Effect of adding Citric acid and Tartaric acid to the diet on productive performance for broiler chickens (Ross-308)

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ABSTRACT

The experiment was conducted in the poultry field belonging to the Department of Animal Production, College of Agriculture, Al-Qasim Green University for the period from (8/10 / 2018) to (12/11/2018). The study aims to identify the effect of different levels of citric acid, tartaric acid, and their interaction on the productive performance for broiler chickens (Ross-308). In the experiment, 270 chicks of unsexed broiler chickens (Ross-308) were used, with one day age, randomly distributed, with a rate of 6 experimental treatments. Each treatment included 3 replicates, each replicate has 15 birds. The treatments of the experiment were as follows: The first treatment: a basic diet (initiator and final) that does not contain organic acids. The second and third treatments: citric acid was added to the feed (2.5 and 3 mg/kg feed). As for the fourth and fifth treatment, tartaric acid was added to the feed (2.5 and 3 mg/kg feed), the sixth treatment: a mixture of citric acid and tartaric acid was added to the feed (1.5 + 1.5 mg/kg feed). The results of the experiment showed a significant difference ($p < 0.01$) for the birds of the second, third and sixth treatment (2.5% citric acid, 3% citric acid, 1.5% citric acid + 1.5% tartaric acid), respectively, at the fifth week in the average of the body weight and total weight gain. The control treatment was significantly excelled ($p < 0.05$) in the average of total feed consumption which amounted to (3297.67 g / bird). The sixth treatment recorded the best total feed conversion ratio amounted to (1.5 g feed / g weight gain) compared to the control treatment.

*Research paper from MSc thesis for the first author.

تأثير إضافة الحامضيين العضويين Citric acid و Tartaric acid إلى العليقة في الاداء الإنتاجي لفروج اللحم (Ross-308)

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الخلاصة

أجريت التجربة في حقل الطيور الداجنة التابع الى قسم الإنتاج الحيواني/ كلية الزراعة / جامعة القاسم الخضراء للفترة من 2018/10/8 ولغاية 2018/11/12. تهدف إلى معرفة تأثير إضافة مستويات مختلفة من الحامضين العضويين الستريك والطرطريك بشكل مفرد وتازري الى عليقة فروج اللحم في الأداء الإنتاجي, أستخدم في التجربة 270 فرخ فروج لحم من سلالة (Ross 308) بعمر يوم واحد غير مجنسة وزعت عشوائيا بواقع 6 معاملات تجريبية وتضمنت كل معاملة 3 مكررات لكل مكرر 15 طير. وكانت معاملات التجربة كما يأتي:- المعاملة الأولى: عليقة أساسية (بادئ ونهائي) لا تحتوي على الاحماض العضوية, المعاملة الثانية والثالثة: تم إضافة حامض الستريك الى العلف (2.5 و 3 ملغم / كغم علف) أما المعاملة الرابعة و الخامسة فقد تم إضافة حامض الطرطريك الى العلف (2.5 و 3 ملغم / كغم علف) المعاملة السادسة: تم اضافة خليط من حامض الستريك وحامض الطرطريك الى العلف (1.5+1.5 ملغم/كغم علف). وقد بينت نتائج التجربة حصول تفوق معنوية ($p<0.01$) لطيور المعاملة الثانية والثالثة والسادسة (حامض الستريك 2.5%, حامض الستريك 3%, حامض الستريك1.5%+حامض الطرطريك 1.5%) على التوالي عند الاسبوع الخامس في معدل وزن الجسم الحي والزيادة الوزنية الكلية, وتفوقت معاملة السيطرة معنويا ($p<0.05$) في معدل استهلاك العلف الكلي (3297.67) غم/طير وسجلت المعاملة السادسة أفضل كفاءة تحويل غذائي كلي (1.5غم علف/غم زيادة وزنية) مقارنة بمعاملة السيطرة.

البحث مستل من رسالة ماجستير للباحث الاول.

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1. INTRODUCTION

In the commercial poultry industry, it is said that the profit comes from healthy intestines, which means that the health of intestinal villi leads to better absorption of nutrients. In contrast, intestinal villi damaged due to toxins results from pathogenic microbes cannot achieve the required feed conversion ratio even if birds are well fed (20). For good health, stimulating growth, and obtaining an economic weight gain, antibiotics were used in non-curative proportions, which improved the health condition of the digestive system and disposal of harmful bacteria competing for the host over nutrients, thus improving absorption (18, 13). Despite the contribution of antibiotics as catalysts for growth in the poultry industry, but their use was accompanied by negative aspects represented in the accumulation of its residues in the tissue of bird meat, which caused problems for consumers, in addition to the emergence of strains of pathogenic bacteria that are not affected by antibiotics (11, 25, 28). Therefore, the European Commission directed not to add antibiotics to poultry feed (38). Various alternatives have been proposed, including organic acids, probiotics, herbs and enzymes (7). Organic acids are used in poultry diets to reduce the activity of microbes, conserving feed and improving the environment within the digestive system for growth and development of beneficial bacteria at the expense of harmful bacteria (36). Various studies have revealed the possibility of using citric acid (citric acid) as feed additives with good potential as a growth stimulus compared to antibiotics where it reduces the pH in the intestines of birds, which inhibits the growth of E. coli, salmonella, and other negative Gram stains while improving the growth and reproduction Lactobacilli (10). Citric acid is considered more effective than other organic acids in increasing body weight and improving other productive traits (21). Among the other organic acids used as feed additives are tartaric acid, which is a natural organic acid found in many fruits, including grapes, bananas, and tamarind dates (35). Studies indicated that the addition of organic acids, including tartaric acid, to broiler chicken diets, which led to improved growth in birds and the immune response (8, 19, 34). Therefore, this study aims to know the effect of different levels of citric acid, tartaric acid, and their interaction on the productive performance of broiler chickens (Ross-308).

2. MATERIALS AND METHODS

The experiment was conducted in the poultry field belonging to the Department of Animal Production, College of Agriculture, Al-Qasim Green University for five weeks. The effect of different levels of citric acid, tartaric acid, and their interaction on the productive performance for broiler chickens (Ross-308) was studied. In the experiment, 270 chicks of unsexed broiler chickens (Ross-308), with one day age, were randomly distributed on 18 cages, the dimensions of each cage (1x 1.5 m^2) according to the ground breeding system, where they distributed on 6 groups, each group has 3 replicates with a rate of 15 birds per replicate, The breeding period was divided into two stages, the first from the age of (1-21), it was fed on the initiator diet and the second from the age of (22-35) which was fed on the final diet. Table (1) shows the composition of the initiator and final diets used in feeding the chicks throughout the experiment and the calculated chemical composition. The treatments for the experiment were as follows: The first treatment (T1) was a basic feed without adding (control treatment), The second treatment (T2) and the third treatment (T3) are a basic diet added to it a citric acid with a rate of (2.5-3%), respectively, the fourth treatment (T4) and the fifth treatment (T5) are a basic diet added to it a tartaric acid with a rate of (2.5-3%), respectively, and the sixth treatment (T6) is a basic diet added to it a 1.5% citric acid + 1.5% tartaric acid. organic acids have been added to diets from the beginning of the second week.

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Table 1: The composition of the initiator and final diets used in feeding the chicks for the period of the experiment and the calculated chemical analysis.

Feed material	initiator diet (1-21 day) %	Final diet (1-21 day) %
yellow corn	48.2	58.7
Local wheat	8	7.5
Soybean meal (44% protein)	28.5	20.5
Concentrated Protein*	10	10
Vegetable oil (sunflower)	4	2.5
limestone	1	0.5
Food salt	0.3	0.3
Total	%100	%100
The calculated chemical analysis		
Metabolization energy (kcal/ kg)	3079.85	3102.6
Crude protein (%)	21.56	18.87
Lysine (%)	1.04	0.85
Methionine + Cysteine (%)	0.455	0.42
Raw fiber%	3.54	3.2
Calcium (%)	1.28	1.07
Phosphorus availability (%)	0.42	0.41

* Concentrated protein from Belgian origin, one kilogram of it contains: 2200 kcal metabolization energy, 40% crude protein, 8% fat, 3.5% fiber, 25% ash, 8% calcium, 3.1 phosphorous availability, 1.2% lysine, 1.2% Methionine, 1.8% methionine + 70 mg, B 30 mg, Vitamin 1, E 300 mg Vitamin, D 2500 IU 3, A Cystine A, 2% Chlorine, 10,000 IU 12 mg folic acid, B 250 mg 12, B 120 mg Pantothenic Acid, 400 mg Niacin, 50 6 mg, Vitamin B B 5000 mg Choline Chloride, 450 mg Iron, 70 mg Copper, 600 mg, C 600 μg Biotin, 1000 mg Special Vitamin, 750 Manganese, 5 mg Iodine, 1 g Cobalt and Antioxidants.

** The chemical composition according was calculated according to the feed materials analyze mentioned in (NRC, 1994).

The following traits were calculated: live body weight, weight gain, an average of feed consumption and feed conversion ratio, according to the method indicated by (4). The data were then analyzed using the Statistical Analysis System (SAS, 32) to study the effect of different treatments on the studied traits according to a completely randomized design (CRD). The significant differences between the averages were compared using Duncan's (12) Multiple Range Test.

3. RESULTS AND DISCUSSION

Live body weight (g)

Table (2) shows the average weekly live body weight where the results of the statistical analysis showed that there were no significant differences between treatments in the average of live body weight during the first week of the experiment. As for the second week of the experiment, the results showed a significant difference ($P < 0.01$) in the average of live body weight where the birds of sixth treatment have excelled on the rest of the different treatment birds recording it the highest average of live body weight amounted to (427 g / bird) and there were no significant differences between the birds of treatments. In the third week of the experiment, the birds of third and sixth treatment (843.67, 844.67 g / bird) were significantly ($P < 0.01$) excelled on the birds of first and fifth treatment and these two treatments did not differ significantly from the birds of second and fourth treatment. In the fourth week, the significant excelling ($P < 0.01$)

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for the birds of sixth treatment continued by recording it the highest average of body weight amounted to (1528.33 g / bird) compared to the rest birds for the treatments of the experiment. In the fifth week from the end of the experiment, the birds of sixth treatment continued by recording them the highest final average of live body weight amounted to (2176.00 g / bird) by excelling it significantly (P <0.01) over all the birds of the experiment treatments followed by the birds of third treatment (2154.00 g / bird) which significantly excelled on the rest treatments of the experiment. The results obtained from the statistical analysis indicate a significant superiority for the birds of adding treatments compared to the birds of control treatment in the average of live body weight. This may be due to the addition of organic acids to the diets that have raised the decomposition of protein and amino acids by enhancing the activity of digestive enzymes (31, 29), where organic acids can provide an appropriate media that helps in converting pepsinogen into Pepsin, thus enhancing protein digestion (5, 22), which may have a positive effect on body weight. The results of this study agree with (6, 24, 3) who observed a significant improvement in the average of live body weight when adding organic acids to the diet of broiler chickens, including citric acid and tartaric acid.

Table 2: Effect of adding different levels of citric and tartaric acidic acid and their interaction to the diet on the average of live body weight (g) for broiler chickens.

Treatments	Weeks				
	First week	Second week	Third week	Fourth week	Fifth week
T1	± 154.67 0.33	± 423.00b1.52	± 826.00b3.78	± 1455.00 d2.08	± 2079.33d3.48
T2	± 155.00 0.57	± 421.67b0.88	± 837.00ab 3.21	± 1470.33 c4.09	± 2113.00c7.23
T3	± 155.67 0.33	± 423.33b1.33	± 843.67a2.90	± 1496.67 b4.91	± 2154.00b8.50
T4	± 156.00 0.57	± 421.00b0.57	± 835.67ab 2.90	± 1466.33 cd4.33	± 2093.67d3.75
T5	± 156.00 0.57	± 420.67b 0.67 b	± 829.67b3.17	± 1469.67 c4.41	± 2097.00 cd4.116
T6	± 155.33 0.33	± 427.00a0.57	± 844.67a5.04	± 1528.33 a3.84	± 2176.00a4.93
Significant level	**NS**	**	**	**	**

NS: It means no significant differences.

* Different letters within a single column differ significantly among them at the probability level of (P <0.05)

** Different letters within a single column differ significantly among them at the probability level of (P <0.01)

The first treatment (T1) was a basic feed without adding (control treatment), The second treatment (T2) and the third treatment (T3) are a basic diet added to it a citric acid with a rate of (2.5-3%), respectively, the fourth treatment (T4) and the fifth treatment (T5) are a basic diet added to it a tartaric acid with a rate of (2.5-3%), respectively, and the sixth treatment (T6) is a basic diet added to it a 1.5% citric acid + 1.5% tartaric acid.

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Weight gain

Table (3) shows the averages of weekly weight gain for the birds of different treatments, where the results of the statistical analysis in the first week of the birds 'age indicate that there is no significant difference between the birds of different treatments. While the data showed that the effect of adding different levels of citric acid and tartaric acid and their interaction to the diet in the second week of the experiment was a significant superiority (P <0.01) for the birds of sixth treatment (271.67 g / bird) on all the birds of the experiment and the birds For the first treatment was excelled giving it a value amounted to (268.33 g / bird) on the birds of fifth treatment which amounted to (264.67 g / bird). While we did not observe any significant differences between the birds of the first, second, third and fourth treatments which amounted to (268.33, 266.67, 267.33, 265.33 g / bird), respectively. As for the third week, the birds of third treatment were significantly (P <0.05) excelled by recording it the highest weight grain compared to the birds of first and fifth treatment, whereas the birds of second, fourth and sixth treatment did not differ significantly, and the averages of weight gain amounted to (403.33, 415.33, 420.33, 414.67, 409.00, 417.67 g / bird) for the first, second, third, fourth, fifth and sixth treatments, respectively. In the fourth week of the experiment, the birds of sixth treatment (683.67 g / bird) showed significant superiority (P <0.01) over all the birds of the treatments of experiment and the third treatment birds (653.00 g / bird) also significantly excelled on the birds of first, second, fourth and fifth which amounted to (629.00, 633.33, 630.67, 640.00 g / bird), respectively, which did not differ significantly among them, and the birds of third treatment were significantly excelled by giving it a value amounted to (657.33 g / bird). In the fifth week of the experiment. the birds of third treatment were significantly excelled by giving it a value amounted to (657.33 g / bird) on the birds of first, second, fourth and fifth treatments which amounted to (624.33, 642.67, 627.33, 627.33 g / bird) while the birds of sixth treatment did not differ significantly (647.67 g / bird), which did not differ significantly from the birds of second treatment (642.67 g / bird). As for the total weight gain, the results of the statistical analysis showed a significant excelling (P <0.01) for the birds of the sixth treatment on the birds of the rest experimental treatments, followed by the birds of third treatment which significantly excelled on the first, second, fourth and fifth treatments, respectively. The birds of second treatment were significantly excelled on the first and fourth treatments, and the results of the statistical analysis did not record a significant difference between the first, the fourth and the fifth, the averages of total weight gain amounted to (2037.33, 2071.00, 2112.00, 2051.67, 2055.00, 2134.00 g / bird) for the first, second, third, fourth, fifth and sixth treatments, respectively. Good intestinal health in poultry is considered with great importance to achieve the targeted growth rates (18). The improvement in the bird's intestinal environment caused by the presence of organic acids that help the growth of beneficial bacteria and reducing the number of pathogenic bacteria, It has contributed to raising the efficiency of the digestive system and its ability to digest and absorb (37, 16, 23). It is also believed that this decrease in the number of intestinal bacteria may contribute to reducing bacterial competition with the host on available nutrients, and this is reflected in an improvement in the weight gain in broiler chickens (15, 7). These results agree with (1, 7, 2) who observed a significant difference in the averages of the weight gain for the groups of treatment with different concentrations of citric and tartaric acid compared to the control treatment.

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Table 3: Effect of adding different levels of citric and tartaric acidic acid and their interaction to the diet on the average weight gain (g/bird) for broiler chickens.

Treatments	Weeks					
	First week	**Second week**	**Third week**	**Fourth week**	**Fifth week**	**Total weight gain**
T1	± 112.67 0.33	± 268.33b 1.20	± 403.33c 2.40	± 629.00c 1.73	± 624.33c 1.67	± 2037.33d 3.48
T2	± 113.00 0.57	± 266.67bc 1.33	± 415.33ab 2.90	± 633.33c 6.33	± 642.67 b 7.22	± 2071.00 c 7.23
T3	± 113.67 0.33	± 267.33bc 1.33	± 420.33a 1.76	± 653.00b 2.08	± 657.33 a 6.35	± 2112.00b 8.50
T4	± 114.00 0.57	± 265.33bc 0.33	± 414.67ab 2.73	± 630.67c 4.25	± 627.33 c 0.67	± 2051.67d 3.75
T5	± 114.00 0.57	± 264.67c 1.20	± 409.00bc 3.78	± 640.00c 3.51	± 627.33 c 2.60	± 2055.00cd 2.16
T6	± 113.33 0.33	± 271.67a 0.33	± 417.67ab 4.48	± 683.67a 2.84	± 647.67ab 1.76	± 2134.00a 4.93
Significant level	NS	**	*	**	**	**

NS: It means no significant differences.

* Different letters within a single column differ significantly among them at the probability level of (P <0.05)

** Different letters within a single column differ significantly among them at the probability level of (P <0.01)

The first treatment (T1) was a basic feed without adding (control treatment), The second treatment (T2) and the third treatment (T3) are a basic diet added to it a citric acid with a rate of (2.5-3%), respectively, the fourth treatment (T4) and the fifth treatment (T5) are a basic diet added to it a tartaric acid with a rate of (2.5-3%), respectively, and the sixth treatment (T6) is a basic diet added to it a 1.5% citric acid + 1.5% tartaric acid.

Feed consumption

Table (4) indicates the averages of weekly feed consumption where the results of the statistical analysis indicated that there was no significant difference between the birds of different treatments in the first week of the experiment, while the results showed that the effect of adding different levels of citric acid and tartaric acid and their interaction to the diet in the second week of the experiment led to a significant difference (P <0.05), where the birds of second treatment recorded the highest average of feed consumption amounted to (375.00 g / bird) excelling on birds of the first, fourth and sixth treatments which amounted to (354.00, 360.33, 361.11 g / bird), respectively, while there was no significant difference from the birds of third and fifth treatment which amounted to (370.33, 369.00 g / bird), respectively, and it did not notice any significant difference between the birds of first treatment that recorded the lowest average of feed consumption and the birds of fourth and sixth treatments. In the third week of the experiment, the first treatment (699.33 g / bird) recorded significant differences (P <0.05) on the fifth and sixth treatments (678.00, 676.00 g / bird), respectively in this trait, and there were significant differences between the birds of the first treatment and the birds of the second, third and fourth treatments in the trait of feed consumption which amounted to (690.67, 694.67, 688.00 g / bird), respectively. As for the fourth week of the experiment, a significant difference (P <0.01) was observed, where the

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first treatment continued to record the highest average of feed consumption amounted to (964.00 g / bird) excelling on the rest of the treatment. The birds of fourth and sixth treatment were also significantly excelled which amounted to (917.00, 915.67 g / bird) respectively, on the birds of third treatment which amounted to (882.67 g / bird) and no significant difference was recorded for the second and fifth treatments which amounted to (891.00, 896.00 g / bird), respectively. In the fifth week of the age of the birds, the birds of fourth and fifth treatment recorded the highest average of feed consumption amounted to (1150.33, 1151.00 g / bird) respectively, compared the birds of the second, third and sixth treatments which amounted to (1131.67, 1134.00, 1127.33 g / bird), respectively, the birds of first treatment (1138.67 g / bird) did not differ significantly from the birds of other treatments. The statistical analysis data show the presence of a significant difference ($P < 0.05$) between the birds of the first treatment that recorded the highest average of total feed consumption and the birds of all other treatments except for the birds of fourth treatment. The averages of total feed consumption amounted to (3297.67, 3230.00, 3224.00, 3258.00, 3236.00, 3221.33 g / bird) for the birds of first, second, third, fourth, fifth and sixth treatments, respectively. The reason for decreasing feed consumption for the birds of experimental treatments may be due to the lack of palatability of birds to the diet due to the acidic taste caused by organic acids (9, 33). These results agree with (14) who observed a decrease in the daily feed consumption of treatment groups with different concentrations of citric acid compared with the control group.

Table 4: Effect of adding different levels of citric and tartaric acidic acid and their interaction to the diet on the average of feed consumption (g/bird) for broiler chickens.

Treatments	Weeks					
	First week	**Second week**	**Third week**	**Fourth week**	**Fifth week**	**Total feed consumption**
T1	± 141.67 0.33	± 354.00c 5.29	± 699.33a 2.33	± 964.00a 16.09	± 1138.67 ab5.23	27.86 ± 3297.67a
T2	± 141.67 0.33	± 375.00a 1.73	± 690.67 ab3.71	± 891.00 bc5.03	± 1131.67b 1.33	7.68 ± 3230.00b
T3	± 142.33 0.33	± 370.33 ab4.91	± 694.67 ab10.26	± 882.67c 4.48	± 1134.00b 4.58	9.93 ± 3224.00b
T4	± 142.33 0.33	± 360.33 bc2.33	± 688.00 ab2.33	± 917.00b 8.38	± 1150.33a 5.24	± 3258.00ab 17.34
T5	± 142.00 0.57	± 369.00 ab2.89	± 678.00b 7.81	± 896.00 bc7.09	± 1151.00a 4.61`	18.09 ± 3236.00b
T6	± 141.33 0.33	± 361.00 bc4.58	± 676.00b 2.64	± 915.67b 4.09	± 1127.33b 3.52	11.79 ± 3221.33b
Significant level	NS	*	*	**	**	*

NS: It means no significant differences.

* Different letters within a single column differ significantly among them at the probability level of ($P < 0.05$)

** Different letters within a single column differ significantly among them at the probability level of ($P < 0.01$)

The first treatment (T1) was a basic feed without adding (control treatment), The second treatment (T2) and the third treatment (T3) are a basic diet added to it a citric acid with a rate of (2.5-3%), respectively, the fourth treatment (T4) and the fifth treatment (T5) are a basic diet added to it a tartaric acid with a rate of (2.5-3%), respectively, and the sixth treatment (T6) is a basic diet added to it a 1.5% citric acid + 1.5% tartaric acid.

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Feed conversion ratio

Table (9) shows there are no significant differences between birds of different treatments in the average feed conversion ratio, while the results of the statistical analysis indicated that the effect of adding different levels of citric acid and tartaric acid and their interaction the diet of broiler chickens in the second week of the experiment was a significant improvement (P <0.01) for birds of the control treatment (1.32 g feed/g weight gain) and the birds of the sixth treatment (1.33 feed/g weight gain) compared to the birds of second treatment (1.44 feed/g weight gain) and the birds of third treatment (1.38 feed/g weight gain) and the birds of fifth treatment (1.39 feed/g weight gain). However, they did not differ significantly with the birds of fourth treatment (1.36 g feed / g weight gain), and no significant differences were observed between the birds of second, third and fifth treatment. In the third week, the feed conversion ratio for the birds of adding treatments was improved compared to the birds of control treatment, and no significant differences were observed between the birds of adding treatments, Where the averages of the feed conversion ratio amounted to (1.73, 1.66, 1.65, 1.66, 1.66, 1.62 g feed / g weight gain) for the first, second, third and fourth and fifth treatments respectively. As for the fourth week of the experiment, the birds of sixth treatment (P <0.01) improved significantly (1.27 g feed / g weight gain) compared to the birds of the other treatments, and an improvement in the birds of the adding treatments was also observed compared to the birds of the control treatment (1.53 g feed / g weight gain). The birds of third treatment (1.35 g feed / g weight gain) showed a significant improvement on the birds of fourth treatment (1.46 g feed / g weight gain) and the second treatment (1.41 g feed / g weight gain), while they did not differ significantly from the birds of fifth treatment which amounted to (1.40 g feed / g weight gain). In the fifth week, the above table data indicated a significant improvement (P <0.01) in the average of the feed conversion ratio for the birds of second, third, and sixth treatment compared to the birds of first, fourth, and fifth treatment Which no significant differences were observed among them and the averages of feed conversion ratio amounted to (1.82, 1.76, 1.73, 1.84, 1.83, 1.74 g feed / g weight gain) for the first, second, third, fourth, fifth and sixth treatments, respectively. As for the averages of the total feed conversion ratio, the data showed a significant improvement (P <0.01) for the birds of the adding treatments compared to the birds of control treatment. The birds of sixth treatment showed a significant improvement on the birds of other adding treatments. The averages of the feed conversion ratio amounted to (1.64, 1.58, 1.55, 1.59, 1.58, 1.50 g feed / g weight gain). The addition of citric and tartaric acid and their interaction treatments recorded the best feed conversion ratio compared to the control treatment since adding organic acid mixtures to each of them was more effective than adding them individually (17, 27). Research has shown that the beneficial effects of organic acids can be improved by using them as mixtures instead of a single acid, where many organic acid mixtures have been tested and have shown that they improve the feed conversion ratio in broiler chickens (30, 31). So the citric and tartaric acid work is a synergistic action that produces a better response when feeding on both.

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Table 5: Effect of adding different levels of citric and tartaric acidic acid and their interaction to the diet on the average of feed conversion ratio (g feed / g weight gain) for broiler chickens.

Treatments	Weeks					
	First week	Second week	Third week	Fourth week	Fifth week	The cumulative feed conversion ratio
T1	± 1.26 0.00	± 1.32 0.01c	± 1.73 0.01a	± 1.53 0.03a	± 1.82 0.01a	0.01 ± 1.64a
T2	± 1.25 0.00	± 1.41 0.01a	± 1.66 0.01b	± 1.41 0.02c	± 1.76 0.02b	0.01 ± 1.58b
T3	± 1.25 **0**.00	± 1.38 0.01ab	± 1.65 **0**.02b	± 1.35 **0**.01d	± 1.73 **0**.01b	**0**.00 ± 1.55c
T4	± 1.25 0.00	± 1.36 0.01bc	± 1.66 0.01b	± 1.46 0.01b	± 1.84 0.01a	0.01 ± 1.59b
T5	± 1.25 0.00	± 1.39 0.01ab	± 1.66 0.02b	± 1.40 0.01cd	± 1.83 0.01a	0.01 ± 1.58b
T6	± 1.25 0.00	± 1.33 0.02c	± 1.62 0.02b	± 1.27 0.01e	± 1.74 0.01b	0.00 ± 1.50d
Significant level	NS	**	**	**	**	**

NS: It means no significant differences.

* Different letters within a single column differ significantly among them at the probability level of (P <0.05)

** Different letters within a single column differ significantly among them at the probability level of (P <0.01)

The first treatment (T1) was a basic feed without adding (control treatment), The second treatment (T2) and the third treatment (T3) are a basic diet added to it a citric acid with a rate of (2.5-3%), respectively, the fourth treatment (T4) and the fifth treatment (T5) are a basic diet added to it a tartaric acid with a rate of (2.5-3%), respectively, and the sixth treatment (T6) is a basic diet added to it a 1.5% citric acid + 1.5% tartaric acid.

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