Research Article

Comparison Effects of Adding Grape Pomace Powder, Grape Seed Oil, and Its Nanoparticles to Broiler Diets on Production Traits

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Abstract | The current study was found that significant improvement in productive performance when used grape pomace powder, grape seed oil or their nano-powder in broiler chicken feed. The broilers weight at 35 days of age was recorded to be statistically higher and so there is a significant improvement in weekly weight gain with dietary-supplementation, along with an impressive improvement on FCR (Feed Conversion Ratio) as compared to the un supplemented control. The best results were obtained with both treatments of 0.25% grape seed oil and 0.5kg/100 kg feed grape pomace powder. This demonstrates the contribution of the phenolics and antioxidants in grape by-products for amelioration of digestive health and to increase nutrient absorption efficiency. The supplements did not significantly affect feed intake, indicating its cost effectiveness and environmental advantage. The findings also indicated a dose-response effect, as escalating doses did not result in further substantial favorable effects. It is indicative that these natural additives can be included in broiler feeding programmes ensuring an increased growth performance and the improvement of nutrients utilization. The optimal levels should be used and further research on meat quality and general bird health is recommended.

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Introduction

The raising of healthier broilers with increasing antibiotic resistance is facing challenges all over the world, and therefore an efficient and safe natural alternative for the promotion of growth and production in poultry has become urgent. Therefore, grape byproducts including dried grape pomace (DGP) and grape seed oil (GSO), which contain bioactive plant compounds, could be an alternative

with potential benefits to recent poultry performance and health.

Plant ingredients and products became the focus of recent attention as natural feed additives to poultry for their antioxidant, antimicrobial, immune-stimulant effects and improving the quality of meat (Alagawany *et al.*, 2024).

Grape pulp is a natural reservoir of bioactive compounds, including polyphenols, flavonoids, resveratrol, quercetin and tannins, which exhibit strong antioxidant potential along with antibacterial and immunomodulatory activities (Chamorro *et al.*, 2015). Grape seed oil is also rich in unsaturated fatty acids such as linoleic acid, which indicates the possibility to promote fat metabolism of birds.

Many studies agree that including grape pulp in broiler diets could positively affect the final live weight gain, feed conversion ratio (FCR), digestive and immune health. In the same line, Brenes et al. (2008) fed grape pulp as a component of ration to the poultry and they reported that using grape pomace reduced indicators of oxidative stress and improve the intestine structure, thus improving nutrient availability.

These results were complemented by data from Gessner et al. (2013) also showed that grape seed extract prevents the progression of chronic colitis and changes intestinal microbiota metabolism to improve overall health. Viveros et al. (2011) demonstrated an increase in intestinal microflora beneficial bacteria such as Lactobacillus spp., leading to the better absorption of intestine. The combination of grape seeds and grape pomace is more effective than sole application (Romero *et al.*, 2021).

Furthermore, nanotechnology has emerged as a tool to enhance the efficacy of these additives. (Yeo and Kang, 2008) demonstrated that using nanoparticles to improve the bioavailability of grape compounds may increase their effectiveness in the body by improving intestinal stability and absorption, without the need to increase the dosage used in the feed. Therefore, this research aims to evaluate the effect of adding grape pomace powder, grape seed oil, and grape pomace Nano powder to broiler feed on growth performance, feed intake, and feed conversion efficiency during a 35-day rearing period. Based on modern scientific indicators to support the use of these additives as effective and natural alternatives in poultry nutrition.

Materials and Methods

This experiment was conducted at Al-Anwar National Poultry Company in Babylon Governorate for a period of 35 days, (December 12, 2024, to January 13, 2025). The aim was to assess the impact of adding grape pomace powder, grape seed oil, as well as nano-powder to the diet on broiler chickens.

A total of 420 One-day-old Ross 308 chicks of unspecified sex were utilized. They were divided randomly into seven dietary treatment groups, each with three replicates and 20 chicks per replicate. The experimental treatments were administered as follows.

1. T1: Control group (no supplementation).
2. T2: Basal diet supplemented with grape pomace powder at 0.5 kg/100 kg of feed.
3. T3: Grape pomace powder at 1 kg per 100 kg feed
4. T4: Grape seed oil at 0.25 L per 100 kg feed.
5. T5: Grape seed oil at 0.5 L per 100 kg feed
6. T6: Grape pomace nanoparticles at 1 g per 100 kg feed
7. T7: Grape pomace nanoparticles at 3 g per 100 kg feed.

Preparation of additives

Grape pomace was sourced from local markets. It was dried at a controlled temperature of 33-36°C, away from direct sunlight (table1 and 3). The seeds were separated from the dried pomace for oil extraction. The oil was obtained using a cold-pressing method, where the seeds were pressed in a mechanical expeller that operates solely by pressure, without the application of heat(Table 2).

The grape pomace nano-powder was synthesized in

the laboratories of the Ministry of Science and Technology. Grape pomace extract-derived zinc nanoparticles were synthesized by modified protocol from Elumalai . The steps included in the process were as follows:

A round bottom flask with 1000 mL of distilled water was coupled with 10 mL extract (20% Grape pomace). The flask was put on stirrer and heated to different temperatures. One minute later, it was under slow stirring that zinc sulfate was gradually added.

About 10 g of the composite were prepared, blended and then purified. Sodium hydroxide (NaOH) was added to adjust the pH and neutralize the mixture's acidity (Jefri *et al.*, 2019).

The mixture was transferred to a glass crucible then placed in an oven at 200°C for two hours. To separate the solution, the mixture was filtered, then the resulting sediment was collected. This sediment was dried in oven on 70°C to remove any remaining moisture. The powder that had dried was then pulverized. A final, gradual addition of 10 grams of zinc sulfate was performed to complete the mixing of components. The final nano-powder was stored in an airtight container (Munir and Begum, 2019). These experimental treatment were added to the diet , chemical analysis (Table 4).

Table 1. *Nutritional value of grape pomace powder*

Compounds	Percent %
Protein	16.2
Lipid	6.4
Ash	9.4
Moisture	20.6
CHO	47.4

*As stated by Noor *et al.*, (2022) that "The Protein Concentrate Brocon-5 Special W: Originating in China. Each kg contains (40% crude protein, 3.5% fat, 1% fiber, 6% calcium, 3% available phosphorus, 3.25% lysine, 3.90% methionine + cysteine, 2.2% sodium, 2100 kcal/kg metabolizable energy, 20,000 IU vitamin A, 40,000 IU vitamin D3, 500 mg vitamin E, 30 mg vitamin K3, 15 mg vitamins B1 + B2, 150 mg B3, 20 mg B6, 300 mg B12, 10 mg folic acid, 100 mcg biotin, 1 mg iron, 100 mg copper, 1.2 1 mg manganese, 800 mg zinc, 15 mg iodine, 2 mg selenium, 6 mg cobalt, 900 mg antioxidant (BHT)."

Table 2. *Estimation of fatty acids in grape seed oil*

Fatty Acids	Concentration %
Palmatic	7.08
Oleic	20.98
Lenolic	60.08
Lenolenic	0.5
Stearic	2.36

Table 3. *Phenolic compounds in grape pomace powder*

Phenolic Compounds	Con (ppm)
Resveratrol	192.5
Ferulic acid	87.4
Callic acid	85.4
Kaempferol	80.9
Qurcetine	117.9
Rutin	124.9

Chemical analysis of the feed was calculated according to NRC (1994).

Preventive program

The following health and preventive program was applied according to the company's standard protocol

Statistical analysis

Completely randomized design (CRD) was used to study the effects of different treatment in all traits (Duncan, 1955).

Measured traits

1. Live Body Weight and Weekly Weight Gain (g/bird):

Procedure: The live body weight of the birds was recorded for each replicate at the end of each first weeks from weeks 1 to 5. All birds in a single replicate were weighed together using a sensitive electronic scale.

Calculation: The average live body weight per bird was calculated using the formula described by (Al-Fayyad *et al.*, 1989).

$$\text{Average live body weight (g/bird)} = \frac{\text{Total live body weight of birds in the replicate at the end of the week (g)}}{\text{Number of birds in the replicate at the end of the week}}$$

As for the average weekly weight gain (g/bird), it was calculated according to Al-Fayyadh (1989) as follows:

Live body weight at the end of the week (g) – live body weight at the beginning of the week

Table 4. *Percentage composition of the experimental diets and their chemical analysis*

Feed ingredient	Starter diet (%) (1–21 days)	Grower diet (%) (22–35 days)
Maize	30	40
Wheat	28.25	24
Soybean meal (48% protein)	31.75	24.8
Protein concentrate*	5	5
Sunflower oil	2.9	4.4
Limestone	0.9	0.6
Dicalcium phosphate (DCP)	0.7	0.9
Vitamin and mineral premix	0.2	0.2
Salt	0.3	0.1
Total	100	100
Crude protein (%)	23.04	20.06
Calculated metabolizable energy (kcal/kg feed)	3021.45	3194.92
Lysine (%)	1.27	1.07
Methionine (%)	0.41	0.38
Cystine (%)	0.35	0.30
Methionine + Cystine (%)	0.82	0.78
Available phosphorus (%)	0.41	0.43
Energy-to-protein ratio (kcal/% CP)	131.14	159.26

Table 5 . *Preventive health program applied in the experiment*

Age / day	Vaccine or vitamins used
1	Oil vaccine (Newcastle + IB + Gumboro)
2–5	Vitamins B-Complex + C + AD3E + antibiotics
14	Newcastle vaccine (Clone 30) + IB (eye drop)

2. Feed Intake (g/bird):

Procedure: Weekly feed intake was calculated for each replicate from weeks 1 to 5. This was determined by weighing the feed provided at the start of the week and subtracting the leftover feed at the end of the week.

Mortality Adjustment: In the event of bird mortality within a replicate, feed intake was adjusted and calculated using the formula specified by (Al-Zubaidi, 1986).

$$\text{Average daily feed intake (g/bird)} = \frac{\text{Amount of feed consumed during the week}}{(\text{Number of chicks at the end of the week} \times 7) + (\text{number of days the dead birds were fed})}$$

3. Feed Conversion Ratio (FCR) (g feed / g weight gain):

Calculation: Feed conversion efficiency was calculated as the ratio of total feed intake to totalbody weight gain, according to the formula referenced by (Al-Zubaidi, 1986).

$$\text{Average live body weight} = \frac{\text{otal live body weight of birds in the replicate at the end of the week (g)}}{\text{Number of birds in the replicate at the end of the week}}$$

Results and Discussion

average live body weight (g/bird)

The data in Table (6) shows the impact of adding grape pomace powder, grape seed oil, and their nano-powder to broiler diets on average live body weight (g). During the first week, all supplemented treatment groups outperformed the control group, demonstrating a statistically significant increase ($p \leq 0.01$) in mean body weight. While differences between treatments were present from the start, they became more pronounced given that the birds aged, from week one through week five, demonstrating that the impact of the supplements increased over time. The results revealed that two treatments, T2 (0.5 kg grape pomace powder / 100 kg feed) as well as T4 (0.25 L grape seed oil / 100 kg feed), resulted in a statistically superior performance given that the birds matured.

Week 1: Treatment T2 demonstrating a statistically significant in weight compared to all other treatments, The difference was not statistically significant compared to treatment T3..

Weeks 2, 3, 4: Treatments T2 as well as T4 were both statistically outperformed ($p \leq 0.01$) other treatments, yielding the highest body weights for broilers. In contrast, treatments T1 (control) as well as T6 showed no significant difference from each other and resulted in the lowest body weights.

Week 5 (Final Week): Treatment T4 (0.25% grape

seed oil) demonstrated a highly statistical significant advantage (p≤0.01) over all remaining treatments. It was proceeded by treatment T2 (0.5% grape pomace powder), which was not significantly different from treatment T7 (3 g nano grape pomace powder / 100 kg feed).

Table 6. *Effect of adding grape pomace powder, grape seed oil, and its nanoparticle form to the diet of Ross 308 broiler chickens on the average live body weight (g/bird) during weeks 1–5 of age*

Treatments	Means ± SE					
	Initial weight	First week	Second week	Third week	Fourth week	Fifth week
T1	42.66± 0.88^{a}	161.33± 0.88^{d}	438.33± 4.80^{d}	901.00± 9.50^{d}	1491.66± 2.66^{c}	2015.00± 5.50^{e}
T2	42.00± 0.57 a	171.00± 0 ^{a}	455.33± 2.66^{ab}	950.00± 2.88^{a}	1587.33± 3.38^{a}	2234.33± 2.40^{b}
T3	42.66± 0.33 ^{a}	170.33± 0.33 ^{ab}	448.00± 2.08^{bc}	915.66± 2.60^{c}	1502.33± 2.84^{c}	2194..67± 7.88^{d}
T4	43.33± 0.33 ^{a}	167.66± 1.45^{c}	457.33±0.33^{a}	947.00± 2.08^{a}	1591.33± 5.17^{a}	2251.00± 3.21^{a}
T5	43.00± 0.57 ^{a}	168.00± 0.57^{bc}	452.00±0^{ab}	922.00± 2.51^{bc}	1552.33± 3.71^{b}	2216.00± 2.00^{c}
T6	43.00± 1.00^{a}	166.66± 0.88^{c}	440.66± 1.20^{cd}	894.00± 0.57^{d}	1496.66± 1.45^{c}	2182.33± 0.66^{d}
T7	43.66± 0.33 ^{a}	171.33± 0.66^{a}	450.00± 2.88^{ab}	929.33± 2.33^{b}	1553.33± 3.33^{b}	2223.00 ±3.51^{b}
T1	NS	**	**	**	**	**

Different letters within the same column indicate a significant difference at the level (p ≤ 0.01).
NS: non-significant

Average weekly weight gain (g/bird)
Results demonstrate a significant effect of the dietary supplements over the control treatment (Table 7), with the additives revealed a statistically superior performance throughout the entire 35-day rearing period.

- Week 1: All supplemented treatments demonstrate a highly significant (p ≤ 0.01) advantage. Specifically, T2 (0.5 kg grape pomace powder) as well as T7 (3 g nano grape pomace powder) outperformed the other treatments as well as were not significantly different from each other. They formed a statistical group with T3 as well as T5.

- Week 2: Treatment T3 (1 kg grape pomace powder) yielded the best weekly weight gain at 289.66g, showing a statistical advantage (p ≤ 0.01) over treatments T1, T4, T6, as well as T7. It was not statistically different from treatments T2 as well as T5.

- Week 3: Treatments T2 as well as T4 (0.25% grape seed oil) were statistically superior (p ≤ 0.01) to all other experimental treatments. Notably, treatment T3 was not significantly different from the control group (T1), indicating a potential drop in efficacy for the higher pomace powder dose at this stage.

- Week 4: Treatment T4 recorded the highest weight gain, significantly outperforming (p≤0.01) most treatments however not differing significantly from T2 as well as T5. The control treatment (T1) showed the lowest weight gain as well as was statistically similar to treatment T3.

- Week 5 (Final Week): Treatments T3 as well as T6 (1 g nano powder) provided the highest weekly weight gains, reaching 692.33g as well as 686g, respectively, showing a significant advantage over all other treatments. The control group (T1) showed the lowest significant gain.

Table 7. *Effect of adding grape pomace powder, grape seed oil, and its nanoparticle form to the diet of Ross 308 broiler chickens on average weekly weight gain (g/bird) during weeks 1–5 of age*

Treatments	Means ± SE					
	First week	Second week	Third week	Fourth week	Fifth week	Total
T1	118.66± 0.88^{d}	276.00± 3.60^{c}	463.66± 7.83^{c}	590.67± 6.83^{d}	613.33± 3.28^{d}	2062.33± 5.21^{e}
T2	129.00± 0.57^{a}	284.33± 2.67^{ab}	494.66± 1.45^{a}	634.33± 3.48^{ab}	647.33± 5.78^{c}	2189.67± 5.33^{ab}
T3	127.66± 0.67^{ab}	277.67± 1.76^{bc}	467.66± 2.03^{c}	586.66± 1.86^{d}	692.33± 6.33^{a}	2152.00± 8.08^{d}
T4	124.66± 1.45^{c}	289.66± 1.20^{a}	489.66± 1.33^{a}	638.33± 6.01^{a}	659.67± 2.60^{b}	2202.00± 6.35^{a}
T5	125.33± 0.88^{bc}	284.00± 0.57^{ab}	470.00± 2.52^{bc}	630.67± 2.60^{ab}	663.00± 2.89^{b}	2173.00± 2.08^{c}
T6	124.00± 0.58^{c}	274.00± 1.00^{c}	453.33± 0.67^{d}	602.66± 1.76^{c}	686.00± 1.73^{a}	2140.00± 0.58^{d}
T7	128.66± 0.88^{a}	278.66± 2.33^{bc}	479.33± 0.67^{b}	624.00± 2.08^{b}	670.00± 4.00^{b}	2180.67± 3.84^{bc}
	**	**	**	**	**	**

Different letters within the same column indicate a significant difference at the level ($p \leq 0.01$).
NS: non-significant

Average feed intake (g/bird)
Results revealed following patterns for weekly as well as total feed intake (Table 8):

- Weeks 1 and 2: Feed intake was relatively similar across all treatments. However, treatments T3 (1 kg pomace powder) as well as T4 (0.25% grape seed oil) recorded a statistically significant higher intake compared to other treatments. The control (T1) recorded lowest intake, though in week 1 it was not statistically different from treatment T2.

- Week 3: All supplemented treatments had a much greater feed consumption than un supplemented control. Treatments T2 (0.5 kg pomace powder) as well as T7 (3 g nano powder) showing the highest values though were not statistically different from treatment T4.

- Week 4: Treatment T2 showed a significant advantage ($p \leq 0.01$) over all other treatments. Meanwhile, treatments T1 (control), T6 and T7 did not differ significantly from each other which represented the groups with the lowest feed consumption.

- Week 5: All supplemented treatments outperformed the unsupplemented control. Treatment T5 (0.5% grape seed oil) recorded the highest significant intake.

Over the entire trial, all supplemented treatments consumed statistically significantly more feed ($p \leq 0.01$) than the control T1. Treatment T4 (0.25% grape seed oil) had the highest total feed intake at 3275 g/bird, showing a significant advantage. However, it was not statistically different from treatment T2 (0.5% pomace powder). Treatments T3 as well as T7 formed another statistical group, consuming significantly more than the lowest-consuming groups, which were T6 as well as the control (T1).

Different letters within the same column indicate a significant difference at the level ($p \leq 0.01$).
NS: non-significant

Feed conversion ratio (g feed consumed / g weight gain)

Table (9) shows the feed conversion ratio during the trial period, highlighting the differences between treatments from the beginning of the first week:

Table 8. *Effect of adding grape pomace powder, grape seed oil, and its nanoparticle form to the diet of Ross 308 broiler chickens on average feed intake (g/bird) during weeks 1–5 of age.*

Treatments	Means ± SE					
	Third week	Second week	First week	Fourth week	Fifth week	Total
T1	635.67± 7.62^{d}	372.33± 2.96^{c}	144.67 ±0.33^{b}	915.67± 0.67^{d}	1105.67 ± 0.33^{e}	3147.00± 7.33^{e}
T2	674.33± 4.33^{a}	380.67± 0.33^{a}	144.67± 2.60^{b}	927.00± 0.58^{a}	1121.33± 1.85^{c}	3248.00± 4.58^{ab}
T3	659.00± 1.53^{bc}	381.00± 0.58^{a}	148.67±0.67^{a}	922.33± 1.45^{bc}	1129.67± 0.33^{c}	3240.67± 1.45^{b}
T4	666.67± 1.67^{ab}	382.67± 1.20^{a}	150.00± 0^{a}	923.00± 1.53^{b}	1135.00± 0^{a}	3257.33± 2.67^{a}
T5	650.33± 5.17c	378.33± 1.67^{ab}	148.38± 0.88^{ab}	919.67± 0.33^{c}	1121.67± 1.45^{c}	3218.33± 5.78^{c}
T6	648.33± 3.84^{cd}	374.33± 2.85^{bc}	146.33± 1.20^{ab}	915.00± 0^{d}	1117.00± 1.53^{d}	3201.00± 1.00^{d}
T7	674.33± 2.33^{a}	378.33± 1.20^{ab}	150.00± 0^{a}	914.33± 0.67^{d}	1117.00± 1.53^{d}	3234.00± 1.53^{b}
	**	**	**	**	**	**

In the first week, a significant improvement (p≤ 0.01) was observed in treatment 2 (T2) compared to the other treatments. Treatment 1 (control) showed the lowest improvement in feed conversion ratio.

In the second week, the differences between treatments were minimal, with significant improvement observed in the two treatments supplemented with grapeseed oil (T4 and T5). These treatments significantly outperformed treatments T3 and T6, which showed no improvement in feed conversion ratio.

In the third week of the birds' age, treatments T2 and T4), which included the addition of 0.5 kg/100 kg of grape pomace powder plus 0.25% grape seed oil, respectively, significantly outperformed the other treatments (p≤ 0.01) , beside it is not differ significantly from the control T1 in terms of improvement in feed conversion ratio. Treatment 6, however, showed no significant improvement.

In the fourth week, treatments T2, T4, T5, in addition to T7 showed significant improvement (p≤ 0.01) over the other treatments as well as did not differ significantly from each other. Treatment T6 significantly outperformed both the control treatment (T1) as well as treatment T3, which did not differ significantly from each other and showed the least improvement in feed conversion ratio.

In the fifth final week of the birds' age, all treatments showed a significant advantage (p≤ 0.01) over the control treatment. Treatments T3 as well as T6) showed a significant advantage (p≤ 0.01) over treatment seven (T7), which did not differ significantly (p≤ 0.01) from treatment five.

Regarding the overall feed conversion ratio, all supplementation treatments significantly outperformed the control treatment, whilst the supplementation treatments did not differ significantly from each other. From the results below, we observe that the supplements improved the feed

conversion ratio during the 35-day rearing period.

Table 9. *Effect of adding grape pomace powder, grape seed oil, and its nanoparticle form to the diet of Ross 308 broiler chickens on feed conversion ratio (g feed consumed / g weight gain) during weeks 1–5 of age*

Treatments	Means ± SE					
	Total	Fifth week	Fourth week	Third week	Second week	First week
T1	1.54± 0.0a	1.80± 0.01^{a}	1.55± 0.02^{a}	1.37± 0.01^{cd}	1.35± 0.01^{ab}	1.22± 0.01^{a}
T2	1.48± 0.0^{b}	1.73± 0.01^{b}	1.36± 0.01^{c}	1.36± 0.01^{d}	1.34± 0.02^{ab}	1.12± 0.02^{d}
T3	1.50± 0.01^{b}	1.63± 0.02^{e}	1.57± 0.01^{a}	1.41± 0.01^{b}	1.37± 0.01^{a}	1.16± 0.01^{bc}
T4	1.48± 0.01^{b}	1.73± 0.01^{bc}	1.45± 0.02^{c}	1.36± 0.0^{d}	1.32± 0.01^{b}	1.20± 0.01^{ab}
T5	1.48± 0.01^{b}	1.69± 0.01^{cd}	1.46± 0.01^{c}	1.38± 0.0^{c}	1.33± 0.01^{b}	1.19± 0.01^{bc}
T6	1.50± 0.0^{b}	1.63± 0.0^{e}	1.52± 0.01^{b}	1.43± 0.01^{a}	1.37± 0.01^{a}	1.18± 0.01^{bc}
T7	1.48± 0.0^{b}	1.67± 0.01^{d}	1.46± 0.0^{c}	1.41± 0.0^{b}	1.36± 0.01^{ab}	1.16± 0.01^{bc}
	**	**	**	**	*	**

Discussion

In this context, the impact of inclusion grape pomace powder (GPP), grape seed oil (GSO) and grape pomace nano-powder (GP-np) into diets of broiler chickens over 35 days rearing period was analyzed on final weight, weight gain, feed conversion ratio (FCR) and feed intake. Results indicated that these additives enhanced the growth indicators and feed efficiency. All additives improved the productive performance of the broiler compared to the treatment of the control. Grape seed oil acts as an energy and digestion enhancer and its effect appears early and persistent. Ordinary grape pomace powder and nano grape pomace increase the overall health of the bird and increase metabolic efficiency through its content of polyphenols and resveratrol, which is cumulative and increases with age.

The results indicated that supplementing the diets with GPP at 0.5 and 1 kg/100 kg feed (T2, T3), GSO at 0.25 and 0.5 L/100 kg feed (T4, T5), as well as grape pomace nano-powder at 1 g and 3 g/100 kg feed (T6, T7) resulted in a significant increase in final body weight of broilers and an improvement on the FCR compared to control treatment group (T1).

Treatments using grape pomace powder (T2, T3) showed notable improvement in productive performance during the early rearing period, in terms of both weight gain as well as FCR, compared to the control. This enhancement is attributed to the fact that grape pomace is rich in polyphenols and flavonoids, such given that resveratrol as well as catechin, which possess potent antioxidant and anti-inflammatory properties. These compounds help improve the gut environment as well as enhance the absorption of nutrients.

The study by Noor *et al.* (2022) confirms that the inclusion rate of grape pomace powder significantly impacts feed intake along with final body weight. Very high inclusion rates (e. g., 20%) can adversely affect feed conversion efficiency (Reyes *et al.*, 2020), primarily due to the high fiber content in grape pomace. However, the inclusion of grape pomace powder at moderate levels (2.5% - 3%) does not negatively impact weight otherwise FCR; in fact, it can improve them in some cases, especially once using fermented grape pomace otherwise in combination with other additives like aloe vera (Erinle *et al.*, 2021). A study on broiler meat (Brenes *et al.*, 2008) that the addition of low levels of grape by-products can improve the qualities of meat without adversely

affecting performance

The addition of grape pomace powder to broiler diets enhances feed conversion efficiency beside final body weight once used at controlled and well-studied inclusion levels. This improvement is mainly attributed to its antioxidant along with anti-inflammatory effects, given that well given that its role in modulating the intestinal microbiota by promoting beneficial bacteria as well as inhibiting harmful pathogens such given that Salmonella such as *E. coli*. A study on broilers supplemented with 3% grape pomace reported a marked improvement in productive performance as well as a reduction in oxidative stress markers compared with the control (Turcu *et al.*, 2019). Antioxidants (such as vitamin E) protect cells and support efficient metabolism (Bail *et al.*,2008), which explains the peak performance in the middle of the growth period.

Research also indicates that incorporating grape seeds, fermented grape pomace, and otherwise raw grape pomace at levels up to 5% in broiler diets can have beneficial effects on growth performance, final body weight, as well as average weekly gain (Gungor *et al.*, 2021). Treatments containing grape seed oil (T4 together with T5) also showed noticeable improvements in final body weight beside feed conversion ratio, with T4 (0.5%) producing the highest performance. The beneficial effects of grape seed oil are largely due to its high content of unsaturated fatty acids, such given that linoleic acid (60.08%) as well as oleic acid (20.98%), along with a rich profile of natural antioxidants. The superiority of the T4 is due to the fact that the oil is a concentrated source of energy (fatty acids). Increasing the dose may upset the balance of fatty acids or reduce the amount of feed consumed According to Turcu et al. (2021), supplementing broiler diets with grape seed oil significantly improved final body weight, enhanced intestinal health, reduced harmful bacteria such given that Clostridium perfringens, as well as increased populations of Lactobacillus, suggesting an improved gut microbial balance and more efficient nutrient absorption.

Similarly, Farahat et al. (2017) reported that grape seed oil improves production efficiency with a reduction in oxidative stress in poultry tissues due to its high levels of biologically active compounds.

In the fifth week, there is an increase in the productive performance of the T5 and T6 , and this increase may be due to the cumulative effect of polyphenols . Phenolic compounds and fiber may need time to strengthen the intestinal flora, which improves the digestion and absorption of nutrients in the advanced stages of life (Viveros *et al.*, 2011)

Treatments T6 and T7, which included grape pomace nanoparticles, also demonstrated improved performance indicators compared with the control, though to a lesser extent than the oil-supplemented treatments. The significance of these nanoparticle additives lies in their high concentration of phenolic compounds, including resveratrol (192.5 ppm) along with quercetin (119.9 ppm), both of which are known to strengthen intestinal immunity in addition to enhance digestive function.

Conclusion

Inclusion of grape pomace powder, grape seed oil and their NP forms in broiler diets had a significant positive effect on the body weight, growth rate and FCR without increasing feed intake. The best results were achieved for 0.25% grape seed oil and 0.5 kg of grape pomace powder per 100 kg feed based treatments. These results confirm that grape by-products, which are good sources of phenolic and antioxidant compounds, can be used as natural, sustainable alternatives to synthetic growth promoters. Optimum supplementation levels can achieve optimal nutrient use and production efficiency, thus such practice would contribute to cost-effective and environmentally friendlier poultry production regimes

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Novelty Statement

To my knowledge very few research as that was found in the literature, also has been conducted to evaluate impact or challenge of grape pomace powder substance, grape seed oil and their Nanoparticles on broiler diets in Iraqi. It is an application of a utilization of grape- processing by-products and nanotechnology to improve poultry performance in a sustainable manner. These results offer new perspective for the application of natural feeding additives in order to enhance growth efficiency and to minimize antibiotic use in broiler production.

Author Contribution

Forqan Qays Mohammed Ali: conceptualization, experimental design, data collection, and manuscript writing.

Fadhil Rasool Abbas Al-Khafaji: supervision, data validation, statistical analysis, and critical review of the manuscript. Both authors approved the final version of the paper.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research.

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