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Influences of Propolis use on Technical, Cost and Allocative Efficiencies of Meat Production of Ross 308 Broilers

Muhammad Sadiq Hashmi[1], Peter Haščík[2], Ibrahim Elimam[2], Jozef Garlík[2], Muhammad Amjad Bashir[3]

[1]Department of Economics, Karakoram International University, Pakistan.
[2]Department of Evaluation and Processing of Animal Products, Faculty of Biotechnology and Food Sciences, Slovak University of Agriculture in Nitra, Trieda A. Hlinku 2, 949 76 Nitra, Slovakia.
[3]Department of Plant Protection, Faculty of Agricultural Sciences, Ghazi University, Dera Ghazi Khan, Pakistan.

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Abstract: The increasing food requirement around the Globe is a big consideration for the researchers as well as for the farmers dealing in food production. The technological enhancement and best use of the resources can promise to meet the increasing needs of food. In this realm, this study is focused to test the influences of propolis on meat production of Ross-308 broiler and its effects on technical, cost and allocative efficiencies of chicken production. Four groups of chicken were raised; one as Control group and three as treatment groups. Reaching upon 42 days of their age, chicken were slaughtered and weights of each economic part of chicken meat were measured separately for each chick in the experiment. To estimate the efficiencies, Data Envelopment Analysis was used to estimate the efficiencies (technical, cost and Allocative). In order to see the differences among the treatment groups, one way ANOVA was performed. The results revealed that with the increase in amount of propolis in the treatment groups, the average feed taken by each chick (on average) in T1, T2 and T3 (treatment groups) decreased by 97.98, 220.58, and 329.37 g, respectively. Moreover, it has different effects on production of different parts of meet. Average meat weight of economic parts of the chicken was calculated in C, T1, T2 and T3 as 2240.57±110.89, 2316.55±92.11, and 2341.26±149.98 and 2339.01±121.15 g, respectively. However, the use of propolis did not influence the technical efficiency of meat production. On the other hand, with an increase in the amount of propolis, the cost and allocative efficiency have been increased.

*Corresponding authors: Muhammad Sadiq Hashmi: sadiqhashmi6@gmail.com

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1. Introduction

Chicken production is very important business to fulfill the meat (food) requirement of the humans all over the world. At the same time, it is a profitable business for the investors, especially in a case when the production is done based on scientific methods. In literature, one can find a number of studies with their findings and recommendation to improve the production process (such as Willem et al., 2013; Aboki et al., 2013; Ohajianya et al., 2013). The producer(s) need to focus not only to increase the production, but also to decrease the cost of production to earn maximum profit. In this regard, the scientists have tried to use a number of different substances as a diet supplements to improve chicken health, which ultimately enhances the production (weight) of chicken and reduces the cost of inputs, such as chemicals/medicines used in chicken feed. Propolis is one of those substances which may improve the health of chicken and ultimately increase the live body weight of the chicken and hence, increasing the profit of producers (Hegazi et al., 1996).

In the market, different parts of the chicken are sold at different prices. Propolis has documented potential to increase live bird weights and weight of individual chicken parts, resulting in an increase in their market value (Freitas et al., 2011; Klarić, 2014). Hegazi et al. (2012) reported a decrease in the mortality rate and an increase in the weight of lymphoid organs of the chicks fed with propolis as diet supplement. likewise, Seven (2008) reported that use of propolis decreases mortality rate and it causes an improvement in digestibility of dry and organic matter, as well as increase in crude protein and ether extract. On the contrary, vitamin C and propolis did not show any marked effect on egg shape, yolk and albumen, however, egg shell thickness and weight increased. On the other hand, Shahryar et al. (2011)

found that alcoholic extract propolis in supplementation with diet had no significant effects on the immunity of Broiler chicken. Similarly, Kleczek et al. (2012) conducted a study to see the effects of propolis and bee pollen on physicochemical properties and strength of tibial bones in chicken. The authors found that the shear strength values and physical properties of bones of the chicken were similar in all of the groups included in the experiment. Other related studies with similar objectives were also reported earlier (Galal et al., 2008; Sulcerova et al., 2011).

This study investigated the effects of propolis in different ratios/amount in the feed. This study, firstly, investigated the effects of propolis on the weight of different body parts of chicken; and secondly, it reported the technical (TE), cost (CE), and allocative (AE) efficiencies of broiler Ross-308 meat production.

2. Materials and Methods

The experiment was carried out in the test poultry station of Slovak University of Agriculture, Nitra, Slovak Republic. For the experiment one day-old total chicken hybrid combination Ross-308 (total 40) were divided into 4 treatment groups (n=10): Control (C) and three experimental (T1, T2, T3) groups. Experimental diets were fed to the chicken from one-day-old to age of 42-days-old by *ad libitum system*, with feed mixture HYD-01 (until the age of 21st days) and HYD-02 (from 22nd to 42nd days of age). Feed mixtures HYD-01 and HYD-02 (taken from the market) were produced without any antibiotic preparation and coccidiostats. Their compositional value (shown in Table 6) was the same in each group during the whole experiment, but the experimental groups of chicken were added with extracts of propolis at doses of 200 $mg.kg^{-1}$ (in diet of T1), 300 $mg.kg^{-1}$ (in diet of T2), and 400 $mg.kg^{-1}$ (in diet of T3).

The feed which was taken by each group was calculated. Similarly, after slaughtering, the weight of each body part of each chick was calculated. The calculated feed and the weight of meat of each part of each chick are given in the Table 1 and Table 2, respectively.

After calculating the weights of body parts, Technical efficiency (TE), Cost efficiency (CE), and Allocative efficiency (AE) (with the help of DEA models given below) were calculated by using software, DEA Max. In this case, the all of the weights of the body parts were considered as outputs, while feed and propolis taken by the chicken were considered as inputs. For the calculation of CE and AE, the prices of inputs and outputs were also considered which are given in Table 7. After the estimation of all efficiencies with the help of models (given below), one way ANOVA was performed with the help of STATA software.

Model 1: Estimation of TE

Let us consider: $x^j = (x_1^j, x_2^j, x_3^j, \ldots\, x_n^j)$ be the bundle of n inputs used and $y^j = (y_1^j, y_2^j, y_3^j, \ldots\, y_m^j)$ be the bundle of m outputs, produced by chick j (j = 1, 2, 3,......, N). Suppose that k is the observed chicks and we want to measure the TE of chick 'k'. The observed input-output bundle of chick 'k' is (x^k, y^k). Then the correspondent mathematical (algebraic) formula for TE will be:

$$\max \varphi \text{ s.t.}$$

$$\sum_{J=1}^{N} \lambda_j x_{ij} \leq x_{ik} \quad (i = 1, 2, \ldots, n);$$

$$\sum_{J=1}^{N} \lambda_j y_{rj} \geq \varphi y_{rk} \quad (r = 1, 2, \ldots, m);$$

$$\sum_{J=1}^{N} \lambda_j = 1; \lambda_j \geq 0 \ (j = 1, 2, \ldots, N); \varphi \text{ unrestricted}$$

Hence TE of chick k would be measured by $\tau_k = 1/\varphi^*$

here φ^* is the optimum solution of the DEA linear programming problem given above.

Model 2: Estimation of output and input oriented TE

It would be better to define the production possibility set constructed from the sample data set D = $\{(x^j,y^j);\ j= 1, 2,3\ldots,N\}$. The sample estimate of the underlying production possibility set 'S' is:

$$S = \{(x,y) : x \geq \Sigma^{N}_{j=1}\lambda_j x^j;\ y \leq \Sigma^{N}_{j=1} \lambda_j y^j;\ \Sigma^{N}_{j=1} \lambda_j = 1;\ \lambda_j \geq 0 \ (j= 1, 2,3 \ldots,N)\}$$

After estimation of the TE of chick, a measure of output oriented TE (TEo) of a chick with observed input and output bundle (xk, yk) is

$$\tau^y_k = 1/\varphi^* \quad \text{where } \varphi^* = \max \varphi : (x^k, \varphi y^k) \in S$$

The above model gives the TE^o in the output oriented context.

When the input conservation is regarded as more important than expanding the outputs, the appropriate measure of performance of chick 'k' would be its input oriented TE (TE^i).

$$\tau^x_k = \theta^* = \min \theta : (\theta x^k, y^k) \in S$$

TE^i can be then presented through the mathematical (algebraic) as:

$$\min \theta \quad \text{s.t.}$$

$$\sum_{J=1}^{N} \lambda_j x_{ij} \leq \theta x_{ik} \quad (i = 1, 2, \ldots, n);$$

$$\sum_{J=1}^{N} \lambda_j y_{rj} \geq y_{rk} \quad (r = 1, 2, \ldots, m);$$

$$\sum_{J=1}^{N} \lambda_j = 1; \lambda_j \geq 0 \quad (j = 1, 2, \ldots, N); \theta \text{ unrestricted}$$

Model 3: Estimation of CE

According to DEA, a chick minimizes cost when it uses an input bundle that can produce the targeted output at the lowest cost at the applicable input prices. Therefore, the choice is only among those input bundles that can actually produce the desired output. For the detail of whole procedure for modeling the cost efficiency measurement DEA model one can see (Ray, 2004). CE model can be presented as:

The minimum cost (w^0, y^0) is $C^* = \min \Sigma^{n}_{i=1} w_{i0} x_{ij}$

s.t.

$$\sum_{J=1}^{N} \lambda_j x_{ij} \leq x_{ik} \quad (i = 1, 2, \ldots, n);$$

$$\sum_{J=1}^{N} \lambda_j y_{rj} \geq y_{r0} \quad (r = 1, 2, \ldots, m);$$

$$\sum_{J=1}^{N} \lambda_j = 1; \lambda_j \geq 0 \quad (j = 1, 2, \ldots, N).$$

Model 4: Estimation of AE

The AE encapsulates the concept that in the process of production, those inputs bundle might be used which have the minimum cost and that ensures the maximum feasible output(s). Therefore, in DEA the AE can be calculated by taking the ratio of cost to the TE. Symbolically, AE would be as:

AE = CE/TE

3.Results and Discussion

Table 1 shows the feed (mixture and propolis) fed to each group of the chicken, whereas Table 2 shows average weight of meat produced in each of the selected part of chicken and feed. Considering the inputs first, the feed mixture taken (on average) by each chick in the C, T1, T2, & T3 was 3754.43, 3656.45, 3533.85, & 3425.06 g, respectively and each chick was fed with propolis as 0.0, 0.73, 1.06, & 1.37 g of in C, T1, T2, & T3, respectively. Hence, it is very clear that there is decreasing trend in feed intake as the amount of propolis was increased.

On the other hand, average weight of carcass increased with the increase in amount of propolis but (as per results of one way ANOVA given in Table 2) show that the difference among the groups is, statistically, insignificant. Similarly, the weight of the heart increased for T1 & T2 and it decreased for T3 and the difference among the groups is statistically not much significant as the F value was calculated as 1.89 with p value as 0.15.

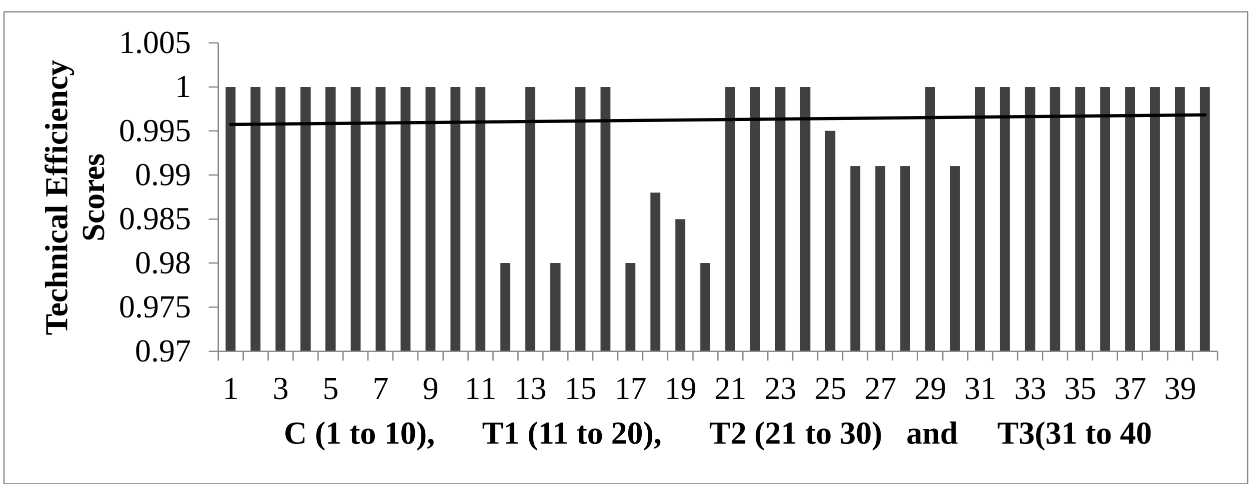

Figure 1. Technical Efficiency Scores of Ross-308. C: control group of chicken; T1: Group of Chicken fed with 200 mg.kg^{-1} of propolis; T2: Group of Chicken fed with 300 mg.kg^{-1} of propolis; T3: Group of Chicken fed with 400 mg.kg^{-1} of propolis

Table 1. Average Feed intake by Groups (in grams)

Groups/ Parts Weight	Inputs			
	Feed Mix. without propolis	**Propolis**	**Total Feed**	**Diff. in Feed Mix. From C**
C	3754.43	0.00	3754.4	0.00
T1	3656.45	0.73	3657.2	-97.98
T2	3533.85	1.06	3534.9	-220.58
T3	3425.06	1.37	3426.4	-329.37

C: control group of chicken; T1: Group of Chicken fed with 200 mg.kg^{-1} of propolis; T2:Group of Chicken fed with 300 mg.kg^{-1} of propolis; T3: Group of Chicken fed with 400 mg.kg^{-1} of propolis.

Table 2: Results of One Way ANOVA of Body Parts of Chicken

Economic Body Parts	Treatments	Mean	SD	F value	P value
Carcass	C	1589.3	84.32	1.24	0.31
	T1	1630.7	57.25		
	T2	1653.5	111.8		
	T3	1654.4	84.72		
Heart	C	10.12	1.77	1.89	0.15
	T1	10.72	1.42		
	T2	10.83	0.97		
	T3	9.63	0.73		
Liver	C	50.3	7.3	3.09	0.04
	T1	42.89	8.91		
	T2	45.64	3.99		
	T3	40.6	8.75		
Neck	C	80.05	8.47	0.45	0.72
	T1	81.54	10.54		
	T2	84.76	8.34		
	T3	81.72	9.79		
Breast	C	256.79	30.37	2.36	0.09
	T1	279.43	26.92		
	T2	281.63	19.13		
	T3	283.89	25.7		
Thigh	C	220.54	14.8	2.87	0.05
	T1	240.06	14.04		
	T2	233.22	19.24		
	T3	239.33	18.77		

C: control group of chicken; T1: Group of Chicken fed with 200 mg.kg^{-1} of propolis; T2:Group of Chicken fed with 300 mg.kg^{-1} of propolis; T3: Group of Chicken fed with 400 mg.kg^{-1} of propolis; SD: standard deviation.

Conversely, the weights of the liver decreased with the increase of propolis and the difference among the groups is, statistically, significant too as the value of F was calculated as 3.09 with P value as 0.04. On the other hand, the average weights of neck, breast and thighs increased with the increase in the amount of propolis. However, the difference in case of neck is insignificant while the difference in case of breast is near to significance level and in case of thigh meat, it is very significant.

Table 3. Results of One way ANOVA for Technical Efficiency score with groups

Summary of TE Score

Groups	Mean	Std. Dev.	Freq.
C	1	0	10
T1	.989	0.0101	10
T2	.996	0.005	10
T3	1	0	10
Total	.996	.007	40

Analysis of Variance

Source	SS	df	MS	F	Prob.> F
Between groups	.000765399	3	.000255133	9.14	0.0001
Within groups	.001004999	36	.000027917		
Total	.001770398	39	.000045395		

Bartlett's test for equal variances: $chi^2(1) = 4.4930$ $Prob>chi^2 = 0.034$.

C: control group of chicken; T1: Group of Chicken fed with 200 $mg.kg^{-1}$ of propolis; T2:Group of Chicken fed with 300 $mg.kg^{-1}$ of propolis; T3: Group of Chicken fed with 400 $mg.kg^{-1}$ of propolis; SD: standard deviation.

Resultantly, this led to an increase in total meat weight of the chicken which shows an ultimate positive effect of propolis on total meat production, thus it also caused an increase in the total economic value of chicken. Secondly, as amount of propolis was increased, the total feed intake was decreased without any negative effect on total meat production.

3.1 Technical Efficiency

The results revealed very small differences among the mean Technical efficiency (TE) scores of the four groups (Fig. 1). However, more numbers of chickens were found in T1 & T2, which exhibited small TE scores than C and T3. Table 3 shows the ANOVA results of TE of all of the four groups of the chicken. It was found that the difference among the TE of four groups is, statistically, significant, as the value of F was calculated as 9.14 with Prob > F as 0.0001. Moreover, the C and T3, both achieved maximum mean TE scores as '1±0', while T2, & T3 achieved mean TE scores as 0.989±0.01 & 0.996±0.01, respectively, which means that the use of propolis, technically, has negative effect on T1 and T2 and no effect on T3. Hence use of propolis has, technically, nonlinear influences on the chicken production.

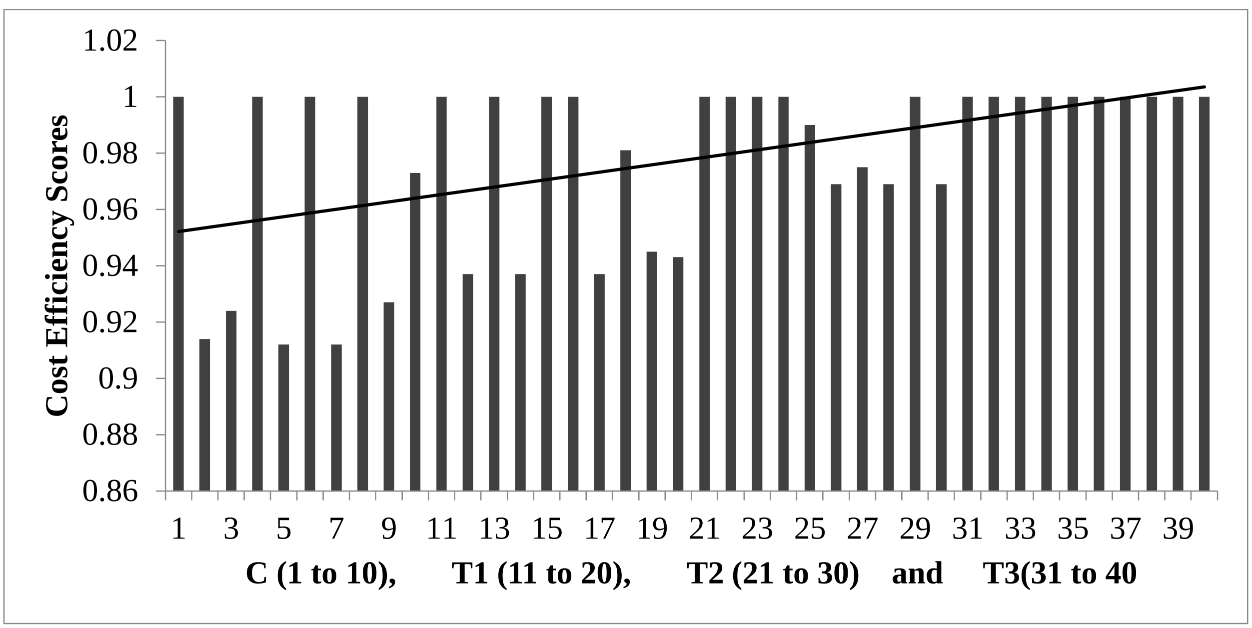

Figure 2. Cost Efficiency of Ross-308. C: control group of chicken; T1: Group of Chicken fed with 200 $mg.kg^{-1}$ of propolis; T2: Group of Chicken fed with 300 $mg.kg^{-1}$ of propolis; T3: Group of Chicken fed with 400 $mg.kg^{-1}$ of propolis.

Table 4. Results of One way ANOVA for Cost Efficiency score with groups

Summary of CE Score					
Groups |	Mean	Std. Dev.	Freq.		
C |	.956	0.042	10		
T1 |	.968	0.030	10		
T2 |	.987	0.015	10		
T3 |	1	0.0	10		
Total |	.978	.031	40		
Analysis of Variance					
Source	SS	df	MS	F	Prob.> F
Between groups	.011437902	3	.003812634	5.32	0.004
Within groups	.025805206	36	.000716811		
Total	.037243108	39	.000954951		

Bartlett's test for equal variances: $chi^2(2)$ = 7.8780 Prob>chi^2 = 0.019.

C: control group of chicken; T1: Group of Chicken fed with 200 mg.kg^{-1} of propolis; T2: Group of Chicken fed with 300 mg.kg^{-1} of propolis; T3: Group of Chicken fed with 400 mg.kg^{-1} of propolis; SD: standard deviation.

3.2 Cost Efficiency

The results of CE of the chicken production indicate that with increase of the amount of propolis in the chicken feed, the feed taken (input) by the chicken decreases, however its output (meat production) increases. By making a comparison between the four groups' meat production, it is very clear that weight of those body parts increased, which have more economic value. Hence, the use of propolis has positive effects on the CE of the chicken production.

Secondly, as per results of ANOVA (Table 4), control and treatment groups of chicken have a significant differences (p<0.05) among them, as the value of F was found as 5.32 and Prob > F was found as 0.004. Moreover, the maximum mean CE score (as 1±0) was achieved by T3 and minimum mean CE score (as 0.956±0.04) was achieved by the Control group (C), while T1 and T2 achieved mean CE scores as 0.968±0.03 & 0.987±0.02, respectively. Hence, it can be stated that the use of propolis has positive linear effects on the CE of chicken production i.e. with the use of propolis in the feed mixture, cost of feed minimizes such that the output also increases or at least it is not compromised. CE has been shown in the Figure 2.

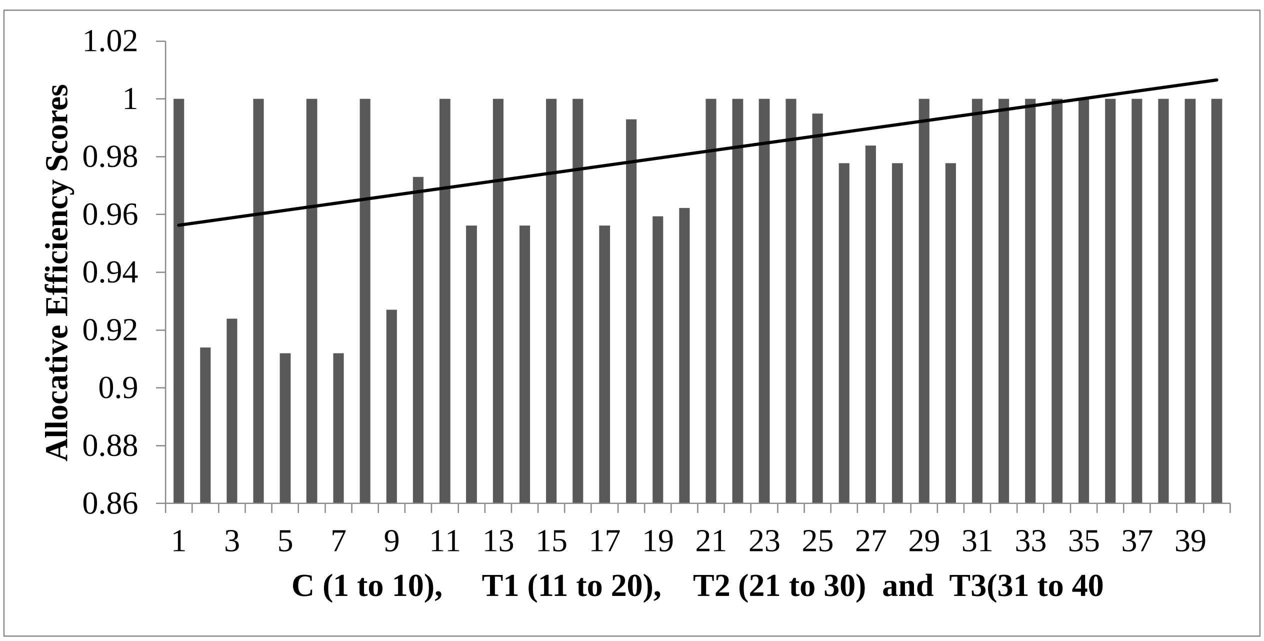

Figure 3. Allocative Efficiency of Ross-308. **C: control group of chicken; T1: Group of Chicken fed with 200 mg.kg^{-1} of propolis; T2: Group of Chicken fed with 300 mg.kg^{-1} of propolis; T3: Group of Chicken fed with 400 mg.kg^{-1} of propolis.**

3.3 Allocative Efficiency

Figure 3 shows the AE of each chick in all of the four groups. The trend line shows that with the increase in amount of propolis in the chicken feed, the AE scores increase. As per results of ANOVA (Table 5), although, the differences in mean AE scores of the four groups are smaller, however, C gained minimum mean AE score as 0.956±0.04 and the maximum AE score was gained by T3 as 1±0. On the other hand, T1 and T2 gained mean AE scores as 0.978±0.02 & 0.991±0.01, respectively. However, the F value was calculated as 6.30 with Prob > F as 0.002, which indicates that with the use of propolis, AE increases and it is, statistically, significant too. Hence, T3 is the most efficient and C is the least efficient.

Table 5. Results of One way ANOVA for Allocative Efficiency score with groups

Summary of AE Score

Groups	Mean	Std. Dev.	Freq.
C	.956	.042	10
T1	.978	.022	10
T2	.991	.011	10
T3	1	0	10
Total	.981	.028	40

Analysis of Variance

Source	SS	df	MS	F	Prob.> F
Between groups	.010871493	3	.003623831	6.30	0.0015
Within groups	.020715672	36	.000575435		
Total	.031587165	39	.000809927		

Bartlett's test for equal variances: chi^2 (2) = 13.9587 Prob>chi^2 = 0.001.

C: control group of chicken; T1: Group of Chicken fed with 200 $mg.kg^{-1}$ of propolis; T2: Group of Chicken fed with 300 $mg.kg^{-1}$ of propolis; T3: Group of Chicken fed with 400 $mg.kg^{-1}$ of propolis; SD: standard deviation.

Table 6 Composition of the broiler feed mixture

Ingredients (%)	Starter (1 to 21 days of age)	Grower (22 to 42 days of age)
Wheat	35.00	35.00
Maize	35.00	40.00
Soybean meal (48 % N)	21.30	18.70
Fish meal (71 % N)	3.80	2.00
Dried blood	1.25	1.25
Ground limestone	1.00	1.05
Monocalcium phosphate	1.00	0.70
Fodder salt	0.10	0.15
Sodium bicarbonate	0.15	0.20
Lysine	0.05	0.07
Methionine	0.15	0.22
Palm kernel oil Bergafat	0.70	0.16
[1]Premix Euromix BR 0,5 %1	0.50	0.50
	Analyzed composition ($g.kg^{-1}$)	
Crude protein	210.76	190.42
Fiber	30.19	29.93
Ash	24.24	19.94
Ca	8.16	7.28
P	6.76	5.71
Mg	1.41	1.36
ME (MJ/kg)	12.02	12.03

[1]active substances per kilogram of premix: vitamin A 2 500 000 IU; vitamin E 50 000 mg; vitamin D3 800 000 IU; niacin 12 000 mg; d-pantothenic acid 3 000 mg; riboflavin 1 800 mg; pyridoxine 1 200 mg; thiamine 600 mg; menadione 800 mg; ascorbic acid 50 000 mg; folic acid 400 mg; biotin 40 mg; vitamin B12 10.0 mg; choline 100 000 mg; betaine 50 000 mg; Mn 20 000 mg; Zn 16 000 mg; Fe 14 000 mg; Cu 2 400 mg; Co 80 mg; I 200 mg; Se 50 mg.

Table 7: Chicken parts' and Propolis prices used for economic analysis

Body parts	Price (€ per kilogram)
Live body weight	1.60 € per kilogram
Carcass weight	1.92 € per kilogram
Breast	3.57 € per kilogram
thigh	2.6 € per kilogram
Giblet (neck+liver+heart+gizzard)	1.64 € per kilogram
Liver	2.02 € per kilogram
Gizzard	1.78 € per kilogram
Heart	1.58 € per kilogram
Neck	1.20 € per kilogram
Feed Mixture	0.56 € per kilogram
Propolis	0.033 € per gram

4. Conclusion

It was concluded that with the increase of propolis in feed mixture, the feed taken by the chicken decreases linearly and it has positive, linear but statistically insignificant influence on carcass meat production. Similarly, it has insignificant influence on heart and neck meat production whereas in case of liver, the propolis has negative, nonlinear and significant influence. On the other hand, use of propolis has almost significant and positive influence on breast and very significant in case of thigh meat production. Moreover, it was found that use of propolis does not influence the technical efficiency of meat production. On the other hand, cost efficiency and allocative efficiency of meat production is influenced significantly. As the amount of propolis is increased, the cost and allocative efficiency increases.

List of Abbreviations:

AE: allocative efficiency; C: control; CE: cost efficiency; TE: technical efficiency.

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Competing Interests: The authors declare that they have no conflict of interest.

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