Effect of the use of three levels of electrolytes on the growth and fattening stage in COB 500 broilers chicks

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Abstract

The objective of this study was to evaluate the use of different levels of electrolytes (potassium, inositol, chlorides) in growth and fattening stages in Broiler COBB 500 broilers subjected to heat stress, which received the same management practices in the different growth stages. The number of birds required for this research was 160 animals distributed in 4 treatments; the size of the experimental units was 10 chicks with 4 repetitions, which were subjected to high temperatures, and received different levels of electrolytes according to the following description: control treatment (T0) 0 gr, treatment (T1) 6 or 50% gr, treatment (T2) 12 gr or 100%, treatment (T3) 18gr or 150% of electrolytes, a completely randomized design was used, with separation of means according to Tukey to determine the degree of statistical significance between each of the treatments. The statistical variables to be measured were: final weight, weight gain, feed conversion, carcass yield, mortality, and cost-benefit. The results allowed to know that there were significant statistical differences for the variables: final weight, observing that the treatment (T3) reached the best final weight (1202.50 gr), weight gain (1152.75 gr), reached the highest responses for the other variables measured, based on these results it was concluded that the addition of electrolytes in chickens subjected to heat stress improves certain productive parameters in broilers, contributing significantly to the sustainability of small producers.

Keywords: heat stress, temperature, broilers, electrolytes, broiler chickens

1. Resumen

El presente trabajo tuvo como objetivo, evaluar la utilización de diferentes niveles de electrolitos (potasio, inositol, cloruros) en etapas de crecimiento y engorde en pollos Broiler COBB 500 sometidos a estrés calórico, recibieron las mismas prácticas de manejo en las diferentes etapas de crecimiento. El número de aves requeridas para este investigación fue de 160 animales repartidas en 4 tratamientos, el tamaño de las unidades experimentales fue de 10 pollos con 4 repeticiones, los mismos que fueron sometidos a altas temperaturas, y recibieron diferentes niveles de electrolitos de acuerdo a la siguiente descripción: tratamiento control (T0) 0 gr, tratamiento (T1) 6 o el 50% gr, tratamiento (T2) 12 gr o el 100%, tratamiento (T3) 18 gr o el 150% de electrolitos, se utilizó un diseño completamente al azar, con separación de medias según Tukey que permita determinar el grado de significancia estadística entre cada uno de los tratamientos. Las variables estadísticas para medir fueron: Peso Final, Ganancia de peso, conversión alimenticia, rendimiento a la canal, mortalidad, beneficio costo. Como resultados obtuvimos que existieron diferencias estadísticas significativas para las variables: peso final, observándose que el tratamiento (T3) alcanzó el mejor peso final (1202,50 gr), la ganancia de peso (1.152,75 gr), alcanzaron las

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respuestas mas altas con respecto a las demás variables en medición, en función a estos resultados se concluyó que la adición de electrolitos en pollos sometidos a estrés por calor mejoran ciertos parámetros productivos en pollos de carne, contribuyendo significativamente a la sostenibilidad de los pequeños productores.

Palabras calve: estrés calórico, temperatura, pollos broilers, electrolitos

2. Introduction

Poultry production is a millenary activity that has coexisted with humankind, providing food and protein of high biological value and contributing significantly to families' food security worldwide. For example, in Ecuador, approximately 494,000 tons are produced from breeding 263 million birds, generating a per capita consumption of 28 kg of chicken meat annually (CONAVE, 2021).

Table 1. Historical growth of chicken meat consumption in Ecuador

Year	Chicken meat consumption in tons
2016	416
2017	445
2018	450
2019	529
	490
2021	486

Source: (CONAVE, 2021).

In Ecuador, there are approximately 1819 farms producing chicken broilers, generating about 32,000 direct jobs and 220,000 indirect sources of employment. This production is concentrated in Guayas at 22%, Pichincha at 16%, Santo Domingo at 14%, El Oro at 8% and Manabi at 6%; the difference is produced in the rest of the country (El telegrafo, 2019).

The highest production is found in the cost region, where the highest production is found, according to data from El Tiempo (2021). The average annual minimum T° in 2021 was 22.5°C, and the average annual maximum T° was 30.5°C. This indicates that at certain times of the year, there are heat waves that put the lives of the animals at risk, especially those raised in semi-intensive systems and that their production sheds do not have automatic systems to control these factors, generating high mortality and consequently economic losses for small producers.

Undoubtedly, this is a great challenge, especially for small producers where the scarcest resource is money, limiting the realization of investments to improve their rearing systems. Therefore, finding alternatives to mitigate the effect that the T° generates in the chicks, especially in the last weeks of life, is to strengthen and generate sustainability in their production systems.

Temperature as a trigger for heat stress

Temperature is one of the environmental factors that most influence feed consumption. This is because birds are homothermic; that is, they must maintain a constant temperature inside their bodies, even when environmental conditions are changing, which means that the bird must be kept in a thermoneutral zone, that is, the energy generated as part of the bird's metabolism must be sufficient to maintain an internal temperature of 41°C (Quishpe, 2006).

According to Corona (2012), the most favorable conditions for broiler production in the last stage of fattening are between 20 to 25°C; if the temperature increases to 28°C, this is considered critical, especially in broilers weighing more than 1.5 kg.

Stress is a physiological response of the animal to adverse circumstances in which different defense mechanisms come into play that define a process of adaptation or simply the animal gives up; however, stress alone does not generate disease, but it does trigger and predispose to the action of pathogens, which cause disease in animals (Vasco, 2019).

When the bird can no longer defend itself, it is said that the animal is stressed, which means that it becomes vulnerable to the attack of pathogenic agents that are always there but in normal health conditions of the animal are kept in a latent state without generating any physiological or metabolic alteration (Babaahmady, 2021).

In these circumstances, heat stress can affect severely or acutely, severely at temperatures above 32°C, causing water consumption to double and feed consumption to decrease by 1 to 1.5% for each 1°C increase in temperature, affecting daily weight gain. In comparison, the acute effect can be observed at ambient temperatures of 38 to 40°C where the internal temperature of the bird can reach 45°C, causing death by heat stroke or acute stress due to cardiac failure, associated with respiratory failure and loss of balance (Corona, 2012).

Effects of temperature on the physiological response of broiler chickens

In high-temperature conditions, the birds spend panting, lie on the floor with open wings, consume twice as much water, and decrease feed consumption. When the animals are exposed to prolonged periods under these conditions generates metabolic decompensation and death (Quinteiro, 2018).

One of the most common effects when birds are subjected to high temperatures is the reduction of feed consumption because digestion releases heat, a reason why the energy requirements e these circumstances come from body fat since this produces less heat at the time the energy needed to meet the biological demands of the animal is released (Amir, 2018).

Basal metabolism and production are responsible for heat generation inside the chicken, and the former is generated when the animal is at complete rest, fasting and in the thermal neutral zone. When the chicken starts moving, the muscles release around 75% more energy as heat (Corona, 2012).

From the physiological point of view, the organic response to stress begins in the nervous and cardiovascular systems. It is known as the fight or flight response, a state in which amines such as epinephrine and norepinephrine are released, substances that immediately increase blood pressure, muscle tone, nervous sensitization, blood glucose, increased heart rate, and some other physiological states that generate harmful effects in the animal's body (Bonilla, 2021).

Basic acid balance

Another important aspect of the physiological response to heat is the basic acid balance related to the electrolyte balance, which diets must maintain, so the participation of milliequivalents of Na, K, and Cl must be controlled, with the addition of bicarbonate to balance the concentration of the animals. (Jimen, 2019)

Miranda (2021) states that an electrolyte ratio (ER) of 250 mEq/kg body weight should be maintained in broilers' starting and finishing stages. Under conditions of heat stress, the basic acid balance is lost, which leads to metabolic alkalosis, generating greater bicarbonate requirements for the buffer effect; the change in PH, together with the loss of bicarbonate and minerals is even more aggravated under conditions of high T° and humidity, resulting in a poor state of health of the bird (Jimen, 2019).

Another physical response of the birds subjected to heat stress is the increase of the respiratory rate (panting) as a regulatory mechanism of the internal temperature of the bird, releasing H20 and CO2 through the utilization of bicarbonate, CO2, H20 of the tissues, which causes a decrease in the concentration of bicarbonate in the blood, thus increasing the blood PH from 7.2 to 7.7, generating an imbalance in the acid-base balance; this condition is increased in environments with high levels of heat and relative humidity (Murillo, 2021).

In summary, the increase of bicarbonate in the diet of the animals as a regulator element of the acid-base balance is significant since research shows that the use of bicarbonate (NaHC03) in comparison with sodium carbonate, although the two treatments maintained a ratio of 300 mEq/kg (COBB-VANTRESS, 2021).

Stress in birds

Alarm phase

When the animal is subjected to episodes of stress, the central nervous system (CNS) releases hormones such as noradrenaline and adrenaline, which are the ones that trigger the immediate production of glucose from the body's glycogen, giving rise to glycolysis, i.e., the production of immediate energy so that the animal can face the unusual situation, if the animal does not release the stressful phase it passes to the next one which is resistance (Pusa, 2020).

Resistance phase

In this phase, the release of large amounts of corticosterone, called the stress hormone, is produced; however, in this phase, the central nervous system, in the face of the unusual situation, stimulates the anterior pituitary gland to produce adrenocorticotropic hormone (ACTH) which acts on the adrenal cortex and produces corticosterone, which generates the rapid activation of glycogenesis providing the animal with the necessary energy from fat and muscle, in order to survive. Therefore, the main characteristic of this phase is that the animal remains in it until it is freed from the stress factor or dies (Pusa, 2020).

Fatigue phase

This phase is before death since the body reserves are exhausted or the corticosteroid hormone is no longer produced, generating organic failures due to the lack of energy (Pusa, 2020).

As explained in the introduction, the T° is one of the factors that condition productivity in broiler chickens, which is why this research aims to evaluate efficient alternatives that are easy to apply and within reach of the economy of small producers.

3. Methodology

The present work was carried out in the Macau canton belonging to the province of Morona Santiago, whose geographical coordinates are: W; 01°26' S latitude and 76°35' W longitude; 03°36' S latitude, with the following climatic characteristics and a duration of 60 days.

Table 2. Meteorological conditions in Macas canton.

PARAMETER	UNIT	AVERAGE 2021
Temperature	°C	22
Humidity	%	76
Precipitation	%	24
Heliofania	Km/hour	5,7

Source: (Weather Spark, 2021).

A total of 160 chickens were used as experimental units, divided into 4 treatments including a control, the size of the experimental unit was 4 chickens with 4 replicates per treatment, i.e., 40 birds per treatment. The experimental design was completely randomized because the experiment was carried out under controlled conditions. The electrolyte doses described below were used.

1. 0 grains Control treatment.
2. 6 grams Treatment 1.
3. 12 grams Treatment 2
4. 18 grams Treatment 3.

The following experimental design was considered:

Table 3. Experiment scheme

Treatments			Code	Repetition	TUE	No. animals/T
T0	0 %	(0 g) Electrolytes	T0	4	10	40
T1	50 %	(6 g) Electrolytes	T1	4	10	40
T2	100 %	(12 g) Electrolytes	T2	4	10	40
T3	150 %	(18 g) Electrolytes	T3	4	10	40
Total number of animals:						

TUE: Experimental unit size

Source: 2022 research team

Table 4. Outline of the analysis of variance.	
SOURCE OF VARIATION	GRADES OF FREEDOM
Total	15
Treatment	3
Error	12
Source: 2022 Research Team	

Table 5. Results obtained from cob 500 chicks subjected to heat stress.							
VARIABLES PRODUCTIVE	ELECTROLYTE LEVELS					Prob.	Sign.
	T0 0 % (0gr)	T1 50 %(6gr)		T2 100 %(12gr)	T3 150 %(18gr)		
Final weight, grams	893,75 c	914,50 b	1127,50 a	1202,50 a	0,01		**
Total feed consumption, grams	2447,50 a	2502,5 a	2491,25 a	2494,25 a	0,286		ns
Weight gain, grams	840,42 c	862,90 b	1081,57 a	1152,75 a	0,000		**
Feed conversion	2,91 a	2,92 a	2,32 b	2,18 b	0,000		**
Yield to carcass, %, %, %, %, %, %, %, %, %, %, %.	83,63 a	83,94 a	86,53 a	79,10 a	0,229		ns
Mortality rate, % Mortality rate, % Mortality rate, % Mortality rate, % Mortality rate, %	7,00 a	2,50 a	0,00 a	5,00 a	0,344		ns
Carried out by Equipo investigador 2022							

Electrolytes (potassium, inositol, chlorides) were deposited in the drinking water and supplied during the third, fourth and fifth week of the experiment and the following experimental variables were considered:

1. Final weight achieved in grams.
2. Total feed consumption.
3. Weight gain in grams.
4. Feed conversion.
5. Carcass yield
6. Mortality.

The following activities were carried out in the experimental procedure:

- Initial weight. It was performed at the arrival of the baby chicks through an electronic scale.
- Weekly weight. It was performed on Fridays of the weeks under study simultaneously.
- Final weight. It was taken in the sixth week
- Feed consumption. This parameter was measured every week
- Feed conversion. It measures the relationship between the amount of feed consumed versus the weight gained by the bird in a given time.

Equation 1

$$\textbf{Feed conversion} = \frac{\textbf{Actual food consumption}}{\textbf{Final weight}}$$

Where

Final Weight

When analyzing this variable there were significant differences (P < 0.01) between the means of the treatments, observing that the best response to the application of electrolytes was the T3 treatment with values of 1,202.50gr[a] followed by the T2 treatment with 1,127.50gr[a], then the T1 with values of 914.5gr[b] and finally the control treatment with 893.75gr. [c]

Carcass weight. Twenty percent of chickens were taken from each treatment, and the animals were weighed before and after slaughter once the inedible parts of the bird had been removed.

Carcass yield. The following formula was used to determine the yield:

Equation 2

$$Carcass\ weight = \frac{PC}{Live\ weight} * 100$$

Where

CR: Carcass yield.

PV: Live weight.

PC: Carcass weight.

Mortality percentage, based on the following formula:

Equation 3

$$\%\ \boldsymbol{Mortality} = \frac{\textbf{Number of dead chickens}}{\boldsymbol{Total\ number\ of\ chickens\ entered}} \text{x } 100$$

- Benefit-cost ratio. The following formula is used:

Equation 4

$$Benefit - Cost\ Ratio = \frac{Total\ revenues\ USD}{Total\ expenses\ USD}$$

4. Results

After the research process, the following results were obtained, described in Table 5.

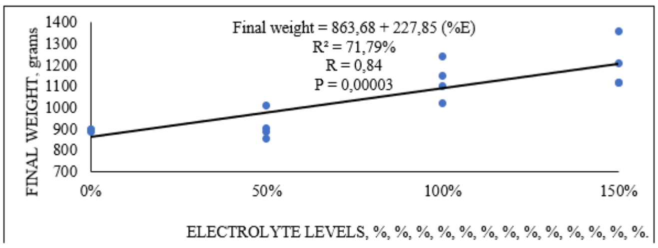

Figure 1.Statistical relationship between the variable electrolyte level and final weight of broilers.
Source: 2022 research team

Figure 1 shows that the coefficient of determination (R) represents a value of 0.84, indicating a statistical correlation between the number of electrolytes supplied to the birds during the trial period and the final weight reached by the chicks. Based on these results, it is assumed that as the amount of electrolytes increases, the final weight of the chickens increases; however, this discussion encourages to carry out trials with higher electrolyte levels until we find the optimum level, that is, one that does not represent a risk for the health of the animal, nor significant increases in production costs. Therefore, starting from an intercept of 863.68, the final weight of the chicken increases by 227.85 grams for each unit of change in the level of electrolytes added to the drinking water.

The results found are ratified by the ones reported by Amir (2018), who states that the addition of electrolytes in the drinking water of chickens increases the final weights achieved. This is undoubted because the addition of electrolytes favors the ionic balance, which also affects the state of stress of the animal, which, being in a moderate range of tranquility, can better express its effective response.

Another aspect to evaluate was the results obtained by Rubina (2019), who evaluated the effect of NaCl (sodium chloride) on live weight, water and mineral intake from 11 to 31 days of age, obtaining the best result with T1 that added to the diet 0.075% NaCl generated the best response in terms of weight gain reached 1612 gr, this tells that if both Na and Cl are indispensable elements in the basic acid balance, an indispensable factor to obtain the best productive response of the animals.

Total feed consumption

When analyzing the results of this variable, there were no significant differences (P≥0.05) between treatments; however, it was determined that T1 registered the highest consumption with 2,502.50 g[a], followed by T3 with an average consumption of 2,494.25 g[a], T2 with an intake of 2,491.25 g[a], and finally, the lowest food consumption registered by T0 with a value of 2,447.50 g.[a]

When analyzing the derivations obtained, we can point out that in T3 and T2, the final weight parameter obtained significant differences with the T0 and T1 treatments; they were more efficient in transforming the feed into weight. In this sense, Silvero (2018) stated that adding Na, Cl and K to the diets makes the animal maintain its acid-base balance, generating a better productive response.

However, the effects found in terms of feed consumption are contrary to those reported by Rubina (2019), who stated that chickens that consumed a greater amount of water with sodium chloride, which are the elements that we found to be part of the electrolytes, significantly increased feed intake.

Weight gain

When analyzing this variable, significant statistical differences were found for treatments T3 and T2 compared to treatments T1 and T0, whose mean values were 1152.75 g[a], 1081.57 g[a], 862.90 g[b], 840.42 g[c], respectively.

These data are ratified by Barsallo (2018), who states that the addition of mineral salts in the diet of animals has a positive effect on skeletal growth, cell wall integrity and osmotic pressure regulation, protein metabolism, regulation of organic processes, basic acid balance, act as antioxidants and energy releasers, electrolyte balance, in addition to improving the production and weight of chickens.

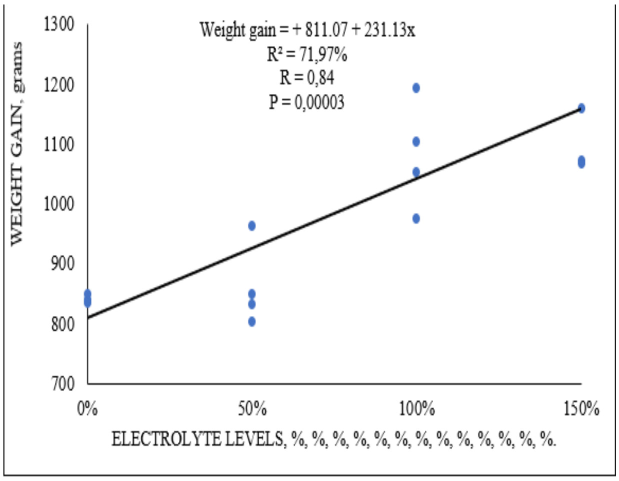

Figure 2. Statistical relationship between the variable electrolyte level and weight gain in broiler chickens.
Source: 2022 research team

Figure 2 shows a highly significant positive linear growth (P= 0.0003), and it starts from an intercept of 811.07, the weight gain increases by 231.13 gr for each unit of change in the level of electrolytes in the drinking water. The coefficient of determination (R^2) is close to one, which indicates that there is a positive correlation between the electrolyte consumption variable and the final weight variable, that is to say, that there is a growing tendency that as the electrolyte consumption increases, the weight gain will be more significant; however, it is essential to carry out new trials to determine the optimum levels of electrolyte consumption without this implying a risk to the animal's health and a negative effect on production costs.

The results obtained are superior to those described by Melo (2020), in the evaluation of productive behavior (weight gain) in the use of different levels of Zn (20ppm, 40ppm, 60ppm, 80ppm) as an additive to replace antibiotics in broiler chicken feed, about the other treatments, from the sixth to the seventh week, the T2 treatment (0.04 g. Zn) a gain of 588.68 g was obtained; likewise, it mentions that the chickens need to be fed correctly daily to ensure the success of the breeding and the obtaining of benefits, it also mentions that some points should be considered so that they do not lack anything in each of the phases through which they pass. A good example of this is to provide high levels of minerals and higher levels of protein in chickens destined for meat production.

Feed conversion

When analyzing this variable, allows determine significant differences ($P < 0.01$) between the means of the treatments, observing the best feed conversion in the treatment that was supplied with 6 g of electrolytes (T1) whose value is 2.91^a followed by the animals with the control treatment, with 2.9^a, then register feed conversion values of 2.32^b the animals treated with 12 g of electrolytes (T2), finally the animals of the treatment (T3) fed with 18 g of electrolytes,^{b}. These results indicate that the genetics of broiler chickens are designed to achieve weight gains in relatively short times, which means a constant supply of protein of high biological value and metabolizable energy at optimal levels so that the full genetic value of the animal can be expressed.

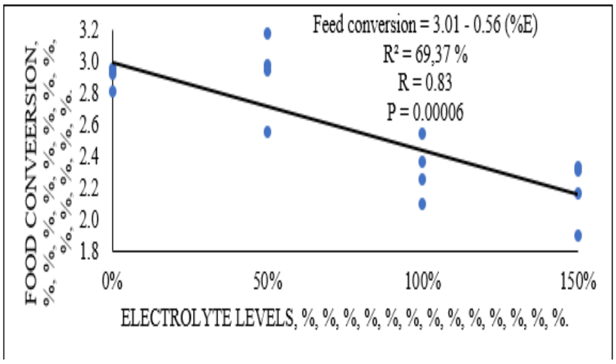

Figure 3. Statistical relationship between electrolyte level and feed conversion in broiler chickens.

Source: 2022 research team

The data are adjusted toward a highly significant positive linear trend ($P = 0.00006$), as illustrated in graph 3, from which it can be deduced that, starting from an intercept of 3.01, weight gain decreases by 0.56 for each unit of change in the level of electrolytes added to the drinking water of the broilers in the fattening growth phase, with a coefficient of determination (R^2) of 69.37 %. In comparison, the remaining 30.63 % depends on other factors not considered in this research, such as the daily management provided to the broilers to avoid caloric stress and the quality of electrolytes and their dosage. In addition, it can be seen that the degree of correlation, which was $r = 0.83$, identifies a high positive association; that is to say that increasing the level of electrolytes in the drinking water also increases the feed conversion of broilers.

Carcass yield

Regarding the analysis of this variable, no significant statistical difference was observed ($P > 0.05$) among the treatments; however, the best performance was observed in treatment T2 fed with 12 g of electrolytes, with an average of 86.53%, followed by treatment (T1) fed with 6 g of electrolytes with an average of 83.94%, then the control treatment with an average value of 83.63%, and finally treatment (T3) fed with 18 g of electrolytes, with a carcass yield of 79.10%. Therefore, according to the data presented, we can conclude that the addition of 12 g of electrolytes in the daily diet of the chickens generates the best carcass yield.

Chicaiza (2018) reports carcass yields of 73.68% and points out that this parameter depends entirely on the anatomical development of the bird and that this factor depends a lot on the animal's state of health (Panizo, 2021). In the same study, the company obtained maximum values of 73.77%; these data differ from those found in the present work, whose values range from 79.10% to 86.53%.

Mortality

No significant statistical differences were found ($P > 0.05$) in this variable, but if there are mathematical differences in terms of the value of the means of each of the treatments, the highest percentage of mortality occurred in the animals of treatment T3 with 5%, followed by treatment T1 with 2.5%, in treatment T2 no deaths were recorded. Therefore, the best treatment in terms of mortality is the one that was supplied with 12 g of electrolytes.

In this regard, the author states that one of the causes of mortality is heat in broiler rearing conditions (Barros, 2009, pág. 44) The problem is of great interest to broiler producers. There are still no absolute solutions; however, there are partial solutions, such as early acclimatization, which consists of exposing the animals for 24 hours to a temperature of 38-40°C during the first week of life. This increases the chickens' resistance to heat stress in the finishing phase, reducing mortality due to heat stress by 50% in broilers. Broiler mortality due to heat stress at the finishing stage can be reduced by early acclimatization. This technique improves chick resistance to heat and sometimes stimulates growth in a real tropical or simulated environment.

During the acute heat stress simulation, chicks that did not receive minerals in the feed probably had the highest level of hyperventilation where an acid-base imbalance plus an effect attributed to mineral depletion is possible, causing high mortality (7%) compared to the other treatments.

Benefit-cost

The best cost-benefit was recorded for the group with the use of 150% of electrolytes (T3), with a cost-benefit of 1.25 USD, obtaining a net benefit of 0.25 cents, which indicates a profitability of 25%, the values of expenses recorded were $ 201.26 against the value of income of $ 250.08. Next, the results obtained in T2 are presented, with the addition of 100% electrolytes, because the chickens obtained a benefit-cost index of $ 1.14, where the total expenditure reported was $ 200.81, while the income presented values of $ 229.9 dollars. In third place is the benefit-cost determined for the control treatment with a profitability of $ 1.10, since the reported expenditure was USD 199.56, with a total income of USD 220.00. Finally, the lowest benefit-cost ($1.07) was obtained in treatment T1 using 50% electrolytes, whose expenses reached values of $200.16, with income totaling $214.50 US dollars. Thus, it can be concluded that the optimum level of electrolytes in drinking water is 150% during the production of broiler chickens since this group was the dominant one in the study due to its greater economic benefit over the other treatments.

5. Conclusions

- In the final weight achieved by the birds, significant differences are observed (P < 0.01) between the means of the treatments, observing that the best response to the application of electrolytes was the T3 treatment with values of 1,202.50 gra followed by the T2 treatment with 1,127.50 gra, then the T1 with values of 914.5 grb and finally the control treatment with 893.75 gr.c
- Regarding feed conversion, there are significant differences (P< 0.01) between the means of the treatments.0.01) between the means of the treatments, with the best feed conversion in the treatment (T1) with a value of 2.91a followed by the animals with the control treatment, with 2.9a, then the animals with the treatment (T2) registered feed conversion values of 2.32b, and finally the animals with the treatment (T3) 2,18b these results indicate that the genetics of broiler chickens is designed to achieve weight gains in relatively short times, this assumes a constant supply of protein of high biological value and metabolizable energy at optimal levels so that the full genetic value of the animal can be expressed.
- When analyzing this weight gain variable, significant statistical differences were found for treatments T3 and T2 compared to treatments T1 and T0, with mean values of 1152.75 ga, 1081.57 ga, 862.90 gb, 840.42 gc, respectively.
- The optimal level of electrolytes in drinking water is 150% during broiler production, as this group was the dominant one in the study due to the greater economic benefit over the other treatments.

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