The Effect of Using Different Levels of American Cockroach (*Periplaneta americana*) powder on Productive and Physiological Performance of Japanese Quail (*Coturnix japonica*)

IOP Conf. Series: Earth and Environmental Science **735** (2021) 012003 doi:10.1088/1755-1315/735/1/012003

The Effect of Using Different Levels of American Cockroach (*Periplaneta americana*) powder on Productive and Physiological Performance of Japanese Quail (*Coturnix japonica*)

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Abstract

This study aimed to investigate the effect of using different levels of American cockroach (*Periplaneta americana*) powder on productive and physiological performance of Japanese quail (*Coturnix japonica*). One hundred and thirty-five, 45 days-old of Japanese quail females were randomly divided into three groups (45 females for each). Each group has three replicates (15 females per each). The groups were included: The first group was fed on experimental diet included with 0 % of insect powder and 6% of protein concentration as the control. The second group was fed on experimental diet included with 3% of protein concentration and 3% of insect powder. The third group was fed on experimental diet included with 0 % of protein concentration and 6% of insect powder. The results showed no significant in the egg weight, egg mass, feed conversion ratio and mortality among groups. The birds in the third group were recorded a significant increase (P≤0.05) in the egg production (%), on the other hand, it recorded a less value in the feed intake compared to other groups. The results of relative weight of ovaries and oviducts showed the birds in the third group were recorded a significant increase (P≤0.05) compared to other groups. On the other hand, the second group was recorded a significant increase (P≤0.05) compared to first group (control). The results were indicated no significant in the levels of estrogen hormone among groups. While, the results of the levels of follicle stimulating hormone and luteinizing hormone were indicated a significant increase (P≤0.05) in the third group compared to other groups. In addition to, the second group was recorded a significant increase (P≤0.05) compared to first group (control). In conclusions, so far proves the potential of the American cockroach (*P. americana*) meal for use in quail production systems. American cockroach (*P. americana*) food based feed can completely replace protein sources by 100 per cent without negative effect on the productive performance of quail and, in some ways, can achieve better than conventional protein based feeds such as protein concentrations. On the other hand, the American cockroach (*P. americana*) meal improved physiological performance of quail.

Keywords: American cockroach, Quail, Physiological performance.

1. Introduction

The world's population is predicted to increase by more than a third, arrival over 9 billion persons in 2050, with the key implication that the planet will have to generate 70% more food. As a result, livestock production would increase exponentially to double the current level. The biggest challenge would therefore be to ensure that there is a global capacity to provide adequate animal feed to prevent as much competition as possible with the demand for human food. In recent years, rising protein concentration prices have become crucial to the economic sustainability of the birds meat industry, especially in some developing nations[1]. Of this reason, insects have already been proposed as a high quality, effective and sustainable different protein source of poultry [2]. Insects are proposed as an different protein source in poultry feed because of the same contents[3]. Moving from conventional insect food protein sources can result in more efficient use of natural resources and lower greenhouse gas emissions, as well as lower greenhouse gas emissions [4]. The potential of insect protein in poultry diets has magnetize a great deal of attention due to the reasons mentioned above. Outdoor exposure chickens pick up insects at all stages of life and eat them readily, suggesting that they are evolutionarily adapted to insects as a natural part of their diet. [5]. It seems rational to allow the comprehension of insect proteins as raw materials to be used in commercial feed production and to establish thorough insect farming systems. FAO strongly advocates the use of insects as human food and

livestock feed as a method for alleviating hunger [6]. Due to all these positive characteristics, as well as being an insect species acceptable for mass processing, various studies have been conducted to determine the probable for insect inclusion in poultry diets. Insect meal was found to be a good source of nutrition, digestible amino acids, for chicken [7], broilers and quails [8; 9] and Barbary partridge [10], maintaining optimum health status and demonstrating adequate growth efficiency and overall quality of meat. One of the most promising insects species identified for industrial production is American cockroach (*Periplaneta americana*). The food and agriculture organization of the united nations (FAO) proposed insects as a different protein source for animal feed [11]. Therefore, this study aimed to study the effect of using different levels of American cockroach (*Periplaneta americana*) powder on productive and physiological performance of Japanese quail (*Coturnix japonica*).

2. Materials and Methods

The present study was conducted in the quails farm in the Agriculture College, Basrah University, Basrah city, Iraq.

2.1. Insect meals

The American cockroach insects were bred by collecting egg bags from the insect and growing it laboratory in breeding cages in the laboratories of the Plant Protection Department, Agriculture College, Basrah University. The insects were dried and ground with an electric grinder. Chemical analysis of insects powder Table 1 was implement according to [12].

Table 1. Chemical analysis of insects power.

Component (%)	%
Dry matter	96.2
Crude protein	80.15
Crude fat	5.80
Ash content	4.05
Crude fiber	10
Metabolizable energy (kcal.kg^{-1})	2375

2.2. Experimental design

One hundred and thirty-five, 45-day-old Japanese quail females were randomly divided into three groups (45 birds for each). Each group has three replicates (15 birds per group). Both birds are reared in cages (replicates) with measurements (100 × 51 × 49) cm. The birds were bred in the same breeding methods. The room temperature was held at 25°C from the start of the research to the end of the study. The groups were included: the first group was fed on experimental diet included with 0 % of insect powder and 6% of protein concentration as the control. The second group was fed on experimental diet included with 3% of protein concentration and 3% of insect powder. The third group was fed on experimental diet included with 0 % of protein concentration and 6% of insect powder. The ingredients of the experimental diets are showed in Table 2

Table 2. Ingredients of the experimental diets (g/kg as fed)[1].

Ingredients %	Diet 1 (control)	Diet 2	Diet 3
Yellow corn	35	35	35
Wheat	25	25	25
Protein concentration	6	3	0
American Cockroach powder	0	3	6
Soybean meal	26.7	26.7	26.7
Soybean oil	1.5	1.5	1.5
Limestone	5.5	5.5	5.5
Iodide salt	0.30	0.30	0.30
Total	100	100	100
Calculated composition			
Metabolizable energy (kcal.kg^{-1})	2947.1	2931.8	2916.5
Crude protein (%)	20.84	21.48	22.11
Crude fibre (%)	2.36	2.36	2.31
Ash (%)	5.06	4.93	4.81
Methionine (%)	0.55	0.37	0.35

Lysine (%)	0.97	1.35	1.02
Methionine + Cysteine (%)	0.55	0.72	0.47
Calcium (%)	2.49	2.50	2.50
Phosphorus available (%)	0.32	0.40	0.39
Calorie: protein ratio	141.41	136.48	131.90

2.3. Productive performance

The productive performance including the estimated to eggs parameters, feed intake, feed conversion ratio and mortality. The total number of egg, egg weight, egg mass and egg production (HD%) were determined according to [13] after 60 days from study begins as follows:

$$\text{HD\%} = \frac{\text{No. of eggs for 60 days}}{\text{No. of hens} \times 60 \text{ days}} \times 100$$

$$\text{Accumulative number of eggs} = \frac{\text{HD\%}}{100} \times \text{No. of days}$$

$$\text{Eggs mass} = \text{accumulative number of eggs} \times \text{eggs weight}$$

Feed intake was determined according to [14; 15]**.** The feed conversion ratio was determined by dividing the feed intake by the egg mass. [16]. Mortality was recorded daily till this study end.

2.4. Organs relative weight

At the end of the 60 days of experiment, five birds of similar body weight from each group were used to study ovaries and oviducts relative weight. The birds were randomly selected, individually weighed and slaughtered. Organs were collected, weighed and expressed as a percentage of the live body weights.

2.5. Hormones measurement

During slaughter, blood samples from the Jugular vein were obtained and centrifuged at 3000 RPM for 10 minutes to extract serum. The radioimmunoassay was used to test the serum hormones LH and FSH [17]. Serum estrogen hormone was tested using an immunoassay kit (DRG Co, Germany).

2.6. Statistical analysis

All data were subjected to a one-way ANOVA procedure by using SPSS program software (2012) significant treatment means were separated by using the Least Significant Difference (L.S.D.) test at $P \leq 0.05$.

3. Results and Discussions

3.1. The productive performance

The productive performance of laying quails were presented in table 3. The results were indicated no significant in the egg weight, egg mass, feed conversion ratio and mortality among groups. The birds in the third group were recorded a significant increase ($P \leq 0.05$) in the egg production, on the other hand, it recorded a less value in the feed intake compared to other groups. American cockroach insects are a nutrient wealthy feed source: the protein and fat content values acquired in this study are compatible with the literature data for this type of product [18]. Even if the feed efficiency and laying performance of the quails are expected to decline gradually with age, the overall results of the laying quails in the present study were satisfactory. These finding may be due to cockroaches were moderately high in crude protein. In addition to these protein quality indices, there are other considerations such as the efficiency of conversion of organic side-streams, the viability of mass production and product protection[11,19,20]. The harmful potential of cockroaches can also be reduced by using them as food for poultry. [21]. Aigbodion et al,[22] indicated *P. americana* may be a different source of protein for birds in the early stages of their production. The significantly lower incidence of mortality among birds fed with *P. americana* may be the result of a potential improvement in their immunity. The use of insects in livestock diets could decrease the cost of protein production for humans as insects turn food materials into tissues extremely well, and their rate of reproduction and fertility gives them a competitive advantage as a feed source for birds. [23].

Table 3. Effect of using different levels of American cockroach (*Periplaneta americana*) powder on the productive performance of quails.

Groups	Hen day production (%)	Egg weight (g)	Egg mass (g/bird/60 days)	Feed intake (g)	Feed conversion ratio (g/g)	Mortality %
Group 1	46.33[b]	12.64	585.78	1840.33[a]	3.15	Mortality %
Group 2	48.00[b]	12.52	600.38	1823.67[a]	3.04	54.4
Group 3	51.67[a]	12.45	642.78	1774.33[b]	2.77	4.44
SEM	0.866	0.168	10.67	10.948	0.065	2.22
P value	0.005	0.917	0.046	0.006	0.013	1.614

[ab]Means in the same column with no common superscript are different significantly (P≤0.05).

3.2. Organs relative weight

The relative weight of ovaries and oviducts were explanted in table 4. The results showed the birds in the third group were recorded a significant increase (P≤0.05) compared to other groups. On the other hand, the second group was recorded a significant increase (P≤0.05) compared to first group (control). These finding may be due to the improvement of bird health after feeding on the source of the insect protein. Insects are a good source of protein, amino acids and fat [3,24]. The full replacement of the dietary protein concentrations meal by the American cockroach meal is responsible of several modifications in the intestinal tracts of quail. The significant improvement in the relative weight of ovaries and oviducts of quail fed the American cockroach meal it may be because the diet was designed with a high protein and a lower energy, which met the quail requirements for maintenance and development. This may also be the product of the complementary impact of the amino acid profile of American cockroach meal [18].

Table 4. Effect of using different levels of American cockroach (*Periplaneta americana*) powder on the relative weight of ovaries and oviducts.

Groups	Group 1	Group 2	Group 3	SEM	*P* value
Relative Weight of ovaries	6.10[c]	6.22[b]	6.37[a]	0.041	0.003
Relative Weight of oviducts	5.86[c]	6.07[b]	6.28[a]	0.065	0.002

[abc]Means in the same row with no common superscript are different significantly (P≤0.05).

3.3. Hormones

Follicle stimulating hormone**,** luteinizing hormone and estrogen hormones level were showed in the table 5. The results were indicated no significant in the levels of estrogen hormone among groups. While, While, the results of the levels of follicle stimulating hormone and luteinizing hormone were indicated a significant increase (P≤0.05)in the third group compared to other groups. On the other hand, the second group was recorded a significant increase (P≤0.05) compared to first group (control). These finding may be due to high nutrition value for American cockroach meal. American cockroach (*P. americana*) food has good nutrient quality and a good source of essentially fat, protein and other essential nutrients. [18]. This encouraged the improvement of bird health, increased blood circulation and thus raised the level of hormones. These finding in agreement with those finding by [25] who indicated in animal studies a high protein diet improved sexual hormone level. They also, showed the protein intake can be manage factor of sexual hormone levels. Thus, diet high in protein content have a positive effect on follicle stimulating hormone and luteinizing hormone bioactivity.

Table 5. Effect of using different levels of American cockroach (*Periplaneta americana*) powder on the some hormones level.

Groups	Group 1	Group 2	Group 3	SEM	*P* value
Follicle stimulating hormone (FSH) IU.L^{-1}	4.81^{c}	4.95^{b}	5.10^{a}	0.043	0.001
Luteinizing hormone(LH) IU.L^{-1}	3.89^{c}	4.01^{b}	4.10^{a}	0.033	0.003
Estrogen (pg.ml^{-1})	161.33	167.33	168.00	1.435	0.094

^{abc}Means in the same row with no common superscript are different significantly (P≤0.05).

Conclusions

In conclusions, so far proves the potential of the American cockroach (*P. americana*) meal for use in quail production systems. American cockroach (*P. americana*) food based feed can completely replace protein sources by 100 per cent without negative effect on the productive performance of quail and, in some ways, can achieve better than conventional protein based feeds such as protein concentrations. On the other hand, the American cockroach (*P. americana*) meal improved physiological performance of quails.

Acknowledgements

The authors are very thankful to the quail farm workers at the Agriculture College, Basrah University for supporting this research.

References

[1] FAO (Food and Agriculture Organization of the United Nations) 2009 How to feed the world 2050: Global agriculture towards 2050. Rome: Food and Agriculture Organization of the United Nations (FAO).
[2] Bovera F, Loponte R, Marono S, Piccolo G, Parisi G, Iaconisi V, Gasco L and Nizza A 2015 Use of Tenebrio molitor larvae meal as protein source in broiler diet: effect on growth performance, nutrient digestibility, and carcass and meat traits. J Anim. Sci. 94:639–647.
[3] Makkar, HPS, Tran G, Heuzé V and Ankers P 2014 State of the art on use of insects as animal feed. Anim Feed Sci Technol. 197:1–33.
[4] van Zanten HHE, Oonincx DGAB, Mollenhorst H, Bikker P, Meerburg BG and deBoer IJM 2014 Can the environmental impact of livestock feed be reduced by using waste-fed housefly larvae Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector;October 8–10; San Francisco, USA. ACLCA, Vashon, WA, USA, p. 1455–1461.
[5] Bovera F, Piccolo G, Gasco L, Marono S, Loponte R, Vassalotti G, Mastellone V, Lombardi P, Attia YA and Nizza A 2015 Yellow mealworm larvae (Tenebrio molitor, L.) as a possible alternative to soybean meal in broiler diets. Br Poult Sci. 56:569–575.
[6] FAO 2010 Promoting the contribution of edible forest insects in assuring food security. FAO Forestry Department Programme. Forest Economy, Policy and Product Divisions. Rome: FAO.
[7] Schiavone A, Dabbou S, De Marco M, Cullere M, Biasato I, Biasibetti E, Capucchio TM, Bergagna S, Dezzutto D and Meneguz M and et al. 2018 Black soldier fly larva fat inclusion in finisher broiler chicken diet as an alternative fat source. Animal 10: 2032–2039.
[8] Cullere M, Tasoniero G, Giaccone V, Miotti-Scapin R, Claeys E, De Smet S and Dalle Zotte A 2016 Black soldier fly as dietary protein source for broiler quails: Apparent digestibility, excreta microbial load, feed choice, performance, carcass and meat traits. Animal 10: 1923–1930.
[9] Shehab Mohamad Hamid, Salim Thanon Younis and Mahmood Ahmed Mohammad. (2020). Effect of Substitution of Vicia Sativa Raw and Treated Seeds as A substitute for Soybean Meal on Productive Performance of Broiler Chickens. Al-Qadisiyah Journal For Agriculture Sciences, 10(2), 408-414.
[10] Secci G, Moniello G, Gasco L, Bovera F and Parisi G 2018 Barbary partridge meat quality as affected by Hermetia illucens and Tenebrio molitor larva meals in feeds. Food. Res. Int. 112: 291–298.
[11] Van Huis A, Van Itterbeeck J, Klunder H et al 2013 Edible Insects: Future Prospects for Food and Feed Security. Rome: Food and Agriculture Organization of the United Nations (FAO).
[12] AOAC: Association of Official Analytical Chemists 2016 Official Method Analysis, 20th ed., Washington: 2: 3172pp.
[13] Younis DTh 2014 Effect of antioxidant enhancement on productive performance and some physiological characters of broiler breeders reared under hot climate. Iraqi Journal of Veterinary Sciences 28(2): 81-85.
[14] Najm ZM and Al-Hilali AHK 2017 The Effect of Aqueous Extract of Anise Seeds. Pimpinella Anisum L. Effect on Body Weight, Weight Gain, Feed Consumption and Feed Conversion Ratio of Japanese quail. AL-Qadisiyah Journal for Agriculture Sciences 7(2):205-212. (In Arabic).

[15] Al-Khauzai ALD 2019 The Effect of Crossbreeding on Some Economic Traits for Chicks of Lohmann Chicken. AL-Qadisiyah Journal for Agriculture Sciences, 9(2):277-282.
[16] Zduńczyk Z, Drażbo A, Jankowski J, Juśkiewicz J, Antoszkiewicz Z and Troszyńska A 2013 The effect of dietary vitamin E and selenium supplements on the fatty acid profile and quality traits of eggs. Archiv Tierzucht, 56(72): 719-732.
[17] Alsultani, M., Abed, H., Ghazi, R., & Mohammed, M.A. (2020). Electrical Characterization of Thin Films (TiO2: ZnO)1-x (GO)x / FTO Heterojunction Prepared by Spray Pyrolysis Technique. Journal Of Physics: Conference Series, 1591, 012002. doi: 10.1088/1742-6596/1591/1/012002
[18] Boate UR and Suotonye BD 2020 Cockroach (Periplaneta americana): Nutritional Value as Food and Feed For Man and Livestock. Asian Food Science Journal, 15(2): 37-46.
[19] Rumpold BA and Schlüter OK 2013 Potential and challenges of insects as an innovative source for food and feed production. Innov Food Sci Emerg Technol, 17: 1–11.
[20] van der Spiegel M, Noordam MY and van der Fels-Klerx HJ 2013 Safety of novel protein sources (insects, microalgae, seaweed, duckweed, and rapeseed) and legislative aspects for their application in food and feed production. Compr Rev Food Sci Food Saf, 12: 662–678.
[21] Ramos-Elorduy J and Pino-Moreno JM 2002 Edible insects of Chiapas, Mexico. Ecology of Food and Nutrition, 41: 271–299.
[22] Dania Mohammed Danish Aladdin Sajadi, Akram Othman Esmail. (2020). Comparison Between Groundwater Quality at North East and South West of Erbil Governorate for Irrigation Using Some Global Systems and Principal Component Analysis. Al-Qadisiyah Journal For Agriculture Sciences, 10(2), 308-324.
[23] Durst PB and Shono K 2010 Edible forest insects: exploring new horizons and traditional practices, pp. 1–4. In Forest Insects as Food: Humans Bite Back (edited by P. B. Durst, D. V. Johnson, R. N. Leslie and K. Shono). Proceedings of a Workshop on Asia – Pacific Resources and their Potential for Development, 19–20 February 2008, Chiang Mai, Thailand. Food and Agriculture Organization of the United Nations (FAO), Geneva.
[24] Van Broekhoven S, Oonincx DGAB, Van Huis A and Van Loon JJA 2015 Growth performance and feed conversion efficiency of three edible 4 mealworm species (Coleoptera: Tenebrionidae) on diets composed of 5 organic by-products. J. Insect Physiol, 73: 1–10.
[25] Longcope C, Feldman HA, Mckinlay JB and Araujo AB 2000 Diet and sex hormone-binding globulin. The journal of clinical endocrinology and metabolism, 85 (1): 293-296.