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Impact of Different Energy Sources on Some Performance Parameters of Japanese quail

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I. Abstract

This stud proved fulfilling its objectives about the growth performance, feed intake, feed efficiency, production efficiency and profit from quails under five different energy sources of dietary oil: unmixed oil control (T1) oil addition at the rate of 1% of the diet of corn oil (T2), sunflower oil (T3), soybean oil (T4), and tallow (T5) and 440 birds randomly assigned to treatment groups. All 7 diets were modeled to meet isonitrogenous and isocaloric levels set by NRC 1994. Performance was tracked over 6 weeks and data analyzed in a completely randomized design. Though early growth (1–14 days) showed little change, at the end of the trial, soybean oil (T4) improved final body weight (247.483 g), and body weight gain (265.163 g) at the low FCR (1.567) than the control. The Feed intake in this treatment was also lowest compared to the rest (418.370 g), indicating improved energy efficiency. The production index from treatment group T4 was also the greatest, in addition to having favorable economic returns. This supports other studies suggesting that vegetable oil, and particularly soybean oil, increases apparent digestibility of nutrients, enzyme functions, and lipid metabolism in poultry. The soybean oil also contains bioactive molecules like lecithin that aids in fat digestion and cholesterol control. Scientific and economic principles regarding Japanese Quail biomass production systems suggest that substituting with soybean oil instead of solid animal fats or carbohydrate sources adds margin.

Keywords: Energy, oil, productive, performance, quail.

II. Introduction

Ongoing assessment of the nutritional needs of breeding birds, alongside adaptations to environmental fluctuations—particularly in light of recent technological advancements—is vital for optimal poultry management (Qureshi et al., 2021). In this context, animal performance has been viewed as secondary to ensuring thermal comfort within the environment (Vercese et al., 2012). Among the key nutritional considerations, energy and protein represent the two most critical constraints on poultry productivity (ElHindawy et al., 2021). These nutrients are also the principal cost components in poultry feed formulations. Therefore, designing diets with lower energy and protein levels could lead to significant cost reductions while maintaining economic sustainability (Alagawany et al., 2022). The performance of Japanese quails, or any livestock animals, can be influenced by the source of energy provided in their diet. The energy source in animal diets primarily comes from carbohydrates, fats, and proteins. The energy content of the diet

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plays a significant role in various aspects of quail performance, including growth rate, reproductive performance, and overall health. Quail birds are an important source of meat and are resistant to harsh weather circumstances; therefore, in the Kurdistan region, numerous lines of quail are raised to provide the local markets with delectable meat varieties (Hussen and Salih, 2019). Because of their early sexual maturity, short generation time, high egg production, high content of vitamins and minerals that are important to humans, and unique traits like disease resistance and weather adaptability, quail birds are biological machines with high nutritional conversion efficiency and make an ideal experimental animal (Al-Tamimi, Nawaf Ghazi Abboud 2019). In developing nations, the demand for quail products, particularly meat, is rising, making it the consumer's second choice after chicken (Jeke ***et al.*** 2018). This is because quail meat has a higher nutritional value than chicken meat. After all, it is lower in fat and cholesterol (Hubrecht and Kirkwood, 2010). Japanese quail birds are small, tamed avian species currently used commercially to produce eggs and meat. They have gained prominence as laboratory birds worldwide (Ayasan, 2013). The two primary nutrients that all animal types need are energy and protein. Before addressing nutrient requirements for additional foods, these requirements must be satisfied. Japanese quails were generally thought to have energy and protein needs similar to laying chickens. The ideal dietary requirements for Japanese quails must, therefore, be updated. It is widely known that the amount of energy and protein in a quail's diet affects its reproductive and productive characteristics (Gunawardana ***et al.*** 2008). The study aims to determine the optimal energy level for quail diets because no nutritional guidance is available regarding quail and how it affects production performance.

III. Materials And Methods

The study was conducted at the College of Agricultural Engineering Sciences' Animal Science and Poultry Farm Department. The experiment followed a completely randomized design with five treatments different in energy sources: T1= Control (without oil), T2= corn oil 1%, T3= sunflower oil 1%, T4= soybean oil 1%, and T5= tallow; all treatments were repeated four times, where the quails were randomly distributed into 20 groups of 22 quails in each pen. All of the quail had unlimited access to food and water, and Table 1 lists the quail's diets.

Table 1. Nutrition composition

Ingredient, % as feed-basis	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**
Wheat	40	42.6	42.6	42.6	42.6
Corn	20.6	16	16	16	16
Meat and bone meal (40%)	5	5	5	5	5
Soybean meal (%44)	33	34	34	34	34
Oil	0	Corn 1	Sunflower 1	Soybean 1	Tallow 1
Dual-calcium phosphate	0.2	0.2	0.2	0.2	0.2
Limestone	0.9	0.9	0.9	0.9	0.9

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Salt	0.3	0.3	0.3	0.3	0.3
Total	100	100		100	
Chemical analysis of the feed[2]					
** Crude protein%	24.356	24.749	24.749	24.749	24.749
* Metabolizable energy Kcal/kg	2852.485	2891.905	2891.905	2891.905	2891.905
* Crude fibre %	3.053	3.069	3.069	3.069	3.069
** Calcium %	0.6757	0.6788	0.6788	0.6788	0.6788
** Phosphor %	0.55618	0.55756	0.55756	0.55756	0.55756
* Lysine %	1.29	1.31	1.31	1.31	1.31
* Methionine %	0.55	0.55	0.55	0.55	0.55
*Cysteine %	0.4132	0.4189	0.4189	0.4189	0.4189

[2] The dietary needs are established by the NRC (1994). * Calculated, ** chemical analysis.

Data collection:

1- Live body weight

At the start of the experiment and then every day (7, 15, 22, 28, 35, and 42 days), we weighed one replicate of the birds (Shawkat, 2016).

2- Body weight gain

Each chick was weighed before the experiment began. There was no discernible difference in the chicks' primary average weight amongst the pens. Every pen’s chicks were considered at the end of each week, and their weights were subtracted from the first week's weight. It is possible to measure weekly weight gain as a result. The same technique was used to calculate weight increase for ages 7 to 14, 15 to 21, 22 to 28, 29 to 35, 36 to 42, and 0 to 42 days (Hadmi, 1994).

3- Feed intake

To measure feed intake, portions of each pan's ration were given to the birds at the beginning of each week. To determine the weekly eaten diet, the remaining rations from each pan were weighed at the end of the week and subtracted from the original ration. It was computed how much food was consumed at intervals of 7-14, 15-21, 22-28, 29-35, 36-42, and 1-42 days of age (Hadmi, 1994).

4- Feed conversion ratio

The following equation was used to calculate the feed conversion ratio after evaluating feed intake and body weight gain during a week:

$$\frac{\text{Feed intake over a}}{\text{week's beginning weight} - \text{week's ending weight}}$$

Feed conversion ratio analysis was computed for animals that were 7-14, 15-21, 22-28, 29-35, and 36-42 days old and for the entire period (Fayad and Naji, 1989).

5- Production Index (P.I.)

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The production index is calculated by the following formula (Martins ***et al.*** 2016):

$$\frac{\text{Average body weight X viability percentage}}{\text{number of days breeding X feed conversion ratio X 10}}$$

The production index was calculated in age periods of 7-14, 15-21, 22-28, 29-35, and 36-42 days.

6- Economic Figure (E.F.)

Economic figures determined by the formulae below (Martins ***et al.*** 2016):

$$\frac{\text{The total weight of the birds marketed (g)}}{\text{number of birds marketed X the length of the rearing (days) feed conversion ratio}}$$

Methods of data analysis

Excel software was used to analyze the data gathered during the trial. The various treatments' calculations for the parameters will be carried out. Data were analyzed using SAS (2012). At the 5% level, significant variations in treatment were discovered (Duncan, 1955).

IV. Results And Discussions

Table 2 displays the average live body weight (g) of Japan quail corresponding to each energy source type. No notable differences were seen at 7, 14, and 36 days of age across all groups (T1, T2, T3, T4, and T5). Birds in T1, the control treatment, weighed an average of 139.390g and 176.037g, respectively, at 21 and 28 days of age, with a significant difference (P≤0.05). T2 birds had the heaviest body weight (249.253 g) at marketing age (42 days of age), while T1 control birds had the lowest body weight (231.603 g). The primary findings demonstrated that soybean oil enhanced quail B.W.G. and F.C.R. This may result from the proper ratio of unsaturated to saturated fatty acids found in soybean oil. The degree of fatty acid saturation and the carbon chain length are two critical factors that determine how much energy may be derived from fats (Abedpour ***et al.*** 2017).

Table (2): Impact of different sources of energy on live body weight (g) (Mean ± S.E.M.)

Treatments	Age (days)					
	1-7	8-14	15-21	22-28	29-35	36-42
T_1	47.897±1.73a	82.693±0.41a	139.390±1.73a	176.037±1.49a	204.567±1.02a	231.603±2.22b
T_2	47.137±0.92a	81.167±0.73a	133.000±1.01b	171.383±3.38ab	205.200±3.94a	249.253±4.56a
T_3	47.533±0.44a	82.413±1.32a	132.090±1.08b	169.603±2.01ab	205.377±2.30a	234.800±1.19b
T_4	47.477±0.75a	82.133±1.57a	139.590±1.98a	169.610±0.32ab	201.077±1.78a	247.483±2.32a
T_5	47.473±0.67a	81.367±0.55a	133.730±0.72b	164.597±2.559b	201.660±3.21a	233.123±3.51b

Means are substantially influenced by distinct letters within the same column (P≤0.05).
T1= Control (without oil), T2= corn oil 1%, T3= Sunflower oil 1%, T4= Soybean oil 1%, and T5= Tallow

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Table 3 presents the effects of various energy sources on Japanese quails' body weight gain (g) at different ages. The findings showed that there were significant differences in body weight gain (P≤0.05) between all treatments in the other age periods, except days (1–7) and (8–14). Overall, the results of treatment T1 during the periods of (36-42) and (1-42) days show less weight gain than the other treatments (27.037 and 246.557 g), while treatment T4 shows more weight gain than the other treatments (46.407 and 265.163 g). According to Abdel-hakim ***et al.*** (2009), feeding developing Japanese quails diets using sunflower oil resulted in maximum body weight gains compared to providing tallow as the fat source. The results obtained conflict with those findings. Abou El-wafa (2000) reported that when compared to animal fats (margarine or camel fat), vegetable oils (soybean, corn, or sunflower oils) improved the growth rate and feed conversion ratio of broiler chicks.

Table (3): Impact of different Sources of Energy on body weight gain (g) (Mean ± S.E.M.)

Treatments	Age (days)						
	1-7	8-14	15-21	22-28	29-35	36-42	Overall
T_1	39.850 ±1.79a	34.797 ±2.02a	56.697 ±1.92a	36.647 ±0.35ab	28.530 ±1.10b	27.037 ±2.06c	246.557 ±2.17b
T_2	39.150 ±0.88a	34.030 ±1.52a	51.833 ±0.51ab	38.383 ±3.13a	33.817 ±2.89ab	44.053 ±4.67ab	264.267 ±4.07a
T_3	39.620 ±0.42a	34.880 ±1.76a	49.677 ±2.20b	37.513 ±0.95ab	35.773 ±0.34ab	29.423 ±1.92c	251.887 ±1.26b
T_4	40.490 ±0.81a	33.657 ±1.32a	57.457 ±3.14a	30.020 ±2.03b	31.467 ±1.84ab	46.407 ±1.46a	265.163 ±2.56a
T_5	39.357 ±0.48a	33.893 ±0.52a	52.363 ±0.88ab	30.867 ±3.18ab	37.063 ±1.06a	31.463 ±0.46bc	250.673 ±3.56b

Means are substantially influenced by distinct letters within the same column (P≤0.05).
T1= Control (without oil), T2= corn oil 1%, T3= Sunflower oil 1%, T4= Soybean oil 1%, and T5= Tallow

Table 4 presents the results of various energy sources on feed intake (g). It can be observed from the data that throughout all periods, there are differences in the amount of feed consumed between the treatments, and there are significant variations (P≤0.05) between the different treatments. The most considerable amount of diet consumed in the age groups (1-7), (8-14), and (15-21) days was by birds belonging to the treatment T_1 control group; also, during the period (1-42) days the highest amount of diet was consumed by *T1* control group, which was (544.593) g. In contrast, the lowest amount of diet consumed in the period (1-42) days was by birds belonging to treatment T_4, which was (418.370) g. According to Attia ***et al.*** (2006), feeding a high-energy diet resulted in more significant growth (5.7%) compared to providing a low-energy diet, as well as lower feed intake (5.8%), a better feed conversion ratio (F.C.R.), and a better energy conversion ratio (E.C.R.) (4%). The usage of fat to boost energy levels and the improvement in nutrient digestibility may be the cause of the improvement in body weight gain, F.C.R., and E.C.R.

Table (4): Impact of different Sources of Energy on feed intake (g) (Mean ± S.E.M.)

Treatments	Age (days)

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	1-7	8-14	15-21	22-28	29-35	36-42	1-42
T_1	34.090 ±3.82a	71.493 ±4.03a	80.780 ±6.13a	118.557 ±1.44ab	114.763 ±5.71a	123.910 ±7.85a	544.593 ±13.46a
T_2	27.603 ±2.13ab	66.570 ±4.59a	72.310 ±4.48ab	102.317 ±4.92b	115.550 ±3.96a	125.747 ±3.35a	512.097 ±7.16a
T_3	26.693 ±1.47ab	70.983 ±2.27a	71.272 ±2.21ab	105.443 ±4.11b	108.177 ±9.86a	118.167 ±7.59ab	504.190 ±21.20a
T_4	26.600 ±0.39ab	63.210 ±4.42a	56.00 ±4.70bc	72.100 ±7.29c	94.803 ±5.17a	102.217 ±2.46b	418.370 ±21.21b
T_5	26.040 ±0.56b	68.530 ±5.57a	54.437 ±3.09c	124.600 ±4.69a	109.343 ±8.87a	114.620 ±2.71ab	503.130 ±29.62a

Means are substantially influenced by distinct letters within the same column (P≤0.05).
T1= Control (without oil), T2= corn oil 1%, T3= Sunflower oil 1%, T4= Soybean oil 1%, and T5= Tallow

Table 5 presents the effects of various energy sources on the feed conversion ratio (g feed intake / g live body weight gain) between the treatments at different age periods. It is evident from the results that there were no significant differences (P≤0.05) between the treatments in any of the periods, except the 8–14 day period. According to data collected during the age range of (1-42) days, the T4 treatment group's feed conversion ratio was (1.567) compared to (2.185), which is lower than the feed conversion ratio recorded by the T1 control group's birds. These results agree with Dahouda ***et al.*** (2013) and Cufadar ***et al.*** (2010). Throughout both study periods, the diet containing soybean source had a generally higher feed conversion ratio (F.C.R.) than the diet containing fish meal; the bird's live body weight may have caused this difference.

Table (5): Impact of different Sources of Energy on feed conversion ratio (g feed intake / g live body weight gain) (Mean ± S.E.M.)

Treatments	Age (days)						
	1-7	8-14	15-21	22-28	29-35	36-42	1-42
T_1	0.852±0.09a	2.084±0.25a	1.428±0.13a	3.235±0.04ab	4.049±0.36a	4.595±0.17a	2.185±0.06a
T_2	0.703±0.02b	1.979±0.26a	1.396±0.11a	2.677±0.09b	3.522±0.37ab	3.142±0.65bc	1.920±0.02b
T_3	0.674±0.03b	2.039±0.05a	1.449±0.08a	2.813±0.14b	3.023±0.32b	4.143±0.42ab	1.984±0.09ab
T_4	0.643±0.01b	1.878±0.14a	0.972±0.06b	2.455±0.39b	3.019±0.13b	2.204±0.14c	1.567±0.07c
T_5	0.675±0.02b	2.018±0.16a	1.042±0.09b	4.153±0.37a	2.963±0.24b	3.646±0.13ab	1.987±0.09ab

Means are substantially influenced by distinct letters within the same column (P≤0.05).
T1= Control (without oil), T2= corn oil 1%, T3= Sunflower oil 1%, T4= Soybean oil 1%, and T5= Tallow.

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Table 6 displays how different energy sources affect the production index. The results revealed significant differences (P≤0.05) at every point. The best measure of the production index was found in T4, except for the age groups of 29–35 and 36–42. T3 has the highest mean (15.864) for the age range of 29 to 35 days, while T1 has the lowest mean (11.725). The highest mean of T4 during the period of (36-42) days was (25.686), while the lowest norm was (11.556) in the T1 control group. There were significant differences (P≤0.05) in the monetary figure between the treatments. The T5 birds had the highest financial figure, 1.527, compared to 1.203 for the T1 control birds.

Table (6): Impact of different Sources of Energy on Production Index and Economic Figure (Mean ± S.E.M.)

T.	Age (days)						
	Production Index						Economic Figure
	1-7	8-14	15-21	22-28	29-35	36-42	
T_1	13.098±1.285b	9.388±1.29a	22.756±2.41b	12.438±0.06ab	11.725±1.00a	11.556±0.49c	1.203±0.27c
T_2	15.329±0.18ab	9.700±1.23a	22.101±1.95b	14.681±0.72a	13..706±1.82a	20.268±4.499ab	2.111±0.22ab
T_3	16.212±0.85a	9.253±0.34a	20.964±1.21b	13.865±0.81ab	15.864±1.59a	13.267±1.54bc	1.382±0.2bc
T_4	17.251±0.37a	10.123±0.87a	33.064±1.82a	16.717±2.56a	15.285±0.73a	25.686±0.55a	2.676±0.14a
T_5	16.099± 0.54a	9.331±0.69a	29.823±2.67a	9.427±1.33b	15.774±1.39a	14.665±0.73bc	1.527±0.23bc

Means are substantially influenced by distinct letters within the same column (P≤0.05).
T1= Control (without oil), T2= corn oil 1%, T3= Sunflower oil 1%, T4= Soybean oil 1%, and T5= Tallow

Vegetable oils have become very important in poultry nutrition to enhance the energy density of the feed and, hence, the interventions during performance enhancement. Soybean oil is one of the most valued oils because of its high concentration of unsaturated fatty acids, which poultry digest more easily than saturated fats. The oils such as soybean, canola, and sunflower are used to correct for energy deficit but also serve other functions like improving feed palatability, decreasing pulverulence, and increasing the bioavailability of fat-soluble vitamins (Ahiwe et al., 2018; Leeson & Atteh, 1995; Azman et al., 2004). Efficient energy utilization is only possible if they are digestible, and this is what fast growth and feed efficiency mean in the species such as the Japanese quail. The data cribbed from Table 2 showed that there were no significant differences in live body weight among the treatment groups at early growth stages (7, 14, and 36 days), whereas birds on diets with soybean oil (T2) attained the greatest final body weight at 42 days (249.253 g), which was significantly larger than the control group (T1) at least in weight average (231.603 g). This gives a clue that it may assist that soybean oil is good for growth performance from its fatty acids profile and metabolizable energy content. The degree of fatty acid saturation and chain length plays a fundamental role in

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determining how efficiently the fat is metabolized, and soybean oil's dominance in unsaturated fats contributes directly to its superior performance (Abedpour et al., 2017). The trend of gain in body weight (BWG) also supports the benefit of oil supplementation. Table 3 suggests that there were no significant differences in BWG in the first two weeks (1–7 and 8–14 days), but statistically significant increases were found thereafter. T1 control group consistently possessed the lowest BWG throughout the later growth stages (36–42 days: 27.037 g; 1–42 days: 246.557 g), while T4, which presumably utilized a different source of oil, reported the highest gains (46.407 g and 265.163 g, respectively). These findings agree with other research by Abou El-Wafa (2000), who reported that vegetable oils, i.e., soybean, corn, and sunflower, were superior to animal fats to increase BWG and FCR in broiler chicks. They disagree, however, with Abdel-Hakim et al. (2009), who explained that sunflower oil caused optimal gains in Japanese quail, which suggests that specific oil effects may be influenced by inclusion levels, bird genotype, or environmental aspects. According to FI data presented in Table 4, there is a need for further insight on energetic efficiency due to oil supplementation. Group T1 was the control one and consumed the highest amount of feed across all ages; it also had the highest intake while cumulatively summing over 1 to 42 days (544.593 g). However, the T4 birds were able to consume less substantially (418.370 g), at even greater BWG. This suggests that the birds fed with these high-energy diets have vegetable oils in them-the-fats and oils feed less to meet their energy requirements, an attitude also supported by Attia et al. (2006) who reported that feeding broilers with high-energy diets led to 5.8% reduction in feed intake and 5.7% increase in growth. Literature is replete with several instances where an inverse relationship between dietary energy density and feed intake has been documented; Gheisari et al. (2011) and Attia et al. (2012) observed that when the diet increases in energy level, birds try to self-regulate their intake to meet the metabolic requirements. Such regulatory mechanism depends on protein level to a certain extent and on nutrient balance: an imbalance may lead to an overconsumption of calories, in particular under a high fat diet (Swennen et al., 2007). Table 5 shows that FCRs were significantly lower in treatment T4 compared to T1 in the 1- to 42-d period (1.567 vs. 2.185), suggesting more efficient feed conversions. These results are in agreement with those of Dahouda et al. (2013) and Cufadar et al. (2010), who reported that diets containing soybean oil produced lower FCRs and better growth efficiency compared to those of animal fats or fish meal. Increased FCRs from higher energy levels supplied by oil may bear an aspect of lesser importance in the whole process, for two other factors-metabolizability and nutrient absorption-may be given even greater emphasis. According to Lee et al. (2003), some bioactive compounds in soybean oil such as lecithin may stimulate lipid metabolism and bile secretion, so as to improve fat digestion. Soybean oil may also control hepatic cholesterol synthesis through regulating the activity of HMG-CoA reductase for higher plasma lipid profiles in birds. Indeed, the presence of soybean meal and lipid supplements stimulates the release of digestive enzymes such as trypsin and amylase crucial for protein and starch digestion (Song et al., 2021). As physiological functions of betaine and L-carnitine supplementation, betaine promotes intestinal enzyme activities and microbial fermentation (Ratriyanto et al., 2014), while L-carnitine promotes fatty acid oxidation and decreases blood cholesterol (Rezaei et al., 2007;

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Parsaeimehr et al., 2012). These developments can be seen in the data on production index (PI) in Table 6. The T4 sample displayed the highest PI results for the majority of the growth periods between day 36 to day 42 (25.686), while T1 exhibited the lowest (11.556). The economic significance of the differences is considerable. The financial index indicates that T5 birds attained the greatest value (1.527), which is much higher than the T1 group (1.203). This suggests that the addition of vegetable oils into poultry diets is not only biologically advantageous, but also economically viable. Altogether, the data gathered, as well as those in previously published work, suggest that vegetable oils containing unsaturated fats, particularly soybean oil, can be beneficial poultry production. Such oils improve live body weights, body weight gain, feed conversion ratio, as well as the activity of certain enzymes, while also minimizing feed intake due to enhanced nutrient absorption. The collective maximization of these parameters results in enhanced productivity, economic profitability, and strong reinforcement of the effect of lipid energy supplementation in the nutrition of Japanese quails.

V. Conclusion

The collective results from Tables 2 to 6, in conjunction with the review of literature, reveal the great advantage of using vegetable oils, mainly soybean oil, as dietary energy sources in Japanese quail production. These oils help the quail grow heavier live body weight-wise, enhance BWG and FCR, reduce feed intake due to the oils' energy density, activate digestive enzymes, and have better economic returns. However, these effects are based on biochemical properties of the unsaturated fats in relation to energy metabolism, nutrient utilization, and physiological efficiency as key elements in optimization of performances in poultry systems.

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