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Research article

Effects of olive oil-treated diet and key lime juice-treated drinking water on intake and growth performance of quail

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Abstract

The study aims to determine the efficacy of an olive oil-treated diet and key lime juice (KLJ)-treated drinking water on the intake and growth performance of quail. A total of 324 quails were divided into 6 groups: commercial feed (I) as a control group and formulated feed (II-VI) as a treatment group. Formulated feeds were prepared using olive oil, and drinking water was treated with KLJ at 0ml/kg+0ml/L (II), 1.5ml/kg+2.0ml/L (III), 3.0ml/kg+2.0ml/L (IV), 1.5ml/kg+4.0ml/L (V), and 3.0ml/kg+4.0ml/L (VI), respectively. Each group included 54 quails with 6 replicates of 9 birds each. The formulated feed contained lower crude protein (CP), ether extract (EE), crude ash (CA), and metabolizable energy (ME), but higher crude fiber (CF) than commercial feed. The treatment groups had no (P>0.05) effect on dry matter, organic matter, or CP intakes. However, there was a higher EE intake in the control group, while a higher CF intake was observed in the treatment group. The control group showed lower water intake than others. Groups IV and V showed higher weight gain than groups II, III, and VI, but no difference was observed in group I. Regarding feed conversion ratio (FCR), groups IV and V showed the lowest and similar values, while group II demonstrated the highest. Considering its positive effects on weight gain and FCR, it can be recommended to add olive oil to the diet and KLJ in water.

Keywords: Feed intake, Growth performance, Key lime, Olive oil

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INTRODUCTION

The use of antibiotics in poultry production has been restricted due to the presence of antibiotic residue in poultry products (Tajick and Shohreh, 2006). These restrictions have forced poultry farmers to find alternatives to antibiotics. The use of plant-derived additives has recently garnered considerable scientific interest, mainly due to their contribution to improved poultry health (Reda et al., 2020). Plant extracts can improve the digestive system, nutrient intake, and feed conversion ratio (FCR), promote immune function, antioxidant, anthelmintic, and antimicrobial activities, as well as increase carcass quality and decrease the mortality rate (Parlat et al., 2005; Dalle et al., 2016). Oils are sometimes used in ration formulation to enhance energy (Ha et al., 2023). It was observed that dietary supplementation with red pepper oil improved growth, immunity, and antioxidant activity while decreasing intestinal pathogens and lipid content, which augments quail performance (Abdelnour et al., 2018). Furthermore, dietary olive leaves improved quail performance and egg quality, as reported by Erisir et al. (2020). Reda et al. (2020) reported that olive oil has powerful antioxidant properties, and a quail-fed olive oil-treated diet showed better health by decreasing the activity of malondialdehyde and increasing the activities of superoxide dismutase and glutathione S-transferase in their blood in contrast to those fed with other sources of oil-treated diets. Velmurugan et al. (2018) also mentioned that olive oil contained higher levels of monounsaturated fatty acids, which can protect pancreatic and liver islets as compared to sunflower oil-fed rats (Oliveras-Lopez et al., 2008). However, investigations regarding the use of olive oil in poultry are still rare. It is hypothesized that the olive oil-treated diet (3 ml/kg of diet) is expected to exert beneficial impacts on the growing quail.

The heat wave in Malaysia is one of the biggest concerns among poultry producers because animals that are exposed to heat stress experience decreased feed intake, with subsequent detrimental effects on their health and production performance (Alagawany et al., 2017; Khang et al., 2024). Khan et al. (2012) observed that poultry fed with a vitamin C-treated diet showed beneficial effects on their performance under stress conditions, which might be a result of the effect of vitamin C on the improvement of antioxidant ability and immune performance (Min et al., 2018). Although quail can synthesize vitamin C, synthesis is inadequate under stressful conditions (McDowell, 1989). Thus, an alternative way to decrease the heat stress in quail production is to provide a diet with supplementation of vitamin C; however, the expenses incurred in buying vitamin C are high. It is known that raw citrus fruits are rich in vitamin C. Hence, this study aimed to find a substitute for vitamin C by using key lime, which is an affordable and easily available local fruit in Malaysia and is a rich source of vitamin C (27.8mg/100g) (Najwa and Azrina, 2017). Therefore, the goal of this study was to investigate the influence of feeding different combinations of olive oil and key lime juice (KLJ) to quail on their intake and growth performance.

MATERIALS AND METHODS

Location and Housing

The study was conducted at the experimental house of the Agro Techno Park (5.748211°N and 101.869027°E), Universiti Malaysia Kelantan, Malaysia. A total of 324 2-week-old unsexed Japanese quails were used in the experiment for 5 weeks, between March and April 2020. The quails were divided into 6 groups with 6 replicates of 9 birds each. The commercial feed, raw ingredients, olive oil, and key lime fruit were purchased from a local supplier. The quails were housed in wired cages with a tray under each cage. Each cage was equipped with a feeder and waterer. During the entire experimental period, the temperatures in the house were recorded using a thermometer (Figure 1). The maximum temperature ranged from

29-35 °C, while the minimum temperature ranged from 22-28 °C. All animal handling and procedures were approved by the UMK Animal Care and Use Ethics Committee (UMK/FIAT/ACUE/UG1/2018).

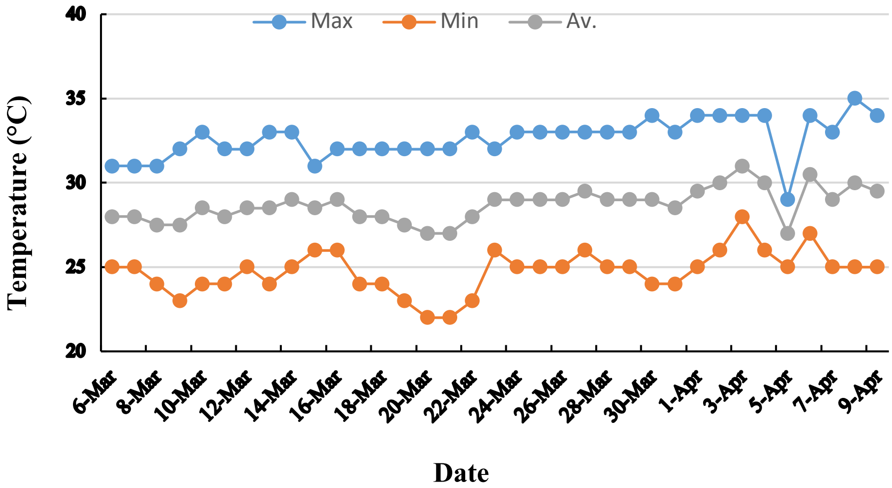

Figure 1 Variation in house temperature during the experimental period.

Experimental design

Quail received commercial pellets as a control diet, while others received formulated feed as a treatment diet. The commercial pellet and drinking water without any additional treatments were chosen as the control feed because these are the usual practices at the farmers' level. It was hypothesized that nutrient composition differences between commercial pellets and formulated feed might have little impact on the results of this study, which can be ignored.

Behboudi et al. (2016) reported that supplementation of 0.5% thyme in diet and 2 ml/L lemon juice in drinking water results in a management strategy to prevent the negative effects of heat stress on broiler chickens' performance. In another study, Reda et al. (2020) observed that dietary supplementation of red pepper oil (0.8 g/kg) can enhance the performance and antioxidant indices and reduce intestinal pathogens in Japanese quail. Based on previously published literature (Behboudi et al., 2016; Reda et al., 2020), 1.5 and 3.0 ml of olive oil/kg of the formulated diet and KLJ at 2 and 4 ml/L were chosen in the current study. In the study, 1.5 and 3.0 ml of olive oil/kg of the formulated diet were added manually to the diets of the treatment groups.

The olive oil was first added to 100g of the feed for every day's feed mixing of each batch. Then, the representative 100g feed was mixed with the rest of the feed. These steps are repeated to make sure that the olive oil is mixed evenly and thoroughly. This feed preparation was done daily so that the feed does not rot quickly and does not lose its quality. Quails were also offered drinking water, which was diluted with or without KLJ at 2 and 4 ml/L.

Quails were randomly divided into 6 groups with 6 replicates of 9 birds each. Each group was assigned one dietary treatment, viz. (I) commercial pellet + drinking water (control), (II) formulated feed + drinking water, (III) olive oil-treated formulated feed (1.5 ml/kg) + KLJ-treated drinking water (2 ml/L), (IV) olive oil-treated formulated feed (3.0 ml/kg) + KLJ-treated drinking water (2 ml/L), (V) olive oil-treated formulated feed (1.5 ml/kg) + KLJ-treated drinking water (4 ml/L), and (VI) olive oil-treated formulated feed (3.0 ml/kg) + KLJ-treated drinking water (4 ml/L). All the experimental quails were fed *ad libitum* with experimental feeds, as shown in Table 1.

Table 1 Composition of experimental diet for growing quail.

Ingredients	Amount (kg) in 100 kg of mixed feed	Amount (kg) in 100 kg of commercial feed+
Broken rice	53	-
Soybean meal	39	-
Fish meal	3.95	-
Vitamin-mineral premix	0.5	-
Limestone	1.2	-
Salt	0.35	-
Palm oil	2	-
Nutritive value (%, DM basis)		
Organic matter	94.54	91.99
Crude protein	18.97	20.12
Crude fibre	5.68	5.01
Ether extract	1.12	3.20
Crude ash	5.46	8.01
Metabolizable energy (kcal/kg)*	2956	3108

*, calculated from secondary data (Yusoff et al., 2005); +, not given because of business privacy.

Key lime juice preparation

The lime used in this study is key lime *(Citrus aurantifolia)*, which was purchased from the market. The limes were washed and cut into two transverse sections with a knife. The juice was expelled manually by squeezing with the hand. The pulp and seeds were filtered to extract the clear juice from them, which was then added to the drinking water and given to the quails. The left-over key lime-treated drinking water was replaced with a newly prepared one every morning, although vitamin C content might be affected and it was not controlled.

Parameters observed

Birds received the feed twice a day: in the morning and evening. Feed and water refusals were collected and weighed every morning to obtain an estimate of intake. Daily feed and water intake were calculated separately by deducting daily refusal from daily offered and dividing by the number of birds in each replicate; feed intake was calculated on a dry matter (DM) basis. Before feeding in the morning, all the quails were weighed individually at the beginning of the experiment, at 1-week intervals, and at the end of the experiment. The daily body weight (BW) gain was calculated by dividing the initial and final BW differences by the total number of experimental days. Water consumption was estimated by calculating the difference between the offer and the leftover on a daily basis. The nutrient intakes were calculated by multiplying the feed consumed by the respective nutrient content of the diet using the following formula:

(i) DM intake = feed given (DM basis) – remaining feed (DM basis)
(ii) Organic matter (OM) intake = DM intake × OM% in feed
(iii) Crude protein (CP) intake = DM intake × CP% in feed
(iv) Crude fiber (CF) intake = DM intake × CF% in feed
(v) Ether extract (EE) intake = DM intake × EE% in feed

Chemical and statistical analyses

Samples of feeds were analyzed for DM, CP, CF, EE, and crude ash (CA) according to the method of AOAC (2000). The OM was determined indirectly by subtracting the CA from 100. Data were analyzed by one-way analysis of variance with a completely randomized design using the SPSS software (version 23.0, SPSS Inc., Chicago, USA), and the differences between the mean values were determined by Tukey's test at $P<0.05$.

RESULTS

The formulated ration consisted of broken rice, soybean meal, and fish meal as the main ingredients. The formulated feed contained lower CP (18.97 vs. 20.12%), EE (1.12 vs. 3.20%), CA (5.46 vs. 8.01%), and ME (2956 vs. 3108 kcal/kg), but higher CF (5.69 vs. 5.01%) than commercial feed (Table 1).

The treatment had no effect (P>0.05) on intakes of DM, OM, and CP (Table 2). The values that were recorded were quite similar between the control group and treatment groups. However, considerable effects (P<0.05) were observed on the intakes of EE and CF. Quails in the control group had a higher (P<0.05) EE intake (0.6 g/bird/d) than other groups. For CF intake, the treatment groups had a higher (P<0.05) intake than the control group. This may be due to the higher amount of fiber in the formulated feed than commercial feed because the quails in Groups II to VI were fed with a formulated ration that contained more CF than those fed to the control group. There were significant (P<0.05) effects on water intake among the dietary groups. Group VI recorded the highest water intake (83.7 ml/bird/d), while Group I recorded the lowest (54.2 ml/d) intake. However, no differences were observed in water intake among Groups II to V. The control group showed a lower (P<0.05) water intake than the other groups.

Table 2 Effect of olive oil and key lime juice on quail feeding on dry matter and nutrient intakes.

Parameter	Group (mean ± standard deviation)						P-value
	I	II	III	IV	V	VI	
Nutrient intake (g/bird/d)							
Dry matter	19.6 ± 1.4	18.9 ± 2.6	19.4 ± 1.8	19.8 ± 3.4	19.8 ± 2.5	19.6 ± 4.7	0.767
Organic matter	18.1 ± 1.3	17.7 ± 2.2	18.4 ± 1.7	18.7 ± 3.2	18.7 ± 2.3	18.5 ± 4.4	0.602
Crude protein	4.0 ± 0.3	3.6 ± 0.5	3.7 ± 0.4	3.8 ± 0.7	3.8 ± 0.5	3.7 ± 0.9	0.088
Ether extract	0.6^{b} ± 0.1	0.2^{a} ± 0.0	0.2^{a} ± 0.0	0.3^{a} ± 0.0	0.3^{a} ± 0.0	0.2^{a} ± 0.1	0.000
Crude fiber	1.0^{a} ± 0.1	1.1^{ab} ± 0.1	1.1^{b} ± 0.1	1.2^{b} ± 0.2	1.2^{b} ± 0.1	1.1^{b} ± 0.3	0.002
Water* (ml/bird/d)	54.2^{a} ± 6.1	73.4^{b} ± 11.8	68.1^{b} ± 7.4	67.5^{b} ± 6.8	68.0^{b} ± 10.2	83.7^{c} ± 22.9	0.000

[ab]Means on the same row with different superscripts differ significantly (P<0.05); *, drinking water.

While the BW values among the groups were similar in the 0 weeks of the experiment, differences were observed among the groups with the advancement of the weeks (except in week 4) (Table 3). For week 1, there were significant (P<0.05) differences among the dietary groups. Group IV showed the highest BW value (149.6 g), while Group II showed the lowest value (97.4 g). For week 2, Group IV showed the highest BW (193.6 g), and Group VI showed the lowest (129.3 g). For week 3, there were significant (P<0.05) differences in BW among the groups. Groups III to V showed higher BW than Groups I, II, and VI. For week 4, differences were observed among the groups, and Group IV showed the highest BW value (251.7 g), while Group II showed the lowest (217.2 g).

For total and daily BW gains, there were significant (P<0.05) differences among the groups. Groups IV and V showed higher (P<0.05) total BW gain and daily BW gain than Groups II, III, and VI, but no difference was observed with Group I. Groups IV and V recorded the highest total BW gain, which was 153.6 g and 152.2 g, respectively. Similarly, the highest daily BW gain was observed in Groups IV and V (5.1 g). There were significant (P<0.05) differences in FCR among the groups. Groups IV and V showed the lowest and similar FCR (3.6), while Group II showed the highest FCR value (4.3).

There were no significant (P>0.05) differences in mortality rates among the groups. Group II showed the highest mortality rate (2.3%), and Groups III and IV showed the lowest (0.6%). The addition of olive oil together with KLJ exhibited improved levels of certain nutrient intakes, water consumption, daily gain, and FCR when compared to the control. These data imply that dietary supplementation with olive oil and KLJ may be beneficial for enhancing antioxidant activity and minimizing heat stress's deleterious influence on immunity.

Table 3 Effect of olive oil and key lime juice on quail feeding on growth performance.

Parameter	Group (mean ± standard deviation)						P-value
	I	II	III	IV	V	VI	
Body weight (g/bird)							
Week 0	94.9 ± 3.9	93.0 ± 4.4	98.4 ± 5.0	98.1 ± 3.0	96.7 ± 5.8	98.2 ± 2.3	0.072
Week 1	113.1^{c} ± 4.7	97.4^{a} ± 6.2	138.6^{d} ± 2.8	149.6^{e} ± 7.4	111.0^{bc} ± 11.0	104.3^{ab} ± 6.9	0.000
Week 2	174.2^{b} ± 2.5	163.2^{b} ± 14.1	168.1^{b} ± 9.9	197.6^{c} ± 7.8	193.6^{c} ± 10.5	129.3^{a} ± 29.4	0.000
Week 3	206.2^{b} ± 1.9	191.9^{a} ± 5.0	217.0^{c} ± 7.3	226.9^{c} ± 9.6	222.7^{c} ± 11.2	190.8^{a} ± 12.2	0.000
Week 4	237.3^{bc} ± 4.2	217.2^{a} ± 7.4	231.9^{ab} ± 7.2	251.7^{c} ± 6.3	248.9^{c} ± 13.7	230.7^{ab} ± 23.3	0.001
Total gain (g/bird)	142.5^{bc} ± 4.2	124.3^{a} ± 8.9	129.6^{ab} ± 7.2	153.6^{c} ± 8.6	152.2^{c} ± 14.8	132.1^{ab} ± 22.2	0.003
Daily gain (g/bird)	5.1^{bc} ± 0.1	4.4^{a} ± 0.3	4.6^{ab} ± 0.2	5.5^{c} ± 0.6	5.4^{c} ± 0.5	4.7^{ab} ± 0.74	0.003
Feed conversion ratio	3.9^{ab} ± 0.1	4.3^{c} ± 0.1	4.2^{c} ± 0.1	3.6^{a} ± 0.1	3.6^{a} ± 0.1	4.2^{c} ± 0.20	0.000
Mortality (%)	0.9 ± 1.6	2.3 ± 3.3	0.6 ± 1.5	0.6 ± 1.5	1.5 ± 1.8	2.2 ± 1.8	0.520

^{abc}Means on the same row with different superscripts differ significantly (P<0.05).

DISCUSSION

Although CF was suggested to be lower than 7%, an increased value up to 8-9% did not really show any noticeable effects (Zhang et al., 2023); hence, it is preferred to lower the fiber level in the feed. In addition, it is essential to consider the specific types of fiber and their potential effects on quail performance because different types of fiber can have varying impacts on nutrient digestibility, gut health, and feed utilization. Hence, further analysis of fiber types and their optimal levels for quail diets could provide valuable insights. A study on broilers showed that there was no adverse effect due to fiber levels lower than 9% in any feed source on growth performance, mortality rate, and feed intakes (Salah, 2012). Moreover, no adverse effects were observed on the egg production performance of layer chicken as well. However, the relationship between the fiber content of the feed and the prevention of cannibalism affects the birds positively (Salah, 2012). Although it is not fully understood, the researcher relates it to increasing time for feed consumption and eating, which decreases the time for them to peck between each other. The ration formulation is also better in CP because lower CP is better for heat-stressed quails. Feed rations with low protein compositions were recommended in order to prevent more heat production in broiler chickens. This is because proteins have the highest heat increment among the other nutrients (Abioja and Abiona, 2021). The situation would be worse for the birds if there was more production of heat from the body under heat-stressed conditions.

The findings in this study indicated that an olive oil-treated diet and KLJ-treated drinking water help increase quails' performance. It can also be concluded that their level of heat stress was reduced. It is because if the quails are under heat stress, they will lower heat production by decreasing their intake, with subsequent detrimental effects on production performance and their health status (Alagawany et al., 2017). Lagana et al. (2007) also observed that heat-stressed birds showed a decrease of about 6.8% in feed intake, which can be minimized by supplementing with vitamin C and minerals. Hence, quails in Group VI, which were fed 3.0 ml/kg olive oil and 4.0 ml/L KLJ, exhibited a higher water intake than the control group. High water intake can also help reduce the internal body temperature. It can also prevent dehydration, which can increase body heat. During hot weather, dehydration often happens in quails, and increasing the water intake can help to prevent dehydration (Takei et al., 1988). To avoid dehydration, increased water consumption can replace the water lost through respiration, feces, and urine excretion (Scottá et al., 2017). The key lime is one of the main food sources of electrolytes (such as calcium, magnesium, potassium, iron, copper, and zinc), which can stimulate water consumption (Rahman, 2022). When the outcomes of these are put together (electrolytes and increased water consumption), the negative performance of birds due to heat stress can be decreased.

Birds fed treatment diets showed positive results, which might be explained by the additional supplements like olive oil and KLJ. Group IV received the highest level of olive oil (3 ml/kg of diet), while Group V received the highest level of KLJ (4 ml/L of drinking water). Key lime contains vitamin C, which is also a potential growth promoter. Recently, vitamin C and vitamin E showed that feeding quail with supra-nutritional levels can be a good feeding practice to promote their growth and egg production traits (Sigolo et al., 2019). Olive oil is also expected to be a potential growth promoter. A 10% inclusion level in the diet substituted for corn gave the highest average live weights in the starter broiler and finisher broiler. However, it did not have any effect on carcasses (Abo Omar, 2005).

It is known that the lower the FCR, the better the feed is. The feed conversion ratio measures the efficiency of an animal in converting the feed provided into a desired output (Yi et al., 2018). For outdoors-rearing poultry, the average FCR is 2.8-3.2, while for poultry reared in an enclosed house, an average FCR of 1.5-1.9 (Feed efficiency in poultry, website: https://www.feedia-techna.com/en/productivity/poultry/feed-conversion-ratio-fcr-feed-cost-broiler-turkey) is observed. In this study, the value of FCR for each group was high (Table 3). Groups IV and V had the lowest FCR, which may be due to the higher levels of olive oil and KLJ, which provided a more beneficial effect in the feed. If the nutritional value in the feed were high, the animals would tend to have a lower FCR. Olive oil and KLJ were also believed to be potential growth promoters in previous studies (Tavakkoli et al., 2014; Velmurugan et al., 2018; Reda et al., 2020). However, for Group II, which was only given a formulated feed ration and normal drinking water without olive oil and key lime, the FCR was quite high, which indicates that the addition of olive oil and key lime is beneficial to quail performance. This might be attributed to the combination effects of olive oil and KLJ that may exploit benefits by creating synergistic effects between active compounds present in the two additives. The findings of this study are in line with the study of Behboudi et al. (2016), who found that feed intake, body weight gain, and feed conversion ratio of broiler chickens are improved by concurrent supplementation of 0.5% thyme to diet and 2 ml/L lemon juice to drinking water.

CONCLUSIONS

The supplementation of olive oil and KLJ in quail diets affected their intakes of EE, CF, and water but did not influence the intakes of DM, OM, and CP. Consequently, it was observed that the olive oil and KLJ added as an additive to the diets of growing quails affected their total BW gain, daily BW gain, and FCR. Considering its positive effects on weight gain and FCR, it may be recommended to add olive oil to diet and KLJ in drinking water with a combination of 3 ml/kg and 2 ml/L, and 1.5 ml/kg and 4 ml/L, respectively. However, further studies under standardized conditions are needed to observe these possible synergistic effects in more detail. More detailed analysis of other essential nutrients could provide a more comprehensive understanding of the dietary effects on quail growth. Additionally, the study needs to prove for gut microbiota analysis and blood parameters related to growth and health, such as serum protein levels, lipid profiles, and hormone concentrations. This would offer physiological indicators of how the dietary interventions influence metabolic processes and overall well-being in quails. This could include exploring long-term effects and assessing potential impacts on egg production or reproductive performance.

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AUTHOR CONTRIBUTIONS

MMR and SAS: Research implementation, statistical analysis, and drafted and revised the manuscript. SAMS: Designed and investigated the study. NU: Critical revision of the manuscript for important intellectual content. All authors have read and approved the final manuscript

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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