 ˚C, respectively (Mishra *et al.* 2004).

Experimental design and feed formulation

A total of 180 white leghorn layers (41 weeks old age) along with 30 male cocks were obtained from Poultry Farm, Haramaya University with similar body weight and age. Then experimental birds were allotted in to five dietary treatments *viz.,* basal diet + 0.0 % tomato waste meal (TWM0), basal diet + 6.5% TWM (TWM6.5), basal diet + 13.0% TWM (TWM13), basal diet + 19.5% TWM (TWM19.5), and basal diet + 26.0% TWM (TWM26) with three replications and each replication have 12 layers and two males. Feed materials were procured from local market in row form than feed formulated at own basis on poultry farm (NRC, 1994). Tomato waste meal was prepared by spreading the fresh tomato waste on plastic sheet on ground and dried for a day in a direct sun light. Then, it was dried for an extra 5 to 6 days under shade with good ventilation because tomato waste meal contained more moisture level. After proper dried, tomato waste meal grinded by hummer milled.

Management of experimental birds

Before arrival of experimental birds; pens, watering and feeding troughs were cleaned and disinfected. The experimental birds were kept in pens and each pen sized of 2 m × 2.5 m. The wood shaving and hay was used as a litter material. On the first day (after one week adaptation period) of the start of the experiment, layers were provided water with vitamin premix (15 mm vitamin premix in 10 litter water). On the second day of the experiment, layers were vaccinated against Newcastle disease and medications provided using broad spectrum antibiotics.

The birds were raised on deep litter system for twelve weeks starting from the actual time of data collection. Feed and water were offered to the layers every day in to two equal parts through *ad libitum*.

Chemical composition of experimental feed

The chemical composition of ration is presented in Table 1. The experimental ration was formulated on an iso-caloric and iso-nitrogenous basis in such a way to consist 2750 to 2900 kcal metabolizable energy (ME) per kg DM and 16.5 to 17.00 percent crude protein (CP) (NRC, 1994). Ration was formulated by using feed win interactive software and excel based on layer metabolic energy and crude protein requirement. The chemical properties of ration were analysed (AOAC, 1990).

Data collection

Fertility and hatchability tested were taken in three rounds and computed mean value. A total of 1350 medium-sized eggs (270 eggs/treatment or 90 eggs/replication) were randomly selected, stored in cold room (14 ˚C) for one week than incubated in three batch and each batch incubated 450 eggs. The fertility and hatchability of eggs were determined by the following formulas.

Fertility (%)= (total number of fertile eggs/total number of eggs set) × 100

Hatchability percentage (on fertile egg basis)= (total number of chicks hatched/total number of fertile eggs) × 100
Hatchability percentage (on total egg basis)= (total number of chicks hatched/total number of eggs set) × 100

Embryonic mortality was determined by candling method of eggs at 14th and 18th days of incubation and at hatching on three times tested periods. Eggs also opened for visual observation, and classified according to time of embryonic mortality was determined 5 to 8 days for the first, 14 days for the second and 18 days for the last time. According to Butcher and Nilipour (2009), the stages of development were classified as early, mid, and late embryonic mortality. Embryonic mortality was computed according to the formula given by Rashed (2004).

Early mortality (%)= (total number of early dead embryo/total number of fertile eggs) × 100
Mid mortality (%)= (total number of mid dead embryo/total number of fertile eggs) × 100
Late mortality (%)= (total number of late dead embryo/total number of fertile eggs) × 100

Chick quality was measured using three different methods: visual scoring, measuring day old chick weight and measuring day old chick length on the three tested periods.

Visual scoring of chicks was determined by North (1984) concept. According to North (1984) quality standards refers to chicks that are not malformed, physically active, stand up well and look lively.

Quality chicks of visual score (%)= (total number of quality chicks /total number of hatched chicks) × 100

To estimate the economic benefits of the incorporated inclusion level of tomato waste meal with layer diets in white leghorn layer ration, the partial budget analysis developed by Upton (1979) and the net profit per bird and benefit cost ratio were employed. To calculate the feed cost for each treatment, the costs of feed ingredients were used registered at purchase and the feed consumed by birds was multiplied by the cost of the ingredient. Cost of transport, labour and other materials expenditure was also considered. The sale price of egg at Haramaya University during study period was used to calculate income from eggs. Net return (NR) per bird was calculated as the amount of money left when total variable costs (TVC) plus depression cost are subtracted from total returns (TR). The calculation was done according to Upton (1979). Net return was calculated as the difference between total return and total production cost.

NR= TR – TVC

Table 1 Proportion of ingredients (%) used in formulating the experimental diets

Ingredients	Treatments[1] TWM 0%	TWM 6.5%	TWM 13%	TWM 19.5%	TWM 26%
Maize	43.6	45.4	52	50	50
Wheat	18.5	15	2	0.5	0
Nuge seed cake	15	5.5	2.5	0.5	0.5
Soybean meal	7.52	15.22	18.12	14.12	7.62
Groundnut cake	6	3	3	4.5	0.5
Bone and meat meal	2	2	2	3.5	8
General layer premix	0.5	0.5	0.5	0.5	0.5
HCL-lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.13	0.13	0.13	0.13	0.13
Di calcium phosphate	0.5	0.5	0.5	0.5	0.5
Limestone	5.5	5.5	5.5	5.5	5.5
Salt	0.5	0.5	0.5	0.5	0.5
Tomato waste meal	0	6.5	13	19.5	26
Total	100	100	100	100	100
ME (Kcal/kg)	2890	2873	2888	2823	2753
Crude protein (%)	16.7	16.6	16.6	16.5	16.5
Crude fiber (%)	7.6	8	8.2	9.1	9.85
Calcium (%)	2.47	2.65	2.71	2.77	2.78
Phosphorus (%)	0.30	0.32	0.34	0.35	0.37

[1] TWM0%: basal diet (BD) + 0% TWM; TWM6.5%: BD + 6.5% TWM; TWM13%: BD + 13.0% TWM; TWM19.5%: BD + 19.5% TWM and TWM26%: BD + 26% TWM.

RESULTS AND DISCUSSION

The effect of different levels of tomato waste meal diets on eggs fertility and hatchability are presented in Table 2. The logistic regression results for fertility, hatchability on total egg base and hatchability on fertile egg bases showed non-significant difference (pr> chiSq 0.09, 1.01 and 0.52 at α=0.05) with Wald chiSq value of 8.12, 7.77 and 3.26, respectively between experimental treatments. However, there was a slightly improvement in egg fertility percentage as a result of increasing tomato waste meal level in the basal diet up to 19.5 percent inclusion. This may be due to the increasing crude protein content of the ration. Protein content of feed is known to affect fertility of egg and its hatchability. This result is in line with value reported by Haftu *et al.* (2012) and Alemayehu *et al.* (2015) who reported non-significant difference in fertility and hatchability of eggs obtained from white leghorn layers fed with fish waste meal and malted barley grain as a substitution for maize. More ever, Gabreil *et al.* (2006) reported that level of dietary protein significantly affected egg fertility and hatchability and poor hatching results occur when nutritionally deficient feeds are used for layer. Hocking *et al.* (2002) and Odunsi *et al.* (2002) also stated that inadequacy of nutrients in the breeder diets resulted in poor hatchability of fertile eggs. Thus, the result indicated that inclusion of tomato waste meal level in layer basal diets up to 19.5 percent did not altered nutrients that enhance fertility and hatchability of eggs.

The effect of different levels of tomato waste meal diets on embryonic mortality is presented in also Table 2. The logistic regression result of early, mid, late and pipe embryonic mortalities provided a Wald value of 0.77, 0.31, 0.36 and 4.81 with pr > ChiSq value of 0.95, 0.99, 0.99 and 0.31, respectively, which showed non-significant difference at all stages of development among the treatments. The results of present study are agreement with Haftu *et al.* (2012) who observed non-significant effect (P>0.05) on embryonic morality of eggs obtained from white leghorn chicken fed diets containing different proportion of malted barley grain as a substitute for maize. Embryonic mortality recorded in the present experiment was contrary with that reported value by Senayt *et al.* (2011). Hocking *et al.* (2002) noted that embryonic mortality of eggs in breeder hen fed low protein was higher than that of hens fed with high protein diets. Since the protein level in the present experiment fulfilled the requirement of laying birds in all treatment rations, differences in embryonic mortality are not expected.

Effect of various levels of tomato waste meal on, visual scoring of chicks, chicks' weight and chick's length are presented in Table 3. The results showed that TWM19.5 (95.30%) was found significantly (P<0.001) superior chicks' quality as compared to TWM13 (95.00%), TWM6.5 (91.30%), TWM0 (89.70%) and TWM26 (86.00%) by visual scoring of chick's method. The major problems observed were deformed legs and toes which were firm and straight in some of the chicks across the treatment indicating that the problem is related to any specific treatment. Such cases were also reported in previous studies and attributed to condition encountered in the incubator or the strains used (Funk and Irwin, 1995; Raghavan, 1999).

Effect of various levels of tomato waste meal on chicks' weight is also presented in Table 3. The chick weight of white leghorn layers fed ration containing different levels of tomato waste meal in basal diets were noted non-significant (P>0.05) differences between experimental treatments. As documented by Wilson (1991), egg weight has a direct impact on the weight of chicks and there is a positive correlation between egg weight and chick weight. Sahin *et al.* (2009) also noted variation in chick weight due to differences in the weight of eggs incubated. However, Alemayehu *et al.* (2015) observed check weight to be affected by different proportion of fish waste meal in white leghorn layers ration. The chick length of white leghorn layers fed ration containing different inclusion levels of tomato waste meal incorporated with basal diets were recorded non-significant (P>0.05) between experimental treatments. The chick length of layers obtained in the present experiment was directly correlated with the chick weight. Chicks with better yolk utilization could have developed more body mass during the incubation period, and therefore grew longer (Meijerhof, 2006). Meijerhof (2005) has reported the importance of chick length as a more practical way to measure chick development.

The economic return in terms of net profit and cost benefit ratio from egg sale and commercial feed costs are calculated and presented in Table 4. Except feed cost, other cost was constant and feed cost was only factor that differed the total production cost of White leghorn birds. The total cost of production per layer was highest in TWM19.5 (346.82 Birr) and gradually lower in TWM13 (Birr 345.81), TWM6.5 (Birr 344.97), TWM0 (Birr 343.80) and TWM26 (Birr 340.94) dietary treatments. As the tomato waste meal is waste feed material in study area. That's why cost of tomato waste meal was added in economic evaluation. The total cost of production per layer highest was recorded in TWM19.5 and the total return per bird also maximum in TWM19.5. The main cause of maximum profit in TWM19.5 group was more egg production yielded by layers. In the present study net profit per bird was highest in TWM19.5 (Birr 122.36) group followed by TWM6.5 (Birr 94.59), TWM13 (Birr 89.90), TWM0 (Birr 72.51) and TWM26 (Birr 70.42) groups.

Table 2 Effect of different levels of tomato waste meal diets on egg fertility, hatchability and embryonic mortality of white leghorn layers

Parameters	Treatments[1]					SEM	LS
	TWM 0%	TWM 6.5%	TWM 13%	TWM 19.5%	TWM 26%		
Fertility (%)	91.7	96	97.7	97.3	89.7	0.79	NS
Hatchability on fertile egg base (%)	82.67	84.00	85.67	92.67	76.67	1.27	NS
Hatchability total egg base (%)	76	80.3	83.3	90	69	0.92	NS
Early embryonic mortality (%)	3.3	4.67	2.67	2.3	4.67	0.8	NS
Middle embryonic mortality (%)	4	3.67	2.67	1.3	4.67	0.6	NS
Late embryonic mortality (%)	5.67	3.3	2.67	1	4.67	0.8	NS
Pipe embryonic mortality (%)	5.67	4.67	5.33	3	9	0.77	NS

[1] TWM0%: basal diet (BD) + 0% TWM; TWM6.5%: BD + 6.5% TWM; TWM13%: BD + 13.0% TWM; TWM19.5%: BD + 19.5% TWM and TWM26%: BD + 26% TWM.
SEM: standard error of the means.
LS: least significant.
NS: non significant.

Table 3 Effect of different levels of tomato waste meal diets on chick quality of white leghorn layers

Parameters	Treatments[1]					SEM	P-value	LS
	TWM 0%	TWM 6.5%	TWM 13%	TWM 19.5%	TWM 26%			
Quality chick visual score	89.7[b]	91.7[b]	95[a]	95.3[a]	86[c]	0.73	0.46	0.001
Chick weight (gm)	34.3	34.67	34	34.3	34.3	0.39	0.83	NS
Chick length (cm)	17	18	16	16.7	16	1.1	0.54	NS

[1] TWM0%: basal diet (BD) + 0% TWM; TWM6.5%: BD + 6.5% TWM; TWM13%: BD + 13.0% TWM; TWM19.5%: BD + 19.5% TWM and TWM26%: BD + 26% TWM.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.
LS: least significant.
NS: non significant.

Table 4 Effect of tomato waste meal on economic analysis of white leghorn layers

S.N.	Attributes	TWM (0%)	TWM (6.5%)	TWM (13%)	TWM (19.5%)	TWM (26%)
A.	Variable cost					
1.	Price of bird (Avg. BW 1.44 kg/bird @ 83.33 Birr/kg BW)	120	120	120	120	120
2.	Total feed consumption /bird (kg)	8.19	8.26	8.31	8.37	8.02
3.	Cost of Tomato waste meal (Birr[2])	0.0	0.0	0.0	0.0	0.0
4.	Cost of experimental feed (Birr 15.0/kg)	122.85	123.90	124.65	125.55	120.30
5.	Misc. expenditure *i.e.*, building rent, medicine, water and labour charges etc. (Birr).	15.00	15.00	15.00	15.00	15.00
6.	**Total variable cost (Birr)**	**257.85**	**258.9**	**259.65**	**260.55**	**255.3**
7.	Interest on total variable cost @ 12%	30.95	31.07	31.16	31.27	30.64
8.	**Grant total of variable cost (Birr)**	**288.80**	**289.97**	**290.81**	**291.82**	**285.94**
B.	**Fixed cost**					
9.	Area of poultry unit used = 1 birds @ 1 Sq. ft/bird (Birr 50/Sq. ft.)	50.00	50.00	50.00	50.00	50.00
10.	Depreciation on building @ 10%	5.0	5.0	5.0	5.0	5.0
11.	**Total fixed cost (Birr)**	55.00	55.00	55.00	55.00	55.00
12.	**Total cost of production (8+11**)	**343.80**	**344.97**	**345.81**	**346.82**	**340.94**
C.	**Sales return**					
13.	Total egg production/bird (No.)	**47.59**	**49.10**	**50.40**	**55.00**	**46.36**
14.	Return from eggs sale @ Birr 6/egg	285.54	294.6	302.4	330	278.16
15.	Average weight of sold birds (kg)	1.53	1.7	1.56	1.63	1.56
16.	Return from sold birds @ Birr 83.33/kg	127.49	141.66	129.99	135.83	129.99
17.	Return from their by-products					
	a. Gunny bag @ 2.5 Birr/bag	0.41	0.41	0.42	0.42	0.40
	b. Manure @ 1.5 Birr/kg	2.87	2.89	2.91	2.93	2.81
18.	**Total return/bird (14+16+17)**	**416.31**	**439.56**	**435.71**	**469.18**	**411.36**
19.	**Net return per bird (Birr)**	**72.51**	**94.59**	**89.90**	**122.36**	**70.42**
20.	**Net profit per egg**	**2.58**	**2.52**	**2.47**	**2.28**	**2.59**
20.	**Benefit: cost ratio (B:C ratio)**	**1:21**	**1:27**	**1:25**	**1:35**	**1:20**

[1] TWM0%: basal diet (BD) + 0% TWM; TWM6.5%: BD + 6.5% TWM; TWM13%: BD + 13.0% TWM; TWM19.5%: BD + 19.5% TWM and TWM26%: BD + 26% TWM.
[2] Birr is Ethiopian currency; the price of the egg during the experiment at local market was 6.00 Birr/egg.

The results of present experiment are agreement with Alemayehu *et al*. (2015) who recorded maximum net return in white leghorn layers inclusion of fish waste meal in basal diet up to 10 percent as compared to other experimental groups. However, net profit per egg was higher achieved in T_5 group as compared to other experimental groups. Therefore, inclusion level of tomato waste meal in layer ration is profitable because of the increased egg production.

CONCLUSION

From the finding of present experiment, it can be concluded that, inclusion of tomato waste meal in layers diets up to 19.50 percent is permissible with no detrimental effect on egg fertility, hatchability and chick's quality as well cost benefit ratio and net return per bird. Tomato waste meal had no deleterious effect on palatability of the diets. Tomato waste meal is waste feed material, therefore it can be used as a poultry feed to reduce feed cost and profitable layer farming.

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