Egypt. Poult. Sci. Vol. (42) (III): (295-311) (2022) (2206-1208)

Egyptian Poultry Science Journal

http://www.epsj.journals.ekb.eg/

ISSN: 1110-5623 (Print) – 2090-0570 (Online)

EFFECT OF INCLUSION DRIED YELLOW EARTHWORM MEAL (*TENEBRIO MOLITOR*) ON PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF JAPANESE QUAIL
1-REPLACEMENT OF BASAL DIET DURING THE GROWING PERIOD

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Received: 16/06/2022 Accepted: 26 /08/2022

ABSTRACT: The purpose of this study was to investigate the effect of partially replacement the yellow mealworm *(Tenebrio Molitor,* YMW) of Japanese quail basal diet on productive performance during 1-42 days of age. Three hundred and fifty unsexed one-day-old chicks were randomly assigned to one of five food treatments (7 pens per treatment, 10 birds per pen) and reared on battery brooders in wire cages (55×50×35 cm) with individual feeders and drinks. A basal control diet (24 % crude protein, CP; 2970 Kcal/kg) was fed to the first group. The 2nd, 3 rd, 4th and 5th treatments were supplied with YMW (2.5, 5.0, 7.5, and 10.0%, respectively), replacing the basal diet. Throughout the experimental period quails were provided feed and water *ad-libitum*. The results indicated that the dry matter of YMW continued 61.5% CP and 21.19 % ether exact (EE). The content of essential amino and fatty acids of YMW as a percentage of CP and EE was higher than that content on the fish and soybean meal. Replacement with 10.0% of YMW maximized both of body weight and gain and improvement the feed conversion ratio compared with control group. Increasing the replacement percentage of YMW significantly increased the carcass, meat quality, and the content of some amino acids and saturated fatty acids. The inclusion of YMW, significantly decreased total cholesterol and triglyceride concentrations and the high lipoprotein concentration, biochemical and immunity statues were significantly improved. In conclusion, replacing YMW up to 10.0% of the Japanese quail diet is acceptable and has no adverse effect on growth and productive performance and immunity states.

Key words: Japanese quail, yellow meal worm, growth performance and immunity statues.

INTRODUCTION

The traditional protein sources in poultry feed fail to meet the increasing demand due to competition between humans and livestock. Also, limited resources, mainly land, raise whether agriculture can meet future needs for livestock feed. Moreover, protein cost accounts for over 15% of the total feed cost (Khan et al., 2010 and Khan et al., 2016). Therefore, the nutritionist will identify alternative sources of protein, energy, and other nutrients produced on a viable and sustainable commercial scale for livestock to avoid such competition. However, determine the feasibility of an alternative protein source be incorporated into the diet, such as the nutritional variability in nutrient level and quality, particularly the essential amino acid balance, presence of anti-nutritional and toxic factors such as tannins and enzyme inhibitors and presence of pathogenic microorganisms (Ncobela and Chimonyo, 2015; Dinani et al., 2019; Mohamed et al., 2021).

In recent years, yellow mealworms (*Tenebrio Molitor*, YMW) have been received growing interest as one potential 'new' protein that can be farmed at relatively low economic and environmental costs. According to Henuk (2017) farming insects' uses up to 50% less land per kilogram protein, 40–80% less feed per kg edible weight. Elahi et al. (2020) demonstrated that YMW contains a higher crude protein (CP) than traditional protein sources. Except for a methionine shortage, YMW has sufficient essential amino acids (EAA) to cover the nutritional requirements of humans (Azagoh et al., 2016) and poultry (Makkar et al., 2014). Other studies have revealed that the EAA content of mealworms is equivalent to that of fish and soybean meals used in cattle feed (Azagoh et al., 2016) and can improve broiler performance (Biasato et al., 2016) with a higher feed conversion ratio (FCR), according to Islam and Yang (2017). Makkar et al. (2014), found that mealworm (the larva of the darkling beetle, Tenebrio Molitor) is a good source of lysine and methionine. In addition, it can quickly transform low-quality plant waste into high-quality protein, fat, and energy. Fresh and dried YMW nutrients and amino acids were equivalent when adjusted to the same dry matter base, with slight changes as reported by (Loponte et al., 2017 and Khan et al., 2018). The nutritional profile discrepancy could be due to artificial or natural conditions in the production or processing of insects (Elahi, 2016).

Assessment of feeding studies undertaken on various types of animals and poultry by FAO scientists in 2014. It was concluded that insect meal may replace 25 percent to 100 percent of soy meal or fishmeal in the diets of the animals without causing harm. Biasatoa et al. (2021) found that increasing levels of YMW inclusion increased body weight, weight gain, and feed intake, but that feed efficiency was slightly harmed. Because insects are naturally devoured by wild birds and free-range chickens, the improvement in FCR could be related to higher feed palatability due to the inclusion of yellow mealworms (Zuidhof et al., 2003).

This work aimed to investigate the effect of including different dietary levels of yellow mealworm (*Tenebrio Molitor*, YMW) on growth performance, carcass and carcass meat (breast + thigh) amino acids contents, lipid metabolism and blood constituents of Japanese quail during the growing period (1-42 days).

MATERIALS AND METHODS

The procedures were carried out in El-Sabahia Poultry Research Station, Alexandria Governorate belonging to Animal Production Research Institute, ARC, Ministry of Agriculture.

Preparation of Yellow Mealworm: Yellow Mealworm (*Tenebrio Molitor*, YMW) diet was produced, in a small unit in El-Sabahia Poultry Research Station, using mealworm beetles, fed on a growth media consisting of three parts of broiler diet (25% CP), two parts of wheat bran and one part of oat as growth media. New larvae were harvested, freeze, dried in an oven-dried at 50 ^{o}C for three days, and ground. The proximate analyses of YMW and muscle samples were determined using the Association of Official Analytical Chemists' method (AOAC, 2003).

Birds and Diets: Three hundred and fifty mixed-sex, one-day-old Japanese quails (individual body weight (BW) ~ 9.5 g) were assigned randomly to one of five food treatments (7 pens/treatment and 10 birds/pen) while being reared on the floor with wood shaving as bedding. Each 0.9 x 1.7 m^2 pen was equipped with its own feeder and drinker. Throughout the experiment period, the quails were provided feed and water ad-libitum. The management and medical programmer were carried out in accordance with standard veterinary care procedures. Birds were subjected to a photoperiod of 16 to 8 (L:D) cycles. Ground mealworms (YMW) were used as replacement of 0.0, 2.5, 5.0, 7.5 and 10.0% of basal diet (Table1). The temperature in the chicken house was maintained at 33 ^{o}C for the first three days and then reduced by 3 ^{o}C each consecutive week until 28 ^{o}C.

Growth Performance: At 14, 28, and 42 d of age, BW and feed intake (FI) were recorded for each pen. Mortality was recorded daily for FI correction. Bodyweight gain (BWG) and feed conversion ratio (FCR) were calculated by using the documented data of BW, FI, and mortality.

Hematological Characteristics: In each treatment group, two blood samples were obtained from the brachial vein in the wing of seven randomly selected birds at 42 days of age. The samples were placed in two tubes, one without anticoagulant and with heparin. Blood was centrifuged at 1500x g for 20 minutes to obtain plasma and serum samples, then frozen at -20°C until needed for analysis. The second blood sample was used to determine the hematological elements of the blood.

White blood cell (WBC) counts were determined and blood film was made according to (Lucky, 1977), uric acid (Urea) by the method of Bartles et al. (1972), plasma triglycerides (Trg, mg/dl) by the method of Fossati and Prencipe (1982), total plasma cholesterol (Chol, mg/dl) by the method of Stein (1986), plasma HDL-cholesterol by the method of Lopez-Virella (1977), plasma LDL-cholesterol calculated according to Friedewald et al. (1972) {LDL= total cholesterol – HDL- (triglycerides/5)}. The activity of serum aspartate aminotransferase (AST) and serum alanine aminotransferase (ALT) according to Reitman and Frankle (1957) Chiu et al. (1976) used to assess glutathione peroxidase (GPx) activity. Serum total antioxidant capacity (TAC) was determined according to (Erel, 2004). Biochemical constituents were determined using commercial kits produced by Diamond Diagnostics Company (29 Tahreer St. Dokki Giza Egypt).

Carcass and Meat Quality: Three birds from each pen were slaughtered at 42 days of age, and the carcass, gizzard, liver, pancreas, intestinal weight and length, spleen, bursa, ovaries, and tests were all recorded. At 24 hours after slaughtering, meat color was determined in triplicate using a Chroma meter and described in the CIE-Lab trichromatic system as lightness (L*), redness (a*), and yellowness (b*). Drip loss is a measure of water holding capacity.

Amino acid analyses: The amino acid compositions of the YMW and meat were determined using an automatic amino acids analyzer according to (AOAC 2005).

Fatty Acid Methyl Esters (FAMEs) Analyses:

Fatty Acid Methyl Esters analyses was determined by using gas chromatography analysis (using Hewlett-Packard 6890 model gas chromatograph equipped with a flame ionization detector and a split injector (Umit, et al., 2015). Folch et al. (1959) and the AOAC (2005) technique were used to extract lipids from 10 g of meat. Fatty acid methyl esters (FAMEs) were prepared from lipid extracts according to AOAC guidelines (1990).

Statistical Analysis: Data was statistically analyzed using one-way ANOVA of SAS®(SAS, 2009). Variables having significant differences were compared using the Tukey test (SAS, 2009). The statistical model used was as follows:

Yij= μ+Ti+eij, Where, Yij= the dependent variable, μ= the overall mean; Ti= the effect of treatments and eij= the random error.

RESULTS AND DISCUSSIONS

Chemical composition of yellow meal warm: Yellow mealworm (*Tenebrio Molitor L.*, YMW) is a vital insect that can represent a valuable alternative protein source, and it can be successfully used as partial feedstuff replacement of soybean meal and fishmeal in poultry diets (Henry et al., 2015; Calislar, 2017). The data indicated that the dry matter of YMW has reached of CP (60.15%) and that levels are more than the content of soybean meal (48.5 %) and almost equal to what fish meal content of CP (72.0%), Table 2. That content of CP reported herein was compatible with the results of several researches, 45–60% (Józefiak and Engberg, 2015), 44-69% (Henuk, 2017), 45.83% (Hussain et al., 2017), 25–60% (Benzertiha et al., 2020), 53.8% (Kröncke et al., 2019), 46.44% (Zadeh, et al., 2019), 51.9% (Gasco et al., 2020) and 53.25 % (Stastnik et al., 2021). The ether exact (EE) was 21.19 %, that content is more than the content of soybean meal and fish meal (1.0 and 10.0%, respectively), and that content results was almost equal with the results of Henuk (2017) 23-47%, Gasco et al. (2020) 23.60 and Stastnik et al. (2021) 29.35%. The present study's ash and crude fiber contents were 4.19 and 8.12 %, respectively, and these percentages ranged between 3.0–4.5% and 5.0–8.8%, respectively, as reported by Ramos-Elorduy et al. (2002).

Protein and ether extract of MWM is high in essential amino acids (EAA) and fatty acids content (FA). The results detected that all amounts of EAA and FA in YMW as a percentage of CP and EE are higher than that on the fish and soybean meals (Table 2). Hall (1992) reported that insects balance their essential and non-essentials, compared with the content of vegetable protein sources, and could have a similar market as fishmeal and soybean meal (Van Huis et al., 2014). Ravzanaadii et al. (2012) remarked that the values of oleic acid along with linoleic acid and palmitic acid were the highest component (43.17, 30.23 and 16.72%, respectively) from the long chain of FAs in larvae meal.

Growth performance: At all experimental periods (14, 28, and 42 days of age), the BW and BWG significantly increased gradually by increasing the amount of YMW meal replacement, and the maximum BW and BWG corresponded to the replacement of 10.0% YMW/kg diet compared with the control group, Table 3. Feed intake has significantly differed among all experimental groups at different periods. The average amount of FI fluctuated among other periods. However, the high mount of FI was recorded for the group fed 10.0% YWM during all experimental periods (0-6 Wk). The FCR at 14, 28, and 42 d of age were significantly differed for each period. The overall FCR showed an improvement for the total period (from 0-6 Wk) with increasing the amount of YMW replacement. The previous results agree with Bovera et al. (2015) and Yoo et al. (2015) demonstrated that broiler growth performance had no detrimental effect due to supplementation of *Tenebrio Molitor* larvae in their diets. Also, Zahra et al. (2019) concluded that increasing YMW inclusion up to 30 g/kg of feed replacement for fish meal in quail diets could improve BW and had better FCR values than other groups.

On the other hand, the similarity in feed intake observed in the present study may be due to the incision of YMW in the diet being acceptable and having no adverse effect on palatability. These results agree with Ballitoc and Sun (2013) who indicated that adding ground yellow mealworms to common feedstuff can improve the growth performance of broiler chickens. Also, Biasato et al. (2018) recorded that body weight may improve by increasing levels of dietary YMW inclusion in the male broiler diet. Khan et al. (2018) concluded that performance and FCR are enhanced by including mealworm on broiler diet. Islam and Yang (2017) demonstrated that average daily gain and daily feed intake increased, while feed conversion ratio (g information/ g gain per bird) decreased due to YMW supplementation on broiler diet. Yellow mealworm meal is suitable as a protein feedstuff in the broiler diet, according to Elahi et al. (2020), with no negative impacts on chick performance. Zuidhof et al. (2003) indicated an improvement in feed intake in the birds fed YMW diets. That may be due to increased feed palatability concerning the addition of YMW, since wild birds and free-range poultry naturally consume insects. Also, Benzertiha et al. (2020) results confirmed that small amount addition (0.2% and 0.3%) of *Tenebrio Molitor* meals to the diet of broiler chickens could improve growth performance. However, Lwalaba et al. (2010) demonstrated that digestive enzymes in drying insects could influence protein properties and be suitable for feed production.

On the other hand, Biasato et al. (2018) reported that high levels of YMW (150g/kg diet) inclusion in male broiler chickens had a negative effect on feed efficiency and intestinal morphology, thus indicating a low level (50 g/kg diet) may be more suitable.

Carcass and meat quality: Table 4 summarizes the slaughtering performance and the meat quality of the quails. The carcass weight, intestinal length, thymus, bursa, ovaries, testes, meat color, and WHC were significantly increased with increasing the replacement percentage of

YMW meal compared with the control group. The maximum increase was observed with 7.5 and 10.0% YMW. The liver, pancreas, intestinal weight, spleen, and meat pH were statistically equal among the experimental groups. The Malondialdehyde in fresh meat was not significantly differed among all experimental groups. After storage in the refrigerator to 48 h was significantly increased on carcass meat for the control and the groups supplemented with 2.5% YMW compared with the control other experimental groups, which statistically equaled Table 4.

The analysis of meat indicated that the content of CP and methionine, lysine isoleucine, valine, arginine, and glycine were significantly increased in the groups fed basal diet replacement with 7.5 and 10.0% YMW compared with the content of control group Table 5. The meat content of lysine was significantly increased for all groups fed basal diet replacement with different levels of YMW meal compared with the range of the control group. Leucine content was boosted considerably in the group that provided basal diet replacement with 10.0% of YMW compared with the content in the different groups. However, alanine content on meat, the total amount of AAs, and the ratio between protein and AAs content were statistically equal among other experimental groups.

Continually for the meat quality, meat content from total saturated fatty acids (TSFA) was significantly increased with all replacement percentages of basil diet by YMW compared with control group Table 6. Also, full mono and polyunsaturated fatty acids were significantly increased for the group fed basal diet replacement with 10.0% YMW compared with the other experimental groups. In the same line, n-6 fatty acids and the ratio between n-6 and n-3 (n6/n3) were recorded the same results, while the n-3 percentages recorded the opposite results.

These results agree with Zahra et al. (2019) who indicated that increasing YMW inclusion up to 30 g/kg of feed replacement for fish meal in quail diets could improve carcass yield and meat quality jejunum. Similarly, Hwangbo et al. (2009) and Ballitoc and Sun (2013) observed an improvement in slaughter, dressed carcass, breast muscle, and thigh muscle weights, and dressing percentage in broilers fed diets with different insect meals inclusion. Ballitoc and Sun (2013) showed that the chemical characteristics of broilers meat (from the right breast) were unaffected by fed YMW dietary treatments. Also, the same research indicated that the addition of ground yellow mealworms to common feedstuff could improve the carcass yield of broiler chickens. Biasato et al. (2018) observed no effect on broiler carcass traits to YMW utilization. Elahi et al. (2020) reported that there was no linear or quadratic effect of dried MWM (0%, 2%, 4%, and 8%) on the broiler chicks meat quality, and 4% of dried MWM showed elevated a* values, which could be because of muscle pH.

Hematological, serum parameters and immunity: the results of hematological and some biochemical traits are summarized in Table 7. Interestingly, the results indicated that WBCs counts, and the lymphocytes (L) percentage showed a linear positive response. In contrast, heterophils (H) percentage showed the opposite reaction. Moreover, the H/L ratio was significantly improved by increasing the YMW inclusion in the quail diet. However, De Marco et al. (2013) and Salamano et al. (2010), indicated that the H/L ratio was not affected by dietary TM meal inclusion.

The lipid profile was significantly affected by the inclusion YMW in the quail diet. The total cholesterol, triglyceride and LDL concentrations were significantly decreased with the inclusion level on a basal diet compared with that control group. On the other hand, the concentration of HDL was improved considerably due to increasing the level of YMW inclusion compared with a control group. However, aspartate aminotransferase and alanine aminotransferase activity and uric acid concentration were not differed among all experimental groups. Also, these results indicated that the inclusion of YMW in the present study might be had a beneficial effect on the biochemical parameters. In the same line, Bovera et al. (2015) and Biasato et al. (2016) reported that yellow mealworm inclusion in the birds did not affect the serum biochemical traits. Elahi (2020) reported that dietary MWM inclusion in broiler diet did not influence the AST and total superoxide dismutase activity. However, Lumej (2008) suggested that the inclusion of YMW meals had no adverse effect on the health status of the animals. Islam and Yang (2017) and Benzertiha et al. (2020) demonstrated that dietary supplementation of YMW improved the immune system traits of broiler chickens. Glutathione peroxidase activity and TAC concentrations were significantly increased by increasing the YMW inclusion level compared with the control group Table 7.

These results indicated that the inclusion of YMW in the present study may have had a beneficial effect on the immune statues of birds.

However, According to Cutter (2006) these results could be attributable to the presence of chitin in the exoskeleton of insects and larvae, also, chitin may include antioxidants and have antibacterial properties against bacteria, moulds, and yeasts. In addition, Esteban et al. (2001) and Xu et al. (2013) found that insects are high in chitin which has a favorable influence on the innate immune system's function.

CONCLUSION

The dry matter of YMW has reached on CP (60.15%). Replacing up to 10.0% of YMW from the Japanese quail diet is acceptable and has no adverse effect on growth performance, could improve carcass yield, significantly decreased the total cholesterol and triglyceride concentrations and had a beneficial effect on the immune's statues.

Table (1): composition and calculated analysis of the experimental diets through the growing period

Ingredients	Basal diet (%)	Calculated analyses	
Yellow corn (maize)	52.90	Crude protein (%)	24.08
Soybean meal (44%)	33.15	ME (Kcal/kg diet)	2970
Broiler concentrate (50%)	10.0	Ether extract (%)	2.43
Di-calcium phosphate	0.75	Crude fiber (%)	1.16
Limestone	1.00	Lysine (%)	1.42
Soybean oil	1.20	Methionine (%)	0.76
Vit.and min mix.	0.50	Calcium (%)	1.08
NaCl	0.50	Av. phosphorus	0.49
Total	100		

[1]Vit+Min mixture provides per kilogram of diet: vitamin A, 12000 IU, vitamin E, 10 IU, menadione, 3 mg, Vit. D_3, 2200 ICU, riboflavin, 10 mg, Ca pantothenate, 10 mg, nicotinic acid, 20 mg, choline chloride, 500 mg, vitamin B_{12}, 10 µg, vitamin B_6, 1.5 mg, vitamin B_1, 2.2 mg, folic acid, 1 mg, biotin, 5 0 µg. Trace mineral (milligrams per kilogram of diet): Mn, 55, Zn, 50, Fe, 30, Cu, 10, Se, 0.10, Anti oxidant, 3 mg.

Table (2): Approximate analysis, essential amino acid and fatty acid compositions of the Yellow Mealworm (*Tenebrio molitor*, *TM*), (% DM)

Parameters	Yellow Mealworm Analyses	Fish meal (Mechanically Extracted) *	Soybean meal (Solvent extracted) *
Crude protein (%)	60.15	72.0	48.5
Ether extract (%)	21.19	10.0	1.00
Crude fiber (%)	8.12	0.7	3.90
Calcium (%)	0.25	2.29	0.27
Phosphorus (%)	2.11	1.70	0.62
Methionine (% protein)	2.99	1.56	0.32
Lysine(% protein)	4.93	3.94	1.43
Leucine(% protein)	5.73	3.59	1.81
Isoleucine(% protein)	4.85	2.33	1.03
Tyrosine (% protein)	5.45	1.62	095
Valine(% protein)	1.38	2.81	1.08
Arginine(% protein)	7.10	3.03	1.69
Glycine(% protein)	5.28	3.10	0.99
Linoleic acid (C18:2)	22.98	0.14	0.47
αLinolenic acid (C18:3)	2.11	0.08	0.07
Oleic acid (C18:1)	38.91	1.196	0.16
Palmitic acid "(C16:0)	18.39	3.61	0.24

* National Research Council. (NRC, 1994)

Table (3): Effect of Yellow Mealworm meal (*Tenebrio molitor*, YMW) replacements (g YMW/Kg diet) on some productive performance productive performance of Japanese quail during growing periods .

Treatment / Items	0.0% YMW	2.5% YMW	0.5% YMW	7.5% YMW	10.0% YMW	SEM	P Value
Body weight (g)							
1 day	9.58	9.52	9.60	9.70	9.60	0.0011	0.0921
2 Wk	59.1 [b]	60.1 [b]	64.7 [b]	65.9 [b]	70.50 [a]	0.0296	0.0001
4 Wk	157 [e]	160 [d]	165 [c]	170 [b]	175 [a]	0.0695	0.0001
6 Wk	226 [e]	236 [d]	240 [c]	246 [b]	251 [a]	0.0734	0.0001
Body weight gain (g/chick/period)							
0-2 Wk	49.6 [e]	50.7 [d]	55.1 [c]	56.2 [b]	60.9 [a]	0.0295	0.0001
2-4 Wk	99 [c]	100 [b]	100 [b]	105 [a]	105 [a]	0.0428	0.0001
4-6 Wk	69 [b]	76 [a]	75 [b]	75 [a]	76 [a]	0.0237	0.0001
0-6 Wk	216 [e]	227 [d]	230 [c]	236 [b]	241 [a]	0.0681	0.0001
Feed intake (g/chick/period)							
0-2 Wk	85.0 [a]	79.7 [e]	80.1 [d]	83.6 [b]	81.5 [c]	0.0184	0.0001
2-4 Wk	190 [d]	188 [e]	194 [c]	191 [c]	192 [b]	0.0065	0.0001
4-6 Wk	275 [a]	263 [c]	267 [b]	267 [b]	276 [a]	0.0371	0.0001
0-6 Wk	550 [a]	531 [e]	544 [b]	542 [b]	550 [a]	0.0556	0.0001
Feed conversion ratio (g feed/g weight gain)							
0-2 Wk	1.71 [a]	1.57 [b]	1.45 [d]	1.49 [c]	1.34 [e]	0.0001	0.0001
2-4 Wk	1.94 [a]	1.88 [b]	1.93 [a]	1.82 [c]	1.84 [c]	0.0013	0.0001
4-6 Wk	4.00 [a]	3.48 [c]	3.61 [b]	3.57 [b]	3.51 [bc]	0.0016	0.0001
0-6 Wk	2.54 [a]	2.34 [c]	2.36 [b]	2.30 [d]	2.28 [e]	0.0013	0.0001

[a,b,c] means having different superscripts in the same row are significantly different (P<0.05). SEM: standard error of means, P value: probability level.

Table (4): Effect of Yellow Mealworm meal (*Tenebrio molitor*, YMW) replacements (g YMW/Kg diet) on some carcass treats of Japanese quail at 6 weeks of age

Treatment / Items	0.0% YMW	2.5% YMW	0.5% YMW	7.5% YMW	10.0% YMW	SEM	P Value
Carcass (%)	75.5 [b]	74.0 [ab]	76.9 [ab]	80.9 [a]	82.0 [a]	0.436	0.0001
Liver (%)	2.5	2.6	2.6	2.6	2.6	0.138	0.0874
Pancreas (%)	0.29	0.29	0.29	0.30	0.31	0.052	0.0621
Color (meat)	0.38 [b]	0.31 [b]	0.52 [a]	0.66 [a]	0.69 [a]	0.068	0.0001
WHC (meat)	5.11 [b]	5.39 [b]	5.29 [b]	6.92 [a]	7.01 [a]	0.302	0.0001
MDA (0h)	11.8	11.0	11.13	11.63	11.55	0.038	0.2135
MDA (48 h)	13.6 [a]	13.5 [a]	12.2 [b]	11.6 [c]	11.2 [c]	0.026	0.0001

[a,b,c] means having different superscripts in the same row are significantly different (P<0.05). SEM: standard error of means, P value: probability level. WHC=Water holding capacity (Cm^2) MD (0 h)= Malondialdehyde in meat on fresh carcass MDA (0 h)= Malondialdehyde in meat after 48 hours storage in the refrigerator .

Table (5): Effect of Yellow Mealworm meal (*Tenebrio molitor,* YMW) replacements (g YMW/Kg diet) on meat (breast + thigh) amino acids contents of quail at 6 weeks of age

Treatment / Items	0.0% YMW	2.5% YMW	0.5% YMW	7.5% YMW	10.0% YMW	SEM	P Value
Protein content	20.01	20.25	20.60	20.72	20.75	0.459	0.2145
Methionine (E)	0.51[b]	0.54[b]	0.55[ab]	0.54[b]	0.57[a]	0.051	0.0001
Lysine (E)	2.10[c]	2.14[b]	2.15[b]	2.14[b]	2.18[a]	0.042	0.0001
Leucine (E)	1.87[c]	1.96[bc]	2.10[b]	2.09[b]	2.15[a]	0.045	0.0001
Isoleucine (E)	1.09[c]	1.11[c]	1.18[b]	1.22[a]	1.25[a]	0.033	0.0001
Tyrosine (E)	0.49[b]	0.55[ab]	0.47[b]	0.67[a]	0.66[a]	0.017	0.0001
Valine (E)	1.09[b]	1.07[b]	1.11[b]	1.18[a]	1.21[a]	0.018	0.0001
Arginine (NE)	1.29[b]	1.33[b]	1.35[b]	1.45[a]	1.44[a]	0.029	0.0001
Glycine (NE)	0.95[b]	1.11[a]	1.09[a]	1.12[a]	1.11[a]	0.020	0.0001
Alanine (NE)	1.29	1.28	1.33	1.36	1.36	0.039	0.3125
EAA (Total)	7.15	7.37	7.56	7.84	8.02	0.190	0.2451
Protein: EAA	2.81 : 1	2.75 : 1	3.06 : 1	3.06 : 1	3.02 : 1		

[a,b,c] means having different superscripts in the same row are significantly different (P<0.05).
SEM: standard error of means, P value: probability level. EAA= Essential amino acids
E: Essential amino acid NE: Non-essential amino acid

Table (6): Effect of Yellow Mealworm meal (*Tenebrio molitor*, YMW) replacements (g YMW/Kg diet) on meat (breast + thigh) fatty acid composition (%) of quail at 6 weeks of age .

Treatme / Items	0.0% YMW	2.5% YMW	0.5% YMW	7.5% YMW	10.0% YMW	SEM	P Value
TFA	99.45[ab]	97.89[b]	98.41[ab]	97.89[b]	100.73[a]	0.041	0.0001
TSFA	58.33[b]	61.33[a]	61.38[a]	61.33[a]	60.63[a]	0.913	0.0001
TMUFA	24.85[a]	22.49[b]	22.76[b]	22.49[b]	24.35[a]	2.330	0.0001
TPUFA	16.27[a]	14.17[b]	14.27[b]	14.07[b]	15.75[ab]	0.89	0.0001
n-3	3.31[a]	2.54[b]	2.59[b]	2.54[b]	2.36[b]	0.151	0.0001
n-6	12.96[ab]	11.53[b]	11.68[b]	11.53[b]	13.39[a]	1.300	0.0001
n-6 / n-3	3.92[c]	4.56[b]	4.53[b]	4.56[b]	5.67[a]	0.752	0.0001

[a,b,c] means having different superscripts in the same row are significantly different (P<0.05).
SEM: standard error of means, P value: probability level. TFA: total fatty acid, TSFA: total saturated fatty acid, TUFA: total unsaturated fatty acid, TPUFA: total poly unsaturated fatty acid, n-3: omega 3, n-6: omega 6,

Table (7): Effect of Yellow Mealworm meal (*Tenebrio molitor*, YMW) replacements (g MW/Kg diet) on some hematological and biochemical parameters of Japanese quail at 6 weeks of age

Treatment / Items	**0.0% YMW**	**2.5% YMW**	**0.5% YMW**	**7.5% YMW**	**10.0% YMW**	**SEM**	**P Value**
WBCs (10^3/mm^3)	17.10[b]	17.67[b]	19.91[a]	20.11[a]	21.25[a]	0.64	0.0001
Heterophils (H) %	34.3[a]	32.2[ab]	29.9[b]	28.9[b]	30.2[c]	1.72	0.0001
Lymphocytes (L)%	48.67[b]	49.91[b]	53.61[a]	53.91[a]	53.89[a]	1.29	0.0001
H/L	0.70 [a]	0.65[ab]	0.54 [b]	0.52 [b]	0.57 [b]	0.10	0.0001
T-Chol mg/dl	190[a]	175[b]	180 [b]	179 [b]	181[b]	6.32	0.0001
Trg mg/dl	151[a]	141 [ab]	135[b]	132[b]	132[b]	7.98	0.0001
HDL mg/dl	32.2[c]	35.4 [b]	38.2 [ab]	40.2 [ab]	42.3[a]	2.60	0.0001
LDL mg/dl	128[a]	111 [b]	114 [b]	112 [b]	112[b]	5.81	0.0001
GPx U/L	27.9[c]	29.3 [b]	31.0 [ab]	31.9 [a]	32.7[a]	0.580	0.0001
TAC mg/dl)	0.783[b]	0.802[a]	0.830[a]	0.864[a]	0.880[a]	0.084	0.0001
Uric acid (mg/dl)	4.01	4.11	4.09	4.15	4.16	0.300	0.6532
AST U/L	172	175	173	178	178	4.400	0.2135
ALT U/L	11.2	12.3	12.4	12.2	12.3	0.806	0.3541
ALP U/L	73.3	75.8	75.6	76.7	77.9	0.560	0.5642

[a,b,c] means having different superscripts in the same row are significantly different ($P<0.05$).
WBC= white blood cells, T-Chol=Total cholesterol, Trg:Triglycerides, LDL=Low density lipoprotein, HDL= High density lipoprotein, GPx=glutathione peroxidase, TAC=total antioxidant capacity, AST=Aspartate Amino Transferase ALT=Alanine Amino Transferase, ALP=Alkaline Phosphatase.

REFERENCES

AOAC, 2005. Association of Official Analytical Chemists International. Officials' methods of analysis. 18^{th} ed. (Washington: Association of Analytical Communities International).

AOAC, 1990. Official Methods for the Analysis, Association of Official Analytical Chemists, Arlington, Va, USA, 15th edition.

AOAC, 2003. Association of Official Analytical Chemists, Official Methods of Analysis. 17th ed. Association of Official Analytical Chemists, Washington D.C., USA.

Azagoh, C., Ducept, F., Garcia, R., Rakotozafy, L., Cuvelier, M.-E., Keller, S., Lewandowski, R., Mezdour, S., 2016. Extraction and physicochemical characterization of Tenebrio Molitor proteins. Food Res. Int. 88, 24-31.

Ballitoc, D.A., Sun, S., 2013. Ground yellow mealworms (*Tenebrio molitor*) feed supplementation improves growth performance and carcass yield characteristics in broilers. Open Science Repository Agriculture (open-access), e23050425, doi:10.7392/openaccess.23050425.

Bartles, H., Bohmer, M., and Heirli, C., 1972. Serum creatinine determination without protein precipitation.Clin, Chem, Acta. 37, 193.

Benzertiha, A.; Kiero´ nczyk, B.; Kołodziejski, P.; Pruszy´ nska-Oszmałek, E.; Rawski, M.; Józefiak, D.; Józefiak, A., 2020. Tenebrio molitor and Zophobas morio full-fat meals as functional feed additives a_ect broiler chickens' growth performance and immune system traits. Poult. Sci. 99:196-2036.

Biasato, I.; Ferrocino, I.; Grego,E. ; Dabbou,S.; Gai, F.; Gasco. L.; Cocolin.L.; Capucchio, M.T.; and Schiavone. A., 2019. Gut Microbiota and Mucin Composition in Female Broiler Chickens Fed Diets including Yellow Mealworm *(Tenebrio molitor*). Animals, 9, 213; doi:10.3390/ani9050213.

Biasato, I., De Marco, M., Rotolo, L., Renna, M., Dabbou, S., Capucchio, M.T, Biasibetti, E., Tarantola, M., Costa, P., Gai, F., Pozzo, L., Dezzutto, D., Bergagna, S., Gasco, L., Schiavone, A., 2016. Effects of dietary *Tenebrio molitor* meal inclusion in free-663 range chickens. J. Anim. Physiol. Anim. Nutr. (Berl). 100: 1104–1112. DOI: 10.1111/jpn.12487

Biasato, I.; Gasco, L.; De Marco, M.; Renna, M.; Rotolo, L.; Dabbou, S.; Capucchio, M.T.; Biasibetti, E.; Tarantola, M.; Sterpone, L.; et al. 2018. Yellow mealworm larvae *(Tenebrio molitor*) inclusion in diets for male broiler chickens: E_ects on growth performance, gut morphology, and histological findings. Poult. Sci. , 97:540–548.

Biasatoa, I., Gasco, L., De Marcoa, M., Renna, M., Rotolo, L., Dabbou, S., Capucchioa, M.T., Biasibetti, E., Tarantola, M., Bianchi, C., Cavallarin, L., Gai, F., Pozzo, L., Dezzutto, D., Bergagna, S.L., and Schiavone, A., 2021. Effects of yellow mealworm larvae *(Tenebrio molitor*) inclusion in diets for female broiler chickens: implications for animal health and gut histology. Department of Veterinary Sciences, University of Turin, Largo Paolo Braccini 2, 10095 Grugliasco (TO), Italy.

Blaxhall, P.C. and Daisley, K.W., 1973. Routine haematological methods for use with fish blood. J. Fish Biol., 5: 771-781.

Bovera, F., Loponte, R., Marono, S., Piccolo, G., Parisi, G., Iaconisi, V., Bovera, F., Piccolo, G., Gasco, L., Marono, S., Loponte, R., Vassalotti, G., Nizza, A., 2015. Yellow mealworm larvae (*Tenebrio molitor*) as a possible alternative to soybean meal in broiler diets. British Poultry Science, 56:569–575.

Calislar, S. 2017. Nutrient content of mealworms *Tenebrio molitor L.* and the utilization possibilities in poultry nutrition. In Proceedings of the International Conference on Agriculture, Forest, Food Sciences and Technologies (ICAFOF), Cappadocia, Turkey, 15–17.

Celi, P.; Cowieson, A.J.; Fru-Nji, F.; Steinert, R.E.; Kluenter, A.-M.; Verlha, V., 2017. Gastrointestinal functionality in animal nutrition and health: New opportunities for sustainable animal production. Anim. Feed Sci. Technol, 234, 88–100.

Cutter, C. N., 2006. Opportunities for bio-based packaging technologies to improve the quality and safety of fresh and further processed muscle foods. Meat Sci. 74:131–142.

De Marco, M., Martinez, S., Tarantola, M., Bergagna, S., Mellia, E., Gennero, M.S., Schiavone, A., 2013. Effect of genotype and transport on tonic immobility and heterophil/lymphocyte ratio in two local Italian breeds and Isa Brown hens kept under free-range conditions. Ital. J. Anim. Sci. 12, 481-485.

Dinani, OP.; Tyagi, P.T.; Mandal,A.B.; Tiwari, S.P.; Mishra, S.; and Sharma, K., 2019. Recent unconventional feedstuffs for economic poultry production in India: A review. Journal of Entomology and Zoology Studies 7: 1003-1008.

Drubkin, D. 1964. Spectrophotometric methods XIV. The crystographic and optical properties of the haemoglobin of man in comparison with those of other species. J. Biol. Chem., 164: 703-723.

Elahi, U., Wang, J., You-biao, M., Shu-geng, W., Jinlong W., Guang-hai, Q. and Hai-jun Z., 2020. Evaluation of Yellow Mealworm Meal as a Protein Feedstu_ in the Diet of Broiler Chicks. Animals. 10, 224; doi:10.3390/ani10020224.

Elahi, U., 2016. Use of Insects as Alternative Feed Source in Poultry Diets. Master Thesis, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany.

Erel, O.A. 2004. Novel automated direct measurement method for total antioxidant capacity using a new generation, more stable ABTS radical action. Clin. Biochem 37: 277-285.

Esteban, M. A., A. Cuesta, J. Ortuno, and J. Meseguer. 2001. Immunomodulatory effects of dietary intake of chitin on gilthead seabream (*Sparus aurata* L.) innate immune system. Fish Shellfish Immunol. 11:303–315.

FAO, 2014. The state of world fisheries and aquaculture, opportunities and challenges. In: Graziano da Silva, J. (Ed.), FAO, Rome. p. 3.

Folch, J. M., Lees, M. and Stanley, G. H. S., 1957. "A simple method for the isolation and purification of total lipides from animal tissues," The Journal of Biological Chemistry, vol. 226, no. 1, pp. 497–509.

Fossati, P. and Prencipe, L.,1982. Colorimetricaly with an enzyme that produce hydrogen peroxide . Clin. Chem., 28: 2077-80.

Friedewald ,W.T., Levy, R.I. and Fredrickson, D.S., 1972. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin. Chem. 18:499–502.

Gasco, L.; Acuti, G.; Bani, P.; Dalle Zotte, A.; Danieli, P.P.; De Angelis, A.; Fortina, R.; Marino, R.; Parisi, G.; Piccolo, G.; et al. 2020. Insect and fish by-products as sustainable alternatives to conventional animal proteins in animal nutrition. Ital. J. Anim. Sci. 19, 360–372.

Hall, G. M., 1992. Fish processing technology. Pages 155–192 in Fishery Byproducts. H. W. Ockerman, ed. VCH Publishers, New York, USA.

Hawkey, C.M., and Dennett, T.B., 1989. A color atlas of comparative veterinary hematology. Wolf Publishing limited, London, England.

Henuk, Y.L., 2017. Mealworm: A promising alternative protein source for animal nutrition 8th International Conference on Animal Health & Veterinary Medicine, J Vet Sci Technol, 8:5 (Suppl) DOI: 10.4172/2157-7579-C1-026.

Henry, M., Gasco, L., Piccolo, G., Fountoulaki, E., 2015. Review on the use of insects in the diet of farmed fish: past and future. An. Feed Sci. Technol. 203, 1-22. doi:10.1016/j.anifeedsci.2015.03.001.

Hollander, C.S. and Shenkman, L., 1974. Radiimmunoassay for triiodothyronine and thyroxine. in rothfeld B, editor. nuclear medicine in vitro. philadelphia: lippincott.

Hussain, I.; Khan, S.; Sultan, A.; Chand, N.; Khan, R.; Alam, W.; Ahmad, N., 2017. Meal worm (*Tenebrio molitor*) as potential alternative source of protein supplementation in broiler. Int. J. Biosci. 10, 255–262.

Hwangbo, J.; Hong, E. C.; Jang, A.; Kang, H. K.; Oh, J. S.; Kim, B. W.; Park, B. S., 2009. Utilization of house fly-maggots, a feed supplement in the production of broiler chickens. Journal of Environmental Biology 30, 609–614.

Islam, M.M. and Yang, 2017. Efficacy of mealworm and super mealworm larvae probiotics ad alternative antibiotics challenged orally with Salmonella and E. coli infection in broiler chicks. Poult. Sci. 96, 27-34. http://dx.doi.org/10.3382/ps/pew220.

Khan S.; Khan, R.U.; W. Alam, W. and Sultan. A., 2018. Evaluating the nutritive profile of three insect meals and their effects to replace soya bean in broiler diet. J Anim Physiol Anim Nutr. 102:e662–e668.

Khan, R. U., Durrani, F. R., Chand, N., and Anwar, H., 2010. Influence of feed supplementation with Cannabis sativa on quality of broilers carcass. Pakistan Veterinary Journal, 30: 34–38.

Khan, S., Khan, R. U., Sultan, A., Khan, M., Hayat, S. U., and Shahid, M. S., 2016. Evaluating the suitability of maggot meal as a partial substitute of soya bean on the productive traits, digestibility indices and organoleptic properties of broiler meat. Journal of Animal Physiology and Animal Nutrition, 100, 649–656.

Kröncke, N.; Grebenteuch, S.; Keil, C.; Demtröder, S.; Kroh, L.; Thünemann, A.F.; Benning, R.; Haase, H., 2019. Effect of different drying methods on nutrient quality of the yellow mealworm (*Tenebrio molitor L.).* Insects. 10, 84.

Lopez-Virella, M. F. et al. 1977. Cholesterol determination in high-density lipoproteins separated by three different methods. Clin. Chem. Vol (23), 882-884.

Loponte, R., Nizza, S., Bovera, F., De Riu, N., Fliegerova, K., Lombardi, P., Vassalotti, G., Mastellone, V., Nizza, A., Moniello, G., 2017. Growth performance, blood profiles and carcass traits of Barbary partridge (*Alectoris barbara*) fed two different insect larvae meals (*Tenebrio molitor* and *Hermetia illucens*). Res Vet Sci. 115:183-188.

Lucky, Z., 1977. Methods for the diagnosis of fish diseases. Ameruno Publishing Co, PVT, Ltd. New Delhi, Bomby, New York.

Lumej, J,T., 2008. Avian Clinical Biochemistry, in: Kaneko, J.J., Harwey, J.W., Bruss, M.L. (Eds.), Clinical Biochemistry of Domestic Animals. Elsevier Academic Press, Oxford, UK, pp. 839-872.

Lwalaba, D.; Ho_mann, K.H.;Woodring, J., 2010. Control of the release of digestive enzymes in the larvae of the fall armyworm, Spodoptera frugiperda. Arch. Insect Biochem. Physiol. 2010, 73, 14–29.

Makkar, H.P.S., Tran, G., Heuz_e, V., Ankers, P., 2014. State-of-the-art on use of insects as animal feed. Animal Feed Sci. Technol. 197, 1e33.

Mohamed I. A., Emhimad A. A.,Ubedullah, K. and Muhammad A., 2021. Nontraditional Feedstuffs as an Alternative in Poultry Feed, Nontraditional Feedstuffs as an Alternative in Poultry Feed. DOI: http://dx.doi.org/10.5772/intechopen.95946

Ncobela, C.N. and M.Chimonyo, M., 2015. Potential of using non-conventional animal protein sources for sustainable intensification of scavenging village chickens: A review, Animal Feed Science and Technology. 208:1-11.

NCR 1994. National Research Council. Nutrient requirements of poultry. 9th ed. National Academy Press. Washington, USA.

Portes, E., Gardrat, C., Castellan, A. and Coma, V., 2009. Environmentally friendly films based on chitosan and tetrahydrocurcuminoid derivatives exhibiting antibacterial and antioxidative properties.Carbohyd. Polym. 76:578–584.

Ramos-Elorduy, J., González, E.A., Hernández, A.R. and Pino, J.M., 2002. Use of Tenebrio molitor (Coleoptera : Tenebrionidae) to recycle organic wastes and as feed for broiler chickens. J Econ Entomol. 95:214–220.

Ravzanaadii, N., Kim, S-H, Choi, W.H., Hong, S-J, Kim, N.J., 2012. Nutritional value of mealworm, Tenebrio molitor as food source. Int J Ind Entomol. 25:93–98.

Reitman, S. and Frankle, S.A., 1957. Colorimetric method for the determination of serum glutamic oxaloacetic and glutamic pyruvic transaminase. Am. J. Clinic. Pathol., 28:56-63.

Salamano, G., Mellia, E., Tarantola, M., Gennero, M.S., Doglione, L., Schiavone, A., 2010. Acute phase proteins and heterophil:lymphocyte ratio in laying hens in different housing systems. Vet. Rec. 167, 749–751.

SAS Inistitute ,2009. SAS User's Guide:statistics Version 5th ed ., SAS Inst., Inc., Cary, NC,USA.

Stastnik, O., Jakub Novotny, Andrea Roztocilova , Petr Kouril , Vojtech Kumbar , Julius Cernik , Libor Kalhotka , Leos Pavlata , Lubor Lacina and Eva Mrkvicova. 2021. Safety of Mealworm Meal in Layer Diets and Their Influence on Gut Morphology. Animals 2021, 11, 1439. https://doi.org/10.3390/ani11051439

Stein, E.A., 1986. Textbook of clinical chemistry, NW Tietz, ed. W.B. Saunders, Philadelphia, pp: 879-886.

Van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G. and Vantomme, P., 2014. Edible insects: future prospects for food and feed security. FAO Forestry Paper, 171.

Zahra, S. Zadeh, Kheirim F., Faghani, M., 2019. Use of yellow mealworm (*Tenebrio molitor*) as a protein source on growth performance, carcass traits, meat quality and intestinal morphology of Japanese quails (Coturnix japonica). Veterinary and Animal Science 8 (2019) 100066.

Zollner, N. and Krisch, K., 1962. Colorimetric method for determination

Xu, Y., Shi,BG.; Yan, S.; Li, T.; Guo, Y. and Li. J. 2013. Effects of chitosan on body weight gain, growth hormone and intestinal morphology in weaned pigs. Asian Austral. J. Anim. 26:1484–1489.

Yoo, S. H.; Kim, H. J. and Kim, Y.Y. 2015. Effect of different type of Tenebrio molitor on growth performance and blood profiles in weaning pigs. Proc. Annu. Congr. KSAST. Konkuk Uni. Seol, Korea.

Zadeh, Z.S.; Kheiri, F.; Faghani, M., 2019. Use of yellow mealworm (Tenebrio molitor) as a protein source on growth performance, carcass traits, meat quality and intestinal morphology of Japanese quails (Coturnix japonica). Vet. Anim. Sci. 2019, 8, 100066.

of total lipids. J, of Exp. Medicine, 135:545-550.

Zuidhof, M.J., Molnar, C.L., Morley, F.M., Wray, T.L., Robinson, F.E., Khan, B.A., Al-Ani, L., Goonewardene, L.A., 2003. Nutritive value of house fly (Musca domestica) larvae as a feed supplement for turkey poults. Anim. Feed Sci. Tech. 105, 225–230.

الملخص العربى

تأثير استخدام دود الأرض الأصفر(*Tenebrio Molitor*) فى علف السمان اليابانى على الأداء الإنتاجى و التناسلى
الإستبدال من العليقة الأساسية خلال مرحله النمو

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تهدف هذة الدراسة الى تقييم الأستبدال الجزئى للعليقه بأستخدام ديدان الأرض الصفراء (YMW, *Tenebrio Molitor*) لعلائق السمان اليابانى خلال مرحله النمو (يوم – ٤٢ يوم). تم توريع ثلاثة مائة وخمسون سمانة عمر يوم عشوائيا الى خمسة معاملات تمثل كل معاملة بسبعة مكررات وتحتوى كل مكررة على عدد ١٠ طيور و ذلك فى اقفاص تربية من السلك (٥٥ x ٥٠ x ٣٥ سم) مزودة بعلافات ومساقى فردية لمياه الشرب. تم تغذية المعاملة الأولى على عليقة اساسية تحتوى على بروتين خام٢٤% و طاقة ٢٩٧٠ كيلو كالورى. تم تغذية المعاملات الثانية والثالثة والرابعة والخامسة على نفس العليقة الأساسية للمعاملة الأولى مع استبدال جزئى لها بديدان الأرض YMW بمعدل ٢.٥ و ٥.٠ و ٧.٥ و ١٠.٠ % على التوالى. تم تقديم العلف والماء بصورة حرة خلاّل فترة الدراسة. أوضحت الدراسة احتواء ديدان الأرض YMW على ٦١.٥ % بروتين خام و ٢١.١٩ % مستخلص دهنى. محتوى ديدان الأرض YMW من الأحماض الأمينية والأحماض الدهنية الأساسية كنسبة مئوية منسوبه الى محتواها من البروتين الخام والمستخلص الأثيرى اكبر مما هو موجود فى كلاً من مسحوق السمك وكسب فول الصويا. استخدام نسبة الأستبدال ١٠.٠ % من ديدان الأرض YMW يعظم من وزن الجسم ووزن الجسم المكتسب ويحسن من الكفاءة التحويلية للعلف مقارنة بالمجموعة المقارنة (المعاملة الأولى). الزيادة لنسب الأستبدال تؤدى الى تحسن فى وزن الزبيحة وجودة اللحم ومحتواها من الأحماض الأمينية والأحماض الدهنية المشبعة. الزيادة لنسب الأستبدال تؤدى الى انخفاض معنوى فى تركيز كلا من الكلوستيرول والجلسريدات الثلاثية وتحسن معنوى فى تركيز الليبوبروتين والحالة المناعية والبيوكيميائية.

الخلاصة: استخدام نسبة الأستبدال ١٠.٠% من العليقة الأساسية لعليقة السمان اليابانى بديدان الأرض YMW تعتبر مقبولة وليس لها اى تأثير سلبي على النمو والأداء الأنتاجى والحالة المناعية.