

## ROLE OF ADDING POWDERED SUMAC FRUIT, RED PEPPER, AND THEIR MIXTURE ON ORODUCTIVE PERFORMANCE OF BROILER CHICKENS.

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### ABSTRACT

This study was aimed to investigate the role of adding powdered sumac fruit, red pepper, and their mixture on the productive performance of broiler chickens. The experiment was conducted in the poultry field, from October 26, 2021, to December 7, 2021 (42 days). Two hundred one-day-old non-sexed Ross 308 broilers were used, with an initial average weight of 37 grams per chick. The experiment consisted of four treatments with five replicates (10 chicks/replicate). During the experimental period, the birds were fed three types of balanced feed containing protein and energy. The starter feed was provided from day one to day 14. The grower feed was provided from day 15 to day 28. The finisher feed was provided from day 29 to day 42. Powdered sumac, red pepper, and their mixture were added at rates of 0.5%, 0.5%, and 0.5% to treatments T2, T3, and T4, respectively, while the control treatment (T1) received standard feed without any additives. Significant improvement was observed in live body weight in favor of the T4 treatment (mixture addition) and in total weight gain compared to the control treatment.

**Key words:** Weight gain, body weight, phenols, antioxidants.



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### INTRODUCTION

Herbaceous plants are important ingredients in poultry feed, such as coriander (*Rhus coriaria*), which belongs to the Anacardiaceae family. It is mainly found in countries surrounding the Mediterranean Sea, southern Europe, northern Iraq, and Iran (Rayne & Mazza, 2007). It is used as a flavoring agent, antioxidant, and anti-inflammatory in traditional medicine and as an appetite stimulant. In addition, it has positive effects on the bird's body when added to the feed, as it contains ascorbic acid, phenolic compounds, flavonoids, tannins, and free amino acids that act as natural antioxidants (Fereidoonfar et al., 2019). Valiollahi, et (2014) observed a significant increase in daily body weight gain and feed

consumption when adding sumac powder to broiler diets, as well as an improvement in feed conversion efficiency. Red pepper (*Capsicum annum*) is also an important plant that is cultivated worldwide due to its economic importance and nutritional value. It contains capsaicinoids, which are responsible for its hot taste, and is a good source of vitamins C, E, A, carotenoids, phenolic compounds, flavonols, flavonoid glycosides, and hydroxy cinnamic acid, which act as natural antioxidants (Morales-Soto et al., 2013). The addition of red pepper to poultry feed has been found to improve bird health (Alagawany et al., 2019; Elwan et al., 2019) and plasma lipid profile, as well as decrease the pH of the cecal content, resulting in a

reduction in Salmonella and coliform bacteria counts and improved performance of birds fed diets containing red pepper powder (Reda et al., 2020). Due to the ban on the use of antibiotics and growth promoters in poultry industry and the increasing focus on health awareness, poultry breeders are seeking safe and natural alternatives to be added to the bird's diet as growth promoters. Therefore, the use of these natural plants, such as medicinal herbs (Alagawany et al., 2019), aromatic herbs (Zangana & Al-Safy, 2018), and spices (Zangana & Mashhadani, 2017), has gained attention due to their benefits and importance in human and animal health, as well as their contribution to enhancing the body's immunity against pathogenic agents, thanks to their numerous active compounds such as phenols, flavonoids, and carotenoids, and their role in increasing the secretion of digestive enzymes and improving nutrient utilization (Moradi et al., 2016). These plants also have natural antioxidant and antimicrobial properties (Al-Rubeii et al., 2009; Zangana & Al-Safy, 2018), which aim to meet consumer desires for food quality and better production performance to fulfill consumer needs (Hernández-Coronado et al., 2019; Onibi et al., 2009; Popovic et al., 2018). This study was aimed to investigate the effect of adding sumac and red pepper powder to the feed on the production performance of broiler chickens.

## MATERIALS AND METHODS

This experiment was conducted at the poultry field of the Animal Production Department at the College of Agricultural Engineering Sciences, University of Baghdad (Al-Jadriya area) for the period from 26/10/2021 to 7/12/2021 (42 days). A total of 200 one-day-old unsexed chicks of the 308 Ross breed were used. These chicks were obtained from the Rashidia hatchery and had an initial average weight of 37 grams per chick. The chicks were raised on a wood shavings bedding with a thickness of 5-7 cm. They were randomly distributed in pens with dimensions of 2m x 1m each. The experiment consisted of four treatments (5 replicates per treatment) with a rate of 10 chicks per replicate. The treatments were as follows:

Treatment 1 (T1): Standard diet without any additives (control). Treatment 2 (T2): Standard diet with the addition of 5 grams of sumac powder per kilogram of feed.

Treatment 3 (T3): Standard diet with the addition of 5 grams of red pepper powder per kilogram of feed. Treatment 4 (T4): Standard diet with the addition of 2.5 grams of sumac powder and 2.5 grams of red pepper powder per kilogram of feed as Table (1) presents the proportions of feed ingredients and their calculated chemical composition in the diets used in the experiment.

**Table 1. The chemical composition of the feeding containers used in the experiment**

Ingredient (%)	Start 1-14Day	Growth 14-28Day	Final 28-42Day
Yellow corn	46	50	52
Wheat protein	11	11.26	11
Soybean meal (% 48 Protein )	33	28	26
Concentrated proteind**	5	5	5
Sunflower oil	3	4	4.4
Di Calcium phosphate DCP	0.7	0.5	0.4
Salt	0.1	0.1	0.1
Limston	1.2	1.14	1.1
Total	100	100	100
<b>The calculated chemical composition***</b>			
Metabolic Energy (Kcal/ kg feed)	3064.75	3174.86	3220.95
Crude Protein (%)	23.13	21.1	20.38
C / P ration (%)	2.7	2.6	2.6
Crude Fat (%)	5.6	6.7	7.2
Lysine (%)	1.32	1.19	1.13
Methionin + Cysteine (%)	0.88	0.83	0.81
Calcium (%)	0.98	0.89	0.85
Phosphorus (%)	0.48	0.44	0.42

The soybeans used are from an Argentinian source, with a crude protein content of 48%

and 2440 kilocalories/kg of representative energy.

\*\*The protein concentrate used is from animal resource, produced by the Dutch company (imported) Brocon. It contains 40% crude protein, 2107 kilocalories/kg protein as represented energy, 5% crude fat, 2.20% crude fiber, 5% calcium, 4.68% phosphorus, 3.85% lysine, 4.12% methionine, 4.12% methionine + cysteine, 0.42% tryptophan, 1.70% threonine. It contains a mixture of rare vitamins and minerals that provide the bird's need for these elements.

\*\*\*According to the chemical composition based on NRC 1994.

The educational hall was prepared with the necessary number of lighting bulbs, providing 23 hours of light and one hour of darkness to accustom the chicks to darkness in case of unexpected power outages. Gas incubators were used to provide heat for the chicks, and the temperature in the hall was initially set at 33°C, then reduced by 2°C every three days until reaching a temperature of 24°C at the age of 21 days. The hall was equipped with air vents for a negative ventilation system to exchange air and regulate the temperature whenever necessary. Circular plastic dishes were used to provide feed during the first week of age, and then they were replaced with hanging cylindrical scoops that were adjusted according to the back level of the bird as it grew. Inverted plastic floor drinkers with a capacity of 2 liters were used, with one drinker per repeat for a period of two weeks, and then they were replaced with 5-liter plastic drinkers adjusted to the back level of the bird. Feed was provided to the birds continuously (ad libitum)

throughout the experiment (42 days). The average live body weight (in grams) was studied weekly, according to the method described by Al-Fayad et al. (2011). The weekly and overall weight gain rates, as well as the weekly and overall feed consumption ratios, were calculated according to Al-Fayad et al. (2011). The data were analyzed using the statistical software SAS (2018) and a complete randomized design was applied for data analysis. Duncan's multiple range test (1955) was used to compare the significant differences between the means of the studied traits.

### RESULTS AND DISCUSSION

Table (2) shows study investigated the effect of adding sumac powder, hot red pepper, and their mixture to the diet on the weekly body weight of broiler chickens. The results showed a significant improvement in the weekly body weight with the addition of T4 treatment (0.25% sumac + 0.25% red pepper) compared to T2 treatment (0.5% sumac), T3 treatment (0.5% red pepper), and the control treatment in the first week of the birds' age. In the second week, a significant superiority ( $P < 0.05$ ) was observed in the T4 treatment compared to the control treatment (T1) and its equivalent effects in the T2 and T3 treatments, which did not differ significantly from each other and the control treatment. The T4 treatment continued to show significant improvement in body weight in the third, fourth, fifth, and sixth weeks compared to the T2 and T3 treatments, which did not differ significantly from the control treatment (T1).

**Table 2. The effect of adding sumac powder, red hot pepper, and their mixture to the feed in the context of the weekly body weight rate. (grams/bird) of broiler chickens (mean  $\pm$  standard error).**

Age in weeks	Treatments				Significance
	T1	T2	T3	T4	
1	96.520 $\pm$ 0.906b	98.60 $\pm$ 2.753b	97.940 $\pm$ 1.207b	104.88 $\pm$ 2.239a	*
2	256.42 $\pm$ 20.893b	270.00 $\pm$ 5.912ab	284.880 $\pm$ 5.664ab	302.76 $\pm$ 6.499a	*
3	579.86 $\pm$ 19.778b	603.62 $\pm$ 13.638ab	614.40 $\pm$ 14.020ab	649.72 $\pm$ 15.974a	*
4	1051.58 $\pm$ 16.365b	1080.20 $\pm$ 23.709ab	1111.58 $\pm$ 42.668ab	1169.82 $\pm$ 28.792a	*
5	1636.50 $\pm$ 35.154b	1697.72 $\pm$ 40.047ab	1723.63 $\pm$ 75.357ab	1842.08 $\pm$ 50.073a	*
6	2531.74 $\pm$ 48.149b	2562.98 $\pm$ 62.912ab	2629.30 $\pm$ 106.807ab	2786.94 $\pm$ 75.930a	*

(1) The treatments include: T1: Control, T2: Use of 0.05% sumac, T3: Use of 0.05% red pepper, T4: Use of a mixture of 0.25% sumac and 0.025% red pepper.

NS means no significant differences between the treatments. \* indicates significant differences between the treatments at a level of ( $P < 0.05$ ).

Different letters within the same row indicate significant differences between the means at a level of ( $P < 0.05$ ).

**Weekly and overall weight gain rate (grams):** Table (3) demonstrates the effect of adding sumac powder, hot red pepper, and their mixture to the feed on the weekly and overall weight gain of broiler chickens. In the first week, there was a significant superiority ( $P < 0.05$ ) in favor of treatment T4 compared to treatments T2, T3, and the control treatment T1. However, there was no significant difference between the three treatments. In the second week, treatment T4 continued to show significant superiority compared to the control treatment and treatment T2, while there was no

significant difference between treatment T3 and treatment T4, as they were similar. In the third, fourth, fifth, and sixth weeks, the data did not show any significant differences between the additive treatments (T2, T3, and T4) and the control treatment, despite an improvement in weight gain rate in favor of the additive treatments compared to the control treatment. However, in terms of overall weight gain, treatment T4 showed a significant superiority compared to the control treatment, with a value of 2749.06 grams compared to 2495.06 grams per bird. Treatment T4 did not differ significantly from treatments T2 and T3, as there was no significant difference between them.

**Table 3. The effect of adding sumac powder, red hot pepper, and their mixture to the feed on the weekly and overall weight gain (grams/bird) of broiler chickens (mean  $\pm$  standard error)**

Age in weeks	Treatments				Significance
	T1	T2	T3	T4	
1	59.84 $\pm$ 0.651b	60.240 $\pm$ 2.499b	59.72 $\pm$ 1.168b	67.00 $\pm$ 2.040a	*
2	180.16 $\pm$ 2.672b	180.40 $\pm$ 4.220b	188.12 $\pm$ 3.889ab	198.00 $\pm$ 4.506a	*
3	318.22 $\pm$ 5.920a	324.64 $\pm$ 8.511a	336.88 $\pm$ 14.790a	346.84 $\pm$ 9.770a	N.S
4	456.68 $\pm$ 10.745a	476.56 $\pm$ 15.319a	497.18 $\pm$ 31.846a	520.310 $\pm$ 15.901a	N.S
5	584.92 $\pm$ 20.016a	617.52 $\pm$ 29.690a	612.10 $\pm$ 40.634a	672.62 $\pm$ 22.312a	N.S
6	895.24 $\pm$ 20.685a	859.26 $\pm$ 26.214a	905.62 $\pm$ 39.431a	944.86 $\pm$ 28.999a	N.S
<b>Total</b>	<b>2495.06<math>\pm</math> 47.983b</b>	<b>2518.62<math>\pm</math> 63.565ab</b>	<b>2599.62<math>\pm</math> 110.287ab</b>	<b>2749.06<math>\pm</math> 76.064a</b>	*

(1)The treatments include: T1: Control, T2: Use of 0.05% sumac, T3: Use of 0.05% red pepper, T4: Use of a mixture of 0.25% sumac and 0.025% red pepper.

NS means no significant differences between the treatments. \* indicates significant differences between the treatments at a level of ( $P < 0.05$ ).

Different letters within the same row indicate significant differences between the means at a level of ( $P < 0.05$ )

**Weekly and total feed consumption rate (g/bird):** Table (4), shows it can be observed that the addition of sumac powder, hot red pepper, and their mixture in the feed have an effect on the weekly and cumulative feed consumption rate of broiler chickens. In the first week, a significant increase ( $P < 0.05$ ) was observed in favor of treatment T4 compared to treatments T1 and T3, which did not differ significantly from each other but were similar to treatment T2, which did not

differ significantly from treatment T4. Treatment T4 continued to show a significant superiority in feed consumption rate compared to treatments T1 and T3. In the second week of the birds' age, treatment T4 was similar to treatment T3, which did not differ from treatments T1 and T3. No significant differences were observed between all addition treatments (T2, T3, and T4) and the control treatment T1 during the third and fourth weeks. Furthermore, a significant superiority ( $P < 0.05$ ) was observed in the feed consumption rate in favor of treatment T4 compared to treatment T2 in the fifth week of the birds' age, and treatment T4 was similar to the effects of treatments T1 and T3, which did not differ significantly from treatment T2. In the sixth week, the statistical analysis did not show any significant differences between all addition treatments and the control treatment, as well as in the cumulative feed consumption rate at the end of the rearing period (42 days).

**Table 4. The effect of adding sumac powder, red chili pepper, and their mixture to the feed on the weekly and total feed consumption rate (grams/bird) of broiler chickens (mean  $\pm$  standard error)**

Age in weeks	Treatments				Significance
	T1	T2	T3	T4	
1	83.00 $\pm$ 1.814b	76.56 $\pm$ 2.902ab	77.88 $\pm$ 2.504 b	85.56 $\pm$ 1.600a	*
2	293.32 $\pm$ 2.023b	299.48 $\pm$ 3.138ab	289.680 $\pm$ 6.190 b	305.34 $\pm$ 1.289a	*
3	471.72 $\pm$ 11.631a	474.52 $\pm$ 10.504a	500.36 $\pm$ 34.587a	481.72 $\pm$ 11.138a	N.S
4	749.86 $\pm$ 17.532a	720.84 $\pm$ 27.81a	717.52 $\pm$ 15.831a	767.68 $\pm$ 11.782a	N.S
5	1007.96 $\pm$ 28.604ab	988.08 $\pm$ 27.191b	997.00 $\pm$ 32.663ab	1078.24 $\pm$ 17.006a	*
6	1490.96 $\pm$ 35.624a	1507.44 $\pm$ 27.191b	1532.98 $\pm$ 55.514 a	1591.12 $\pm$ 33.481a	N.S
<b>Total feed consumption</b>	<b>4096.82 <math>\pm</math> 76.386a</b>	<b>4066.92 <math>\pm</math> 59.152a</b>	<b>4115.42 <math>\pm</math> 119.981a</b>	<b>4309.66 <math>\pm</math> 60.615a</b>	<b>N.S</b>

(1) The treatments include: T1: Control, T2: Use of 0.05% sumac, T3: Use of 0.05% red pepper, T4: Use of a mixture of 0.25% sumac and 0.025% red pepper.

NS means no significant differences between the treatments. \* indicates significant differences between the treatments at a level of ( $P < 0.05$ ).

Different letters within the same row indicate significant differences between the means at a level of ( $P < 0.05$ ).

The impact of adding sumac powder, red hot pepper, and their mixture in the feed on the weekly and cumulative feed conversion ratios (grams/bird) for broiler chickens were observed in Table (5). It was noticed that there was a significant improvement ( $P < 0.05$ ) in the feed conversion ratio during the first week in favor of the treatments with the additives (T2, T3, and T4) compared to the control treatment

(T1). However, in the second week, a significant improvement ( $P < 0.05$ ) was observed in favor of treatments T3 and T4 compared to the additive treatment T2, and there was no significant difference between treatments T3 and T4 compared to the control treatment, which showed similar results to treatments T3 and T4. In the third, fourth, and fifth weeks of the birds' age, no significant differences were observed between all the additive treatments compared to the control treatment. The same applies to the cumulative feed conversion ratio, as the data did not show any significant differences between all the additive treatments and the control treatment at the end of the rearing period, despite the fact that the additive treatments had lower feed conversion ratios compared to the control treatment.

**Table 5. Effect of adding sumac powder, red chili pepper, and their combination to the feed on the weekly and cumulative feed conversion ratios (FCR) of broiler chickens (mean  $\pm$  standard error).**

Age in weeks	Treatments				Significance
	T1	T2	T3	T4	
1	1.386 $\pm$ 0.025a	1.271 $\pm$ 0.012b	1.304 $\pm$ 0.038b	1.278 $\pm$ 0.016b	*
2	1.629 $\pm$ 0.018ab	1.663 $\pm$ 0.046a	1.54 $\pm$ 0.024b	1.545 $\pm$ 0.038b	*
3	1.483 $\pm$ 0.034a	1.465 $\pm$ 0.04a	1.489 $\pm$ 0.101a	1.389 $\pm$ 0.011a	N.S
4	1.642 $\pm$ 0.028a	1.515 $\pm$ 0.059a	1.464 $\pm$ 0.087a	1.479 $\pm$ 0.027a	N.S
5	1.726 $\pm$ 0.046a	1.609 $\pm$ 0.060a	1.650 $\pm$ 0.088a	1.608 $\pm$ 0.037a	N.S
6	1.665 $\pm$ 0.011a	1.75 $\pm$ 0.046a	1.695 $\pm$ 0.025a	1.687 $\pm$ 0.034a	N.S
<b>Cumulative feed conversion rate</b>	<b>1.64 <math>\pm</math> 0.007a</b>	<b>1.62 <math>\pm</math> 0.023a</b>	<b>1.59 <math>\pm</math> 0.031a</b>	<b>1.57 <math>\pm</math> 0.029a</b>	<b>N.S</b>

(1) The treatments include: T1: Control, T2: Use of 0.05% sumac, T3: Use of 0.05% red pepper, T4: Use of a mixture of 0.25% sumac and 0.025% red pepper.

NS means no significant differences between the treatments. \* indicates significant

differences between the treatments at a level of ( $P < 0.05$ ).

Different letters within the same row indicate significant differences between the means at a level of ( $P < 0.05$ ).

In light of these positive and significant results that have emerged in some of the studied traits

in favor of adding turmeric and red pepper powder compared to the control treatment, this improvement can be attributed to the role of active compounds such as cinnamaldehyde, eugenol, phenols, flavonoids, glycosides, and hydroxycinnamic acid (Mansoub, 2011) in red pepper, as well as in turmeric (Rayne & Mazza, 2007). Flavonoids act as growth promoters that contribute to increasing muscle tissue growth by supporting protein synthesis for muscle mass building in the body (Feide et al., 2003; Valenzuela-Grijalva et al., 2017). They also play a role in activating the thyroxine hormone synthesis process and increasing metabolic rates. Hosna et al. (2011) have previously indicated that adding powdered plant sources rich in polyphenols as dietary supplements to chicken feed can improve the taste and palatability of the feed, thereby increasing feed consumption, enhancing immune function, and improving the productive performance of birds. Additionally, Al-Balushi (2016) has pointed out that the active compounds in sumac fruits contribute to improving the utilization of consumed feed during the release of energy for other compounds in the feed. Our study's results are consistent with Mansoub (2011) and Rasheed et al. (2023) in demonstrating that feeding broiler chickens with different levels of sumac powder had a significant effect on weight gain and improved feed conversion ratio. Furthermore, Indications suggest (Chen et al., 2018) that feeding poultry a mixture of herbal plants improves production performance studies by Chen et al. (2018), Hashemi and Davoodi (2010), and Tag El-Din et al. (2019) have shown that adding powdered medicinal plant sources rich in active compounds contributes to increased secretion of digestive enzymes, which improves the digestion and absorption of nutrients, resulting in body growth, cumulative weight gain, and improved feed conversion ratio, reflecting the extent of the bird's utilization of consumed feed. The reason for the improvement in the productive performance of the birds fed both sumac and red pepper may also be attributed to their being good sources of vitamins such as vitamin E and vitamin A, which have high

antioxidant activity against lipid oxidation. They break the chain reaction of oxidation and inhibit the final chain of free radicals, thus preserving the cellular membranes of proteins from oxidative damage and reducing their tearing, which contributes to preserving the internal components of the muscle tissues (Morales-Soto et al., 2013). Furthermore, the chemical composition of both sumac and red pepper includes vitamin C, which contributes to regulating the chemical reactions of metabolic processes within the living organism's body, thereby promoting body growth. Kossah et al. (2009) have also highlighted the diverse content of vitamins in sumac, such as thiamine and riboflavin (B2), which play a role in improving the metabolism process within the body's muscles, cell formation, development, and protection against oxidation, playing beneficial roles in various other physiological processes. These digestive enzymes play a role in stimulating the liver to secrete bile, which Afolabi et al. (2017) previously indicated as the effect of red pepper added to the feed in increasing the effectiveness of digestion and nutrient absorption within the bird's digestive system. These findings are consistent with those of Puvača et al. (2019), who found that adding some spices, including red pepper, to the feed led to a significant superiority in post-slaughter weight gain and cooling compared to the control treatment.

#### **CONCLUSION**

The findings of this study confirm that the dietary inclusion of powdered sumac, red pepper, and their mixture as natural feed additives significantly enhances the productive performance of Ross 308 broiler chickens. Specifically, the supplementation of a 0.5% mixture of sumac and red pepper (Treatment T4) yielded the most superior results, leading to a significant improvement in live body weight and total weight gain compared to the control group. This synergistic effect suggests that the combination of bioactive compounds found in sumac and red pepper—such as phenolic compounds, flavonoids, and capsaicinoids—effectively stimulates growth and improves nutrient utilization over a 42-day

production cycle. Consequently, these natural herbs can be recommended as safe and efficient growth promoters in poultry nutrition, offering a sustainable alternative to synthetic additives while meeting modern production standards for broiler performance.

#### CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

#### AUTHORS' DECLARATION

The authors declare that this manuscript is original, has not been published previously, and is not currently under consideration by any other journal. All figures and tables are original and prepared by the authors. Any material obtained from third parties has been included with the required permissions. All authors have read and approved the final manuscript.

#### AUTHORS' CONTRIBUTION STATEMENT

All authors made equal contributions to the study design, methodology, experimental work, data analysis, and manuscript writing. All authors reviewed and approved the final version of the manuscript.

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تأثير إضافة مسحوق ثمار السماق (*Rhus coriaria*) والفلفل الاحمر (*Chilli pipper*) وخليطهما الى العليقة في الاداء

### الانتاجي لفرج اللحم

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### المستخلص

هدفت الدراسة الى معرفة دور اضافة كل من مسحوق ثمار السماق والفلفل الاحمر وخليطهما في الاداء الانتاجي لفروج اللحم، للفترة من 26/10/2021 ولغاية 7/12/2021 اذ استخدم 200 فرخ نوع Ross 308 بعمر يوم واحد غير مجنس وبمعدل وزن ابتدائي 37 غم / فرخ، وقد تضمنت التجربة اربع معاملات بواقع خمسة مكررات ( 10 فرخ/ مكرر)، تم تغذية الطيور خلال فترة التجربة بثلاثة انواع من العلائق المتزنة بالبروتين والطاقة، البادى تقدم من عمر يوم واحد ولغاية 14 يوماً، عليقة النمو قدمت من عمر 15 يوماً ولغاية 28 يوماً، اما العليقة النهائية فقدمت من عمر 29 يوماً ولغاية 42 يوماً. اضيف مسحوق السماق والفلفل الاحمر الحار بنسب 0.5% و 0.5% وخليطهما بنسبة 0.5% للمعاملات T2، T3، T4 على التوالي بينما كانت معاملة السيطرة T1 مكونة من عليقة قياسية بدون اضافة، وجود تفوق معنوي في وزن الجسم الحي لصالح معاملة اضافة الخليط T4 والزيادة الوزنية الكلية مقارنة بمعاملة السيطرة.

كلمات مفتاحية: الزيادة الوزنية، وزن الجسم، الفينولات، مضادات اكسدة.

جزء من رسالة ماجستير للباحث الاول