Research Article

1- Comparative study on the effect of Organic Acids, Prebiotics and Enzymes Supplementation on broiler Chicks' Immunity, hematobiochemical parameters and Economic Performance.

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Abstract:

This study was conducted to evaluate the effect of different feed additives (Organic acids, Prebiotics and Enzymes) on chicks' immunity (Antibody titer against Newcastle vaccine, differential leukocyte count, total proteins, albumin and globulin value) and economic efficiency analysis by using production functions for two different broiler breeds. Our results clarified that Indian River (IR) breed showed an increased immunity against NDV than Cobb breed except for organic acid group of Cobb breed. In regard to hemoglobin value prebiotic group of IR breed showed the highest value of hemoglobin. Concerning the differential leukocyte count we found that prebiotic treated group for IR breed recorded the highest value of white blood cells. Enzyme treated group for Cobb breed had the highest value for lymphocyte percentage. Regarding, albumin value, it was the highest for enzyme treated group of IR breed, while globulin value for Cobb and IR breed showed higher value for all treated groups compared with the control group. Our results showed that the effect of these additives on body weight and total return have positive relationship between feed additives and body weight and total return. On the basis of our results, it would be concluded that organic acids, prebiotic and enzymes had positive effect on immunity and economic performance of broilers.

KEY WORDS: Organic acids, Prebiotics, Enzymes, NDV, Hematology, Economic performance.

1. Introduction

The possibilities to attain optimum broilers performance have led the producers to search for and use alternative promoters, in a particular with the ban of using the antibiotic growth promoters. Thus, their use in feed rations of productive live stocks leads to resistance formation against bacteria that are pathogenic to humans (Langhout, 2000), So Several substances have been investigated in recent years for finding alternatives to growth-promoting antimicrobials which are able to support productive performance and prevent the incidence of some diseases in poultry (Huyghebaert et al., 2011).

Dietary supplementation of prebiotic had greater IgA content in the duodenum and by increasing the concentration of dietary prebiotic, IgA content increased linearly (Gao et al., 2008). Chicks fed acidified diets had better immune response represented in their higher serum globulin (Abdel-Fattah et al., 2008).

The productive efficiency can be achieved when obtaining maximum production with minimum cost and using the least amount of resources to produce a given output level or the average cost is at the lowest point on the average cost curve (Atallah, 1997)**.** The production functions used to determine the major important variables that affect broiler production which were (starter, finisher, feed conversion, total feed, drugs, vaccines, disinfectants, veterinary supervision and total veterinary management) (Liza et al., 2016). Therefore, the aim of this study was to make comparative study on the effect of organic acids, prebiotics and enzymes supplementation on broiler Chicks' Immunity, hematobiochemical parameters and economic analysis of production functions and their effect on the economic performance of broiler chicken of both Cobb and IR breeds.

2. Materials and Methods

Experimental Chicks:

Our study was carried out at Poultry Research Farm belonging to Animal Wealth Development department, Faculty of Veterinary Medicine, Benha University, Egypt, at the period from 7th of May 2016 till 15th of Jun 2016. A total of 264, healthy one

day old unsexed broiler (Cobb and Indian River (IR) breed), Cobb breed was purchased from El-Kashlan Company and Indian River IR breed was purchased from El-Desoki Company.

Management and Housing:

The broiler chicks were weighted, and wing banded for their identification, and randomly allocated in to eight groups (33 chicks/each group). Each group consists of three replicates (11 chicks/each replicate). They were housed in a clean, well ventilated litter floor house (5cm wood shaving litter depth). The house was provided with heaters to adjust the environmental temperature according to the age of chicks. Each partition contained suitable feeders and waterers. The house floor was partitioned into 24 partitions (Fardos, 2009). Brooding temperature started at 33°C during the first 3 days, then 31ºC till the end of the 1st week, followed by reduction of 2°C/week until the temperature reached 28°C at the end of experiment (Marwa, 2013 and Liza, 2016).

Vaccination:

The chicks were vaccinated against most common viral diseases as shown in the table below:

Age	Name of vaccine	Type	Route of vaccination	Company
7th day	Hitchner-IB	Live	Eye drop	FATRO
8th day	Oil in activated Newcastle vaccine	Inactivated	(I/M)	VET SER&Vacc. RES.INST.cairo .EGYT
9th day	SER-VAC-FLU	Inactivated	(S/C)	VET SER & Vacc. RES.INST.cairo .EGYT
11th day	GUMBOL	Live	Eye drop	CEVA
17th day	CLONE30	Live	Eye drop	Intervet
19th day	(UNIVAX-BD*)	Live	Eye drop	Intervet

Experimental Diets:

The chicks were randomly allocated into eight groups. Birds were fed on well-balanced diet **(NRC, 1994)** as shown in **Table 2**. Starter diet was given till the 14th day of age after that chicks were fed on grower diet that was given till the 28th day of age after that chicks were fed on finisher diet till the end of the experiment (38th day

of age) according to (Isabel and Santos, 2009). Chicks were allocated as the following:

- Group 1 received basal diet
- Group 2 received basal diet +Organic acid.
- Group 3 received basal diet +prebiotics.
- Group 4 received basal diet + Enzymes.

Immune response evaluation:

a. Blood Sampling

About 1~2 ml of blood from the birds were aseptically collected from the jugular vein with a sterile 2 ml disposable syringe. Blood samples were collected at 6 day old (pre vaccination) and 1st, 2nd and 3rd week post vaccination and at the end of growing period. About 0.5-1 ml of blood was taken in a vial containing EDTA as anticoagulant at 1mg/ml, for estimation of hematological parameters.

Hematological parameters measurement:

Hematological variables including white blood cells (WBCs) and red blood cells (RBCs) were performed in a Neubauer hemocytometer using a 1:200 dilution with Natt and Herrick solution. Differential leukocyte count, hemoglobin (Hb) concentration, packed cell volume (PCV) were determined as described previously (Campbell, 1995).

b. Haemagglutination inhibition (HI) test:

1. Serum samples and preparation:

Blood samples were collected at the six day old, and then taken weekly for 3 successive weeks.Clotted blood samples were centrifuged at 3000 r.p.m. for 15 minutes to obtain clear serum. The serum samples were kept in small labled sterile tubes and stored at - 20 °C till used (Stoot and Fellah, 1983).

2. Reagents:

Reagents used in the HI test were prepared according to the standard microplate system described by Majiyagble and Hitchner (1977) as follow:

-Phosphate buffer saline pH.

-Virus antigen: Newcastle disease virus (NDV). Live Hitchner vaccine.

The virus was previously titrated and adjusted to 4 HAU/50 µl (Haemagglutination unit)

-Chicken RBCs suspension (1% in PBS pH).

Blood was collected from the wing vein of a chick in a centrifuge tube containing EDTA as anticoagulant. The red cells were washed by centrifugation three times with sterile physiological saline. The RBCs suspension (1%) was prepared by adding 1 ml of washed RBCs to 99 ml PBS-pH to be used in the HI test.

3. Equipments:

- 96 well microtiter plates of U-shaped bottom (Greiner bio-one®, Germany).

- Multichannel microtiter pipette of 10-200 µl capacity (Costar®, USA).

4. Method of HI test:

HI test was performed as the following:

-Using the multichannel microtiter pipette, 50 µl of PBS-pH were dispensed in each well of the 96-well microtiter plates.

-50 µl of each serum sample (all serum samples of all group) from the beginning till the end of the experiment were dispensed in the first well of plates (one column in each plate was left as RBCs control).

-Two-fold serial dilutions of the serum samples were applied along the column length to generate eight consequent dilutions.

-50 µl of the pre-diluted virus antigen were added to all wells of the plates except the control column.

-Plates were incubated at room temperature for 60 minutes.

-50 µl of chicken RBCs suspension (1%) were added to all wells of the plates (including the control).

-Plates were incubated at room temperature for 15-30 minutes before recording the results.

-The HI titres were expressed as the reciprocal of the highest dilution showing complete hemagglutination inhibition activity (appearance of button shape).

Biochemical analysis of blood:

Total protein of serum was determined by using chem7 and albumin also was determined.

Economical analysis:

Production function:

It was carried out in the forms of linear and logarithmic forms according to Doll and Orazem ,1978 ; Afifi ,1988 and Atallah ,1997). Aimed to estimate the effect of feed additives on body weight of broiler for each group and all groups by the two forms of the function (linear and logarithmic), by using enter method by using (SPSS/PC+ 2004).

Statistical Analysis:

Differences between studied groups and breeds were analyzed by using One-Way ANOVA and Duncan's multiple comparison Post Hoc tests (Duncan, 1955). Statistical analysis was performed using the statistical software package SPSS for Windows SPSS/PC^{+} "version 16"(SPSS, 2004). Statistical significance between mean values was set at ($p \leq 0.05$). Data were reported as means and standard error.

3. Results:

Effect of different treatments among different breeds on Hematological parameters of broiler chickens:

Result in table (3) and showed that erythrocytes, white blood cells, hemoglobin value, packed cell volume had non-significant differences ($p>0.05$) among both Cobb and IR breeds.

Effect of different treatments among different breeds on differential Leukocytic Count of broiler chickens:

Results in table (4) clarified non-significant differences ($p>0.05$) among both Cobb and IR breeds on differential leukocytic count.

Effect of different feed additives on antibody titer against Newcastle disease virus:

Results in table (5) showed that antibody titer was significantly differed ($p \leq 0.05$) among different groups and breeds.

Effect of different feed additives on biochemical parameters of blood

Results in table (6) cleared that Albumin, Globulin, Total protein, Albumin / Globulin ratio were differed significantly ($p \leq 0.05$) for both Cobb and IR breeds

Effect of different feed additives on Production functions:

The results in Tables (7, 8, 9) showed that the logarithmic production function was significant ($p \leq 0.05$).

Concerning the average of feed additive cost it was about (-0.4) …total cost

and the average elasticity of feed additive cost was about (+0.6), ….total return by (6%).

4. Discussion

Hemoglobin value was ranged from (8.20 to 10.07 gm/dl) for control group and prebiotic groups of IR breed respectively. These results were in agreement with Nyamagonda et al. (2009) and Al-saad et al. (2014) they found that Hemoglobin value increased by prebiotic supplementation. It was higher in treated group than control of both breed except in enzyme treated group of Cobb breed. This result may be due to addition of these additives might stimulate the hematopoietic organs and causes erythropoiesis, also high environmental temperature increased the hematological parameters (Hasan et al., 2015).

Value of RBCS was ranged from (2.86 x 106 /µl) to 3.30 x106 /µl) for enzyme group of Cobb and prebiotic group of IR breed respectively. These result agreed with Sosan et al. (2010) they concluded that there was a significant increase in erythrocyte count due to prebiotic supplementation, while disagreed with Abeer and Soltan (2015) who found that value of RBCS decreased by prebiotic supplementation. In regard to enzyme result it was agree with Chuka (2014) who concluded that value of RBCs was lower in enzyme group compared with the control, while disagree with Rahman et al. (2013) they reported that value of RBCS increased by enzyme supplementation.

Value of packed cell volume was ranged from 27% for control and enzyme treated group of Cobb breed to 30% for OA supplemented group of the same breed.

Value of white blood cells showed non- significant differences among different groups of both IR and Cobb breeds, in Cobb breed value of WBCs was lower in all treated group compared with control group. These results in accordance with Abeer and Soltan (2015) who found that supplementation of prebiotic decreased the value of WBCs, on the other hand Salim et al. (2011) found that prebiotic group showed

higher WBCs count than the control one. In IR breed it was ranged from (48 x103 to to 69.33 x103) for control and prebiotic groups of IR breed respectively. These result agreed with Al-saad et al. (2014) and Helal et al. (2015) they indicated that prebiotic supplementation increased the leukocyte count for broiler chicken, also there was non-significant differences (p>0.05) for both Cobb and IR breeds on differential leukocytic count.

Concerning the heterophile %value, the highest value was found for control group of IR breed (65.60 %) followed by OA group of Cobb breed (60.50 %), and the lowest value was found for enzyme group of Cobb breed (47.60 %) followed by prebiotic group of same breed (52.40 %). These results was agreed with Kim et al. (2011) who found that heterophile was lower in MOS supplemented group compared to control group, also Helal et al. (2015) mentioned that prebiotics supplementation decreased the neutrophil % in broiler chicken (Cobb breed).

Value of lymphocyte % showed non-significant differences among different groups, it was higher in all treated group compared with control group except in OA supplemented group of Cobb breed. The highest value was recorded in Cobb breed treated with enzyme (49.20 %), and the lowest value was recorded in control group of IR breed (31.60 %). These results agree with Nyamagonda et al. (2009) and Salim et al. (2011) they found that prebiotic group showed higher lymphocytic count in comparing with the control, while disagree with Abeer and Soltan (2015) who mentioned that supplementation of prebiotic decreased the lymphocyte count.

The monocyte % was ranged from 2.20 % for OA group of IR breed to 3.67 % for prebiotic group of the same breed. These results were in agreement with Abeer and Soltan (2015) they found that prebiotic supplementation increased Monocyte percentage. Concerning OA result, Mahdavi and Torki (2009) they noted that the dietary inclusion of OA did not affect the counts of monocyte, at days 21, 42 and 49 of broilers life,

The eosinophil % showed non- significant difference among different groups. The highest value (0.80%) was recorded in control group of Cobb breed.

Result in table (5) revealed that antibody titer at the 3rd week after vaccination, showed non-significant differences (p>0.05) between different groups of both breeds.

IR breed showed an increased immunity against NDV than Cobb breed except for organic acid group of Cobb breed, these results indicate the genetic impact of breed on immune response. These results were in agreement with Younis et al. (2016) who reported that Ross breed showed an increased immunity against NDV than Cobb breed.

The albumin value showed non-significant differences ($p>0.05$) for both breed, it was ranged from 1.81 gm/dl for control and enzyme groups of Cobb breed to 2.06 gm/dl for enzyme group of IR breed. These results were in agreement with Fathi et al. (2016) they showed non- significant changes ($p>0.05$) of albumin value due to OA supplementation, also Liza (2016) reported that supplementation of prebiotic, OA and enzymes showed non-significant effect on albumin value.

Regarding the globulin value, there were significant differences ($p\leq0.05$) for both Cobb and IR breeds. The highest value was found for OA group of IR breed (3.24gm/dl), while the lowest value was recorded in control group of Cobb breed (1.38gm/dl). These result in respect with Ghazalah et al. (2011), Azza and Naela (2014) and Hedayati et al. (2015) they indicated that value of globulin was increased with OA supplementation which might indicated that broiler chicks fed the acidifiers supplemented diets had better immune response and disease resistance.

Concerning total protein value, there were a significant differences ($p\leq0.05$) among different groups of both breeds, it was higher in all treated group compared to control group. The highest value was found for OA group of Cobb breed (5.20gm/dl), while the lowest value was recorded in control group of Cobb breed (3.19gm/dl). Regarding the total protein value for OA group, it agreed with those reported by Abdul Aziz (2006) and Azza and Naela (2014) who indicated positive effect of organic acid on value of total protein. On the contrary Fathi et al. (2016) showed non- significant changes ($p>0.05$) in total protein value due to OA supplementation. Concerning the high value of prebiotic supplemented group, it agreed with Abdel Raheem and Abd Allah (2011) who stated that total protein was higher in prebiotic treated group compared with control one, while disagreed with Wang et al. (2015) they found that total protein value decreased by prebiotic supplementation, also Ajdar et al. (2016) clarified that prebiotic supplementation had no effect on total protein. In regard to

enzyme result Chuka (2014) concluded that total protein value was higher in enzyme group in comparing with control.

The albumin / globulin ratio showed a significant differences ($p \leq 0.05$) for both Cobb and IR breeds. The highest value was found for prebiotic group of Cobb breed treated (1.41), while the lowest value was recorded in organic acid group of IR breed (0.66). This result was disagree with Helal et al. (2015) they found that prebiotics supplementation decreased A/G ratio in Cobb breed.

About 33 % from the changes in body weight were attributed to changes in production resources.

The average elasticity of drug cost was about (+0.39), meaning that increasing drug cost by about 10 % resulted in increase of body weight by (3.9 %).

The average elasticity of vaccine cost was about (+0.172), meaning that increasing vaccine cost by about 10 % resulted in increase of body weight by (1.72 %).

The average elasticity of disinfectant cost was about (+0.140), meaning that increasing vaccine cost by about 10 % resulted in increase of body weight by (1.40 %).

The average elasticity of feed additive cost was about (+0.15), meaning that increasing feed additive cost by about 10 % resulted in increase of body weight by (1.5%). These results were in agreement Helal et al. (2015) they reported that Broiler chicks of dietary feed additive supplementation improved body weight.

The average elasticity of feed additive cost it was about (-0.4), meaning that increasing feed additive cost by about 10 % resulted in decrease of total cost by (4%).

The average elasticity of feed additive cost was about (+0.6), meaning that increasing feed additive cost by about 10 % resulted in increase of total return by (6%).

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Table 1: Composition of starter, grower and finisher diets. (Basal diet)

Ingredients %	Starter	Grower	Finisher
Corn grain	53.55	52.88	59.46
Soyabean (44%) protein	33.2	31.10	25.5
Corn gluten meal	5.5	5.60	5.5
Vegetable oil	2.85	5.85	5.40
Mono-calcium phosphate	2.03	1.85	1.825
Limestone	1.18	1.17	0.95
L-Lysine	0.50	0.455	0.335
D-L methionine	0.33	0.24	0.20
Sodium chloride	0.30	0.30	0.30
Vit &min premix	0.30	0.30	0.30
Sodium bicarbonate	0.15	0.15	0.15
L- threonine	**0.12**	**0.10**	**0.08**

Table 2: Chemical composition of starter, grower and finisher diets.

Item	Starter %	Grower %	Finisher %
Crude protein	22	21	19
MEn	3000	3177	3225
Lysine	1.35	1.27	1.05
Lysine dig	1.25	1.17	0.97
Methionine	0.67	0.57	0.51
Methionine Dig	0.64	0.54	0.48
Methionine+ cysteine	1.05	0.94	0.85
Methionine+ cysteine Dig	0.95	0.84	0.76
Threonine	0.90	0.85	0.76
Threonine Dig	0.78	0.73	0.65
Calcium	1.05	1.00	0.90
Available phosphorus	0.50	0.46	0.45
Chloride	0.22	0.22	0.22
Na	0.17	0.17	0.17

Calculated according to (NRC, 1994).

Table (3): Effect of different treatments among different breeds on Hematological parameters of broiler chicken (Mean ± SE).

Breed	Group	Number	Hemoglobin	RBCS	PCV	WBCS
			Mean±Std. ± Error	Mean±Std. Error	Mean±Std. Error	Mean±Std. Error
Cobb	Control	33	8.72^{a}±0.80	2.92^{a}±0.26	27.00^{a}±1.34	62.00^{a}±8.00
	Organic	33	10.00^{a}±0.61	3.10^{a}±0.25	30.00^{a}±1.22	48.75^{a}±8.26
	Prebiotic	33	9.68^{a}±0.58	3.00^{a}±0.16	29.20^{a}±0.49	50.00^{a}±6.32
	Enzyme	33	8.36^{a}±0.32	2.86^{a}±0.17	27.00^{a}±1.10	52.00^{a}±5.83
IR	Control	33	8.20^{a}±0.50	3.04^{a}±0.33	27.20^{a}±1.02	48.00^{a}±7.35
	Organic	33	9.66^{a}±0.15	3.04^{a}±0.09	29.00^{a}±0.00	58.00^{a}±8.00
	Prebiotic	33	10.07^{a}±1.30	3.30^{a}±0.31	29.67^{a}±1.45	69.33^{a}±10.97
	Enzyme	33	9.13^{a}±0.95	2.88^{a}±0.33	28.25^{a}±2.14	62.50^{a}±6.29

Means within the same column carrying different superscripts are significant at ($P \leq 0.05$)

Table (4): Effect of different treatments among different breeds on differential Leukocytic Count of broiler chickens (Mean ± SE).

Breed	Group	Number	Heterophile %	Lymphocyte%	Monocyte%	Esinophile
			Mean±Std. Error	**Mean±Std. Error**	**Mean±Std. Error**	**Mean±Std. Error**
Cobb	**Control**	33	58.80^{a}±4.81	37.20^{a}±4.84	3.20^{a}±0.58	0.80^{a}±0.37
	Organic	33	60.50^{a}±5.69	35.75^{a}±6.69	3.25^{a}±0.75	0.50^{a}±0.50
	Prebiotic	33	52.40^{a}±9.13	44.60^{a}±8.55	3.00^{a}±0.95	0^{a}
	Enzyme	33	47.60^{a}±7.16	49.20^{a}±6.65	3.00^{a}±0.63	0.20^{a}±0.20
IR	**Control**	33	65.60^{a}±4.99	31.60^{a}±4.79	2.40^{a}±0.24	0.40^{a}±0.40
	Organic	33	58.20^{a}±2.50	39.20^{a}±2.94	2.20^{a}±0.20	0.40^{a}±0.40
	Prebiotic	33	55.00^{a}±10.00	40.67^{a}±8.74	3.67^{a}±1.33	0.67^{a}±0.67
	Enzyme	33	54.00^{a}±11.45	42.50^{a}±11.09	3.50^{a}±0.87	0^{a}

Means within the same column carrying different superscripts are significant at ($P \leq 0.05$).

Table (5): Effect of different treatments among different breeds on antibody titer against Newcastle disease virus of broiler chickens at different weeks. (Mean ± SE).

Breed	Group	Number	Pre vaccination (6 day old)	1wpv	2wpv	3wpv
			Mean±Std. Error	**Mean±Std. Error**	**Mean±Std. Error**	**Mean±Std. Error**
Cobb	**Control**	33	1.51^{ab}±0.17	0.80^{a}±0.10	0.30^{b}±0.17	0.30^{a}±0.17
	Organic	33	1.51^{ab}±0.17	0.80^{a}±0.10	1.10^{a}±0.27	1.00^{a}±0.56
	Prebiotic	33	1.40^{b}±0.20	1.00^{a}±0.20	0.40^{ab}±0.20	0.70^{a}±0.27
	Enzyme	33	1.61^{ab}±0.10	0.60^{a}±0.30	0.60^{ab}±0.17	0.30^{a}±0.001
IR	**Control**	33	1.81^{ab}±0.001	1.00^{a}±0.10	0.90^{ab}±0.30	1.00^{a}±0.20
	Organic	33	1.91^{a}±0.10	1.00^{a}±0.10	0.70^{ab}±0.20	0.40^{a}±0.27
	Prebiotic	33	1.91^{a}±0.10	1.10^{a}±0.10	0.60^{ab}±0.001	1.00^{a}±0.36
	Enzyme	33	1.81^{ab}±0.001	1.10^{a}±0.10	0.90^{ab}±0.35	0.90^{a}±0.17

Means within the same column carrying different superscripts are significant at ($P \leq 0.05$).
wpv: Week post vaccination

Table (6): Effect of different treatments among different breeds on biochemical parameters of blood of broiler chickens (Mean ± SE).

Breed	Group	Number	Albumin	Globulin	Total protein	AG ratio
			Mean±Std. Error	**Mean±Std. Error**	**Mean±Std. Error**	**Mean±Std. Error**
Cobb	**Control**	33	1.81^{a}±0.17	1.38^{b}±0.24	3.19^{b}±0.35	1.37^{ab}±0.23
	Organic	33	1.83^{a}±0.17	1.75^{b}±0.08	3.58^{b}±0.19	1.05^{ab}±0.11
	Prebiotic	33	2.05^{a}±0.20	1.49^{b}±0.12	3.53^{b}±0.15	1.41^{a}±0.23
	Enzyme	33	1.81^{a}±0.30	2.27^{ab}±0.36	4.08^{ab}±0.26	0.87^{ab}±0.28
IR	**Control**	33	1.83^{a}±0.36	1.81^{b}±0.18	3.64^{ab}±0.54	0.99^{ab}±0.10
	Organic	33	1.96^{a}±0.20	3.24^{a}±0.91	5.20^{a}±1.10	0.66^{b}±0.10
	Prebiotic	33	2.04^{a}±0.17	1.96^{ab}±0.38	3.99^{ab}±0.21	1.17^{ab}±0.35
	Enzyme	33	2.06^{a}±0.17	1.99^{ab}±0.30	4.05^{ab}±0.19	1.10^{ab}±0.21

Means within the same column carrying different superscripts are significant at (P ≤ 0.05)

AG: Albumen to Globulin ratio

Table (7): Production function of final body weight and production resources (feed cost, additive cost and drug cost)

Function	**Log weight = 0.270+ 0.39 (log drug) + 0.172 (log Vaccine)**
t	**(3.915)** (1.905)** (2.13)****
t	**+0.140 (log disinfectant)+ 0.15 (log additive)**
	(2.755) (0.929)****
F	**7.671*****
R^{-2}	**0.330**

** Significant at ($p \leq 0.05$).

Table (8): Production function of total cost (TC) and additive cost.

Function	**Log Total cost =1.427-0.4 (log additive)**
t	**(7.750***) (-0.209)**
F	**5.43****
R^{-2}	**0.60**

** Significant at ($p \leq 0.05$).

Table (9): Production function of total return (TR) and feed additives.

Function	**Log Total return =1.617 + 0.6 (log additive)**
t	**(9.872)*** (0.377***)**
F	**(14.142)*****
R-2	**0.53**

** Significant at ($p \leq 0.05$).