

THE EFFECT OF USING *VESPA ORIENTALIS LINNAEUS MEAL* INSTEAD OF SOYBEAN MEAL ON THE GROWTH AND FEED UTILIZATION OF V-LINE MALE RABBITS

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(Received 7/6/2022, accepted 12/7/2022)

SUMMARY

The current study aims to determine the effect of partial substitution of soybean meal (SBM) with *Vespa Oriental* meal (VOM) [(0%, VOM₀), 25% (VOM₂₅), and 50% (VOM₅₀)] in the diets of thirty 12-week-old V-line male rabbits with an average body weight of 1.060±0.01kg on growth performance, digestion, and some blood biochemical changes. The experiment lasted for 90 days. The results revealed that the crude protein (CP) contents of VOM and SBM used in the present study were 76.84 and 43.76 %, respectively. Furthermore, the digestibility of CP (74.65 % & 76.07 %,) and nitrogen free extract (NFE) (68.390 & 70.123 %,) was considerably higher in rabbits fed VOM₂₅ and VOM₅₀, respectively than in rabbits fed VOM₀ (72.033 % & 65.44 %). The daily body gain in rabbits fed the VOM₅₀ diet was 9.18 %, higher than in rabbits on the VOM₀ diet. Also, the VOM₂₅ and VOM₅₀ diet-fed rabbits had considerably larger carcass weight, liver, kidney, and cecum length than the control group. Total volatile fatty acids were significantly higher in the caecal contents of VOM₂₅ and VOM₅₀ rabbits, despite lower caecal Ammonia-N concentration compared to the control diet. Hematological parameters, live and renal functions of rabbits fed the VOM₅₀ diet were considerably improved compared to those fed the control diet. The VOM₂₅ and VOM₅₀ groups exhibited better TDN and DCP values (P < 0.05) than the control group in terms of nutritional value. It is concluded that *Vespa Orientalis* wasp meal can be used as an effective alternative high-quality protein source to soybean meal, up to 50%, with no adverse impacts on rabbit's performance.

Keywords: Insect meal, rabbits, growth, digestibility and carcass characteristics.

INTRODUCTION

Agriculture is being confronted with several complicated problems, including decreasing agricultural land availability, climate change, and the threat of low water resources. So the challenge is to meet rising demand with fewer resources. Meat and milk demand are expected to be 58% and 70% higher in 2050, respectively, than in 2010, with developing countries accounting for the majority of this increase (FAO, 2011). Food security is a critical concern for all nations around the world, especially those in developing nations fighting hunger and malnutrition. Furthermore, the rising expense of conventional feed ingredients for animal farming has encouraged feed researchers and producers to find other sources of protein and energy to ensure long-term animal nutrition supplies (Bikker et al., 2016). Thus, more research is needed to explore alternative and cheaper sources of nutrients.

One technique to improve food and feed security is to rear insects (Van Huis et al., 2013). Insects are easy to breed and grow, have high feed conversion efficiency, and can be raised on bio-waste (Makkar et al., 2014). The FAO strongly advises including insect protein in poultry diets to reduce feed costs while improving growth and production parameters (FAO, 2014). According to the FAO report (FAO, 2013), the cost of insect breeding is significantly reduced by saving agricultural land, feed, and drinking water, whereas an average of two kilograms of feed biomass can be used to produce one kilogram of insect biomass (Collavo et al., 2005). In contrast to conventional animal farming, such insect production has no

detrimental environmental impact. It requires minimal carbon dioxide emissions into the atmosphere as well as decreases greenhouse gas and ammonia emissions (Oonincx et al., 2010).

Insects are a novel alternative protein that will certainly become more important in the future. Edible insects have been identified as prospective dietary protein sources due to their higher protein content than traditional protein sources such as meat, dairy, and nuts (Cerritos, 2009). Whereas, insect protein has a digestibility similar to chicken eggs, and it is considered a complete protein on par with milk and cow proteins (Shockley and Dossey, 2013).

The majority of experiments on giving insect meals to farm animals were carried out on aquaculture (Belghit et al., 2018), chickens (Józefiak et al., 2016), and dogs (Lei et al., 2019).

According to Pretorius, (2011), broiler chicken feed can contain up to 25% housefly larvae without impacting weight increase, feed intake, or conversion rate. Park et al. (2017) found that laying hens given a compound diet including *Hermetia illucens* larvae produced more eggs and gained weight.

Vespa Orientalis L. is a hazardous insect that attacks honeybee colonies in many regions of the world and is considered a major beekeeping problem (Abou-Shaara, 2017). So, harvesting this *Vespa* spp. can be a kind of biocontrol, but it also has the potential to lead to their utilization as human food or animal feed (Ghosh et al., 2021). The population of wasps peaked in October, then declined until it vanished at the end of December (Omran et al. 2011).

Indeed, there has been little research into the use of *Vespa Oriental* meal in livestock feed (Józefiak et al., 2016). So, it's important to figure out the nutrient value of *Vespa Oriental* (Van Huis et al., 2013). Although there is a scarcity of literature on the use of insects in rabbit feeding, it is encouraging to observe that interest in this area has grown in the last 10 years. As a result, this study aimed to see how giving rabbit's diets with dried *Vespa Oriental* meal affected their performance, nutrient digestibility, blood parameters, and meat quality.

MATERIALS AND METHODS

Study area:

This experimental investigation was conducted in Sids Research Station, Beni-Suef Governorate, Animal Production Institute (APRI), Agriculture Research Center (ARC), Ministry of Agriculture, Egypt. The laboratory research was carried out at the Agricultural Research Center's By-products Utilization Research Department, Animal Production Research Institute. The purpose of the study was to detect how rabbit performance would be affected by using insect meal as a cheap protein source.

***Vespa Orientalis* harvesting and preparation**

In two places near Baraka Apiaries, Kfer Shibin in Shibin Al Qanater, Qalyubia Governorate, Egypt. Fifty triangular traps were employed to obtain oriental wasps. In the wasp traps, there was attractive bait that didn't contain any chemicals. The attractive bait cake, which was placed in the trap's drawer, had Sugar, sugar fermented syrup, honeybee, and supplement Baraka organic.

Four baits (100g per treatment weekly) and four traps for every bait used (25g for every trap) were used in this experiment. Sugar, sugar fermented syrup, honeybee, and supplement Baraka organic were used to make the baits. This trap is placed near the wasps, which are counted and collected once a month by inserting a new cake bait into the traps every week. and the temperature and relative humidity were measured (Table 1).

The trap prototype has three funnels (Fig 1) and is made from locally sourced materials (wire gauze, wooden bars, and a stainless steel cone with Moshtohor feeder and baits).

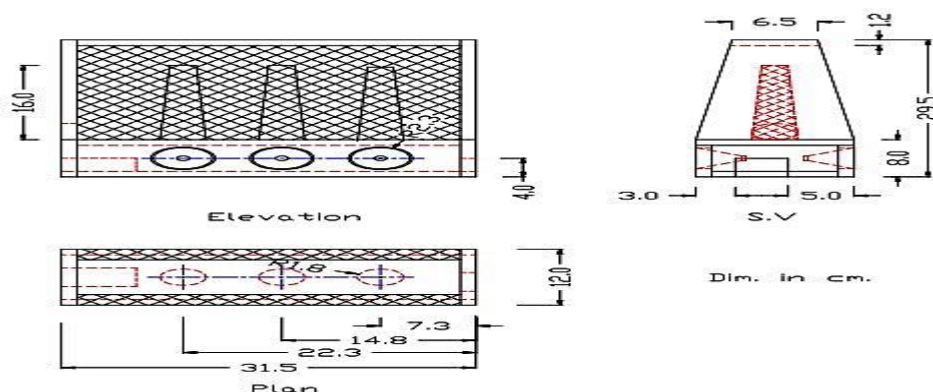


Figure (1): The traps have three funnels each.

The design of the experiment:

In this study, thirty V-line male rabbits of 12-week-old and live body weight 1.06 ± 0.03 kg were monitored for nearly ten days before the trial began to rule out any underlying infections. Three equal groups of rabbits (10 males each) were randomly split individually and fed three different diets. As a control, VOM_0 was given (100 % soybean meal as the main protein source). In the other two diets, 25 and 50 % of the soybean protein in the meal was substituted with insect meal (VOM_{25} and VOM_{50} , respectively). The rabbits were kept in galvanized metal rabbit battery cages (60×50×40) with separate feeds. All the animals were kept in the same sanitary and management settings. Rabbits were grown in 24 m length and 12 m width semi-closed rabbitries with wire-netted windows on the sides allowing natural ventilation. During the experiment (90 days), all diets were offered ad libitum, and clean water was provided via automated nipple drinkers.

Table (2) provides the approximate chemical analysis of the basal diet, and they were implemented as indicated (Al-Sagheer et al. 2017). Weekly records of feed consumption and body weight were obtained. Both feed conversion ratio and body weight gain were computed as previously stated (Berger and Halver, 1987). All animal operations were done in accordance with the Animal Ethics Committee of APRI, ARC, Egypt's recommendations for the care and use of experimental animals.

Digestibility trial and analytical methods:

At the end of the experiment (90 days), four rabbits from each group were individually used in a digestibility experiment. Feces were collected daily, weighed, and dried for 48 hours at 60-70° C before being finely powdered and preserved for chemical analysis. The nutrients' digestion coefficients and the nutritive values of the dietary treatments were determined according to AOAC (2000).

Carcass measurements:

The slaughter technique was carried out in the slaughterhouse of the Department of Agricultural By-Products Utilization Research, APRI, ARC, Egypt. The slaughtering of the animals was done humanely. All rabbits were fasted and weighed at the end of the study. Carcasses were weighed (without the head and internal organs) (empty carcass). The values of the dressing, edible giblets, and non-edible components were determined.

Cecum activity:

Cecum contents were sampled from the same slaughtered rabbits for each treatment and immediately used to estimate cecum pH, cecum microflora (bacteria), aerobic total count, Fecal coliforms, Escherichia coli count, Bacillus cereus, Enterobacter, Clostridium sp., Enterococcus, yeasts, Salmonella, and Shigella. Another cecum content sample was strained through four folds of gauze and separated into two halves. The first half was employed right away to calculate the ammonia nitrogen concentration. To determine total volatile fatty acids, the second portion was maintained by adding 1 ml of N/10 HCL and 2 ml of

orthophosphoric acid to each 2 ml of cecum content juice. A digital pH meter was used to determine the pH of the cecum contents.

Postage (1969) for aerobic total bacterial counts and Difco (1989) for fecal coliforms and *E. coli*, respectively, examined the microbial contents in their selective mediums. For *Enterococcus* and *Bacillus cereus*, the procedures provided by Baired Parker (1962) and Kim and Goepfert (1971) were employed, also Difco (1989) for *Enterobacter* and *Clostridium* Spp, as well as the method published by Lodder (1952) for yeast determination. *Salmonella* and *Shigella* were counted using the AOAC's recommended techniques (1998). The colony forming units (CFU) methodology was used. For 2-7 days, the samples were incubated at 30 degrees Celsius. Conway's technique (1958) was used to determine the ammonia nitrogen concentration. According to Eadie et al., (1967) total volatile fatty acids were measured by steam distillation of the distillate.

Specimens of blood:

Following the euthanasia of rabbits, 5 mL of blood was taken in a sterile vacutainer tube. For the haematological analysis, 1 mL of blood was placed in a bottle with ethylene diamine tetra acetic acid (EDTA) as an anticoagulant. The remaining 4 mL of blood was allowed to coagulate for serum preparation by centrifugation at $1.370 \times g$ for 15 min. and then transferred into sterilized tubes and stored at - 20 °C until use. An automated approach was used to determine the haematological test (automatic cell counter). After placing the samples on an electric mixer, they were analyzed using a veterinary haematology analyzer (Abacus junior, Radim, Italy). Each sample was evaluated twice to ensure accuracy (the mean of each duplicate was introduced to the statistical analysis).

The levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), Gamma-glutamyl transferase (GGT), total bilirubin (TB), creatinine, and urea were measured using Biosystems automated reagent kits obtained from Costa Brava 30, Chemical Company, Barcelona (Spain), according to the Young et al. (2000) method.

Chitin determination:

As reported by Porter and Jaworski (1965), the chitin content of VOM samples was detected. According to Waterhouse et al., (1961) the dried residue was solubilized in water and hexosamines were detected. Chitin values were adjusted using a factor derived from pure chitin in known quantities.

Animal ethics statement

The research was carried out in conformity with the European Union's guidelines for the protection of animals used for scientific purposes, No. 2010/63/EU of the European Parliament and the Council on the protection of animals used for scientific purposes, approved on September 22, 2010.

Efficient economics:

The ratio between income (weight gain price) and the cost of feed consumption, determined according to Egyptian market prices of 2021, was used to determine the economic effectiveness of the experimental diets.

Analytical statistics:

Using SAS (2002) software version 9.1.3, a one-way analysis of variance was undertaken using the General Linear Model (GLM) procedure with the dietary treatment as a fixed effect. Duncan's Multiple Range Test was performed to detect variations between the Means (Duncan, 1955), and ANOVA was used to test the impact of treatment

RESULTS AND DISCUSSION

A comparison of four wasp trapping baits:

The results listed in Table (1) showed that the most effective bait for catching wasps was cake supplement (351.50 wasps), followed by sugar fermented syrup (230.25 wasps) and honeybee (226.25 wasps) ($P < 0.05$) compared to sugar (158.75 wasps), noting that the most influential months were October and November. These results agree with Abou El-Enain *et al.* (1999) and Ghania (2007).

Table (1): Comparative between four baits for trapping wasps.

Item	Bait type				±SEM	P. value	RH (%)	AT (°C)
	SR	SRF	HNB	CKS				
September	135 ^c	184 ^b	170 ^b	215 ^a	6.18	0.0001	58-90	36
October	174 ^c	239 ^b	251 ^b	378 ^a	7.60	0.0001	60-70	31
November	180 ^c	313 ^b	295 ^b	564 ^a	16.25	0.0001	40-80	26
December	146 ^c	185 ^b	189 ^b	249 ^a	6.01	0.0001	60-70	21
Total	635	921	905	1406				
Overall mean	158.75	230.25	226.25	351.50				

^{a, b and c} Mean within each row with different superscripts are significantly different ($P < 0.05$).

Air temperature (AT), Relative humidity (RH), Sugar (SR), Sugar fermented syrup (SRF), honeybee (HNB) and cake supplement (CKS).

Chemical Composition of the experimental diets:

The proportions of all components of the formed diets and the proximal composition of the experimental diets are presented in Table (2). The three diets examined are chemically compatible in terms of crude protein content (ranging from 18.77 to 19.43 %), and gross energy content (4.18- 4.19 Kcal/Kg DM) as they all fell within the recommended range for optimum rabbit growth and performance (NRC, 2011). The crude fiber content of the experimental diets was within the recommended dietary fiber ranges of 10–12 % for rabbit growth by Trocino et al. (2012).

Table (2): Composition and calculated chemical composition of growing experimental diets fed to V-line rabbits.

Item	SBM	VOM	Experimental diet		
			VOM ₀	VOM ₂₅	VOM ₅₀
Clover hay			30.00	30.00	30.00
<i>Vespa Oriental</i> meal (VOM)	---	---	0.00	2.85	5.69
Soybean meal (SBM)	---	---	20.00	15.00	10.00
Yellow corn	---	---	20.00	20.00	20.00
Wheat bran	---	---	24.20	26.35	28.51
Vitamins & Minerals mixture*	---	---	0.50	0.50	0.50
Di-Calcium phosphate	---	---	1.00	1.00	1.00
Molasses	---	---	3.00	3.00	3.00
Salt	---	---	0.30	0.30	0.30
Limestone	---	---	1.00	1.00	1.00
Total			100	100	100
Calculated nutrients analysis: ¹					
Dry matter %	88.51	96.76	86.77	87.01	87.24
GE (Kcal/Kg DM)	4.662	5.210	4.183	4.189	4.195
Crude protein %	43.76	76.84	18.77	19.10	19.43
Ether extract %	2.67	2.84	2.11	2.08	2.05
Crude fiber %	7.64	0.44	12.11	11.96	11.80
NDF% ²	33.94	29.21	36.88	36.78	36.68
ADF% ³	16.40	9.83	20.48	20.34	20.19
Hemicellulose % ⁴	17.54	19.38	16.40	16.44	16.48
Nitrogen free extract %	39.08	14.05	61.16	61.07	60.99
Ash %	6.85	5.83	5.86	5.79	5.73
Chitin content (%)	-	34.53	-	0.853	1.695

* Each 1.5Kg. of Vita. Mix contained: 50,000,000 IU Vit.A; 1,000,000 IU D3; 10,000 mg Vit. E; 1170 mg Vit. K3; 735 mg Vit.B1; mg Vit.B2; 15000 mg vit B6; 15 mg vit; B12; 500 mg Vit.B5 Panathonic acid; 30,000 g Nicotinic acid; 84 mg Biotin; 500g Folic acid; 300g choline cholride. Each 1.5 Kg Min. mix contained 25 g Zn(oxid); 33.4g Mn; 26.7g Fe ; 2.67g Cu; 67mg cobalt; 1mg Se and.0.334g I

¹ Calculated according to Cheeke (1987). ² % NDF = 28.924 + 0.657 (% CF)

³ % ADF = 9.432 + 0.912 (% CF). ⁴ Hemicellulose = %NDF - % ADF

The fat levels inside these examined diets (2.05–2.11%) were near the minimal level of 3% to supply essential fatty acids and keep the hair shiny and silky (Cheeke et al., 1986). More notably, the CP contents of VOM and SBM used in the present study were 76.84 and 43.76%, respectively, which led to a slight increase in the CP content in the experimental diets with the higher inclusion of VOM. It's worth noting that the conversion factor used to convert the N content into CP content is 6.25, but, this factor ranges from approximately 4.43 to 5.75 in different insect species (Finke, 2007; Yi et al., 2013). This might lead to an overestimation of the insect's protein content (Finke, 2015). This finding is comparable to Yang et al. (2009) and Ramos-Elorduy et al. (1997), who determined the protein content of dry matter in nearly a hundred insect species to be between 13 and 77 % and 15 to 81 %, respectively. On the other hand, Rumpold and Schluter (2013) showed that whole edible insects range from 30 to 60% CP, depending on the species of investigated materials and life cycle stage (Finke, 2013). Interestingly, the chitin content of VOM on a DM basis was 34.53 % (Table 1). Huet et al. (2020) declared 45% chitin in the dry matter of *Bombyx eri*, which is close to the chitin findings in this study. In addition, Sajomsang and Gonil (2010) found 36.6% chitin in *Periostracum Cicadae* (cicada sloughs) in their investigation. The chitin content in the present study (34.53%), however, is higher than previously observed by Kaya et al. (2015b), who reported that chitin content of *Vespa Orientalis*, *Vespa Crabro*, and *Vespula Germanica* was 6.4, 8.3, and 11.9 percent, respectively. Also, Hahn et al. (2018), found the average insect chitin content was 5–25 %. The chitin content of insects has disclosed great interspecific variation, which is strongly affected by differences in extraction methods used, species, stage of development (Kaya et al. 2015a), and the quantity of wasp wings collected, as established by Kaya et al. (2015b), who noticed that the wings of butterfly species (*Argynnis pandora*) contain a higher amount of chitin (22 %) than in other parts of the body (8 %).

Apparent nutrient digestibility:

The dry matter (DM), organic matter (OM), and ether extract (EE) digestibility of rabbits fed the control diet (VOM₀) was significantly lower (P < 0.05) than rabbits fed the VOM₂₅ and VOM₅₀ diets (Table 3). Furthermore, in rabbits fed diets with insect meal (VOM₂₅ and VOM₅₀), the digestibility of crude protein (CP, 74.648% & 76.068%, respectively) and nitrogen free extract (NFE, 68.390 & 70.123%, respectively) were significantly (P < 0.05) greater than in rabbits fed VOM₀ (72.033 % & 65.443 %, respectively). Hardly, crude fiber (CF) digestibility in the control group was significantly (P < 0.05) better than it was in the VOM₂₅ diet (56.820 % vs. 55.945%, respectively). It is of interest to notice that the VOM₂₅ and VOM₅₀ groups exhibited better TDN and DCP values (P < 0.05) than the control group in terms of nutritional value.

Only a few studies have focused on how insect meal replacement affects digestibility in rabbit diets. Similarly, Narang and Lal (1985) found that nitrogen digestibility increased significantly when *Alphitobius diaperinus* substituted soybean meal protein. It is worth mentioning that the present findings of CP digestibility were near the range of 76.4 to 93.3 % for the *in vitro* protein digestibility of 11 freeze-dried insect species (Bosch et al., 2014 & 2016). Likewise, the protein digestibility coefficient in rats fed diets supplemented with dried *Tenebrio Molitor* larvae was 75.1% (Goulet et al., 1978). Additionally, Gariglio et al. (2019) showed that the EE apparent digestibility was better in defatted black soldier fly larva meal groups of ducks than in the control group, which agrees with the current findings. Furthermore, Ahmed et al. (2021) found that using edible insects at 25% of SBM enhanced nutrient degradability significantly.

Table (3): Digestion coefficient and nutritive value of V-line rabbits fed the experimental diets.

Item	Experimental diet			±SEM	P. value
	VOM ₀	VOM ₂₅	VOM ₅₀		
Digestion coefficient (%)					
DM	70.410 ^b	71.585 ^a	71.745 ^a	0.262	0.0179
OM	58.250 ^b	61.315 ^a	61.225 ^a	0.512	0.0032
CP	72.033 ^c	74.648 ^b	76.068 ^a	0.207	0.0001
CF	56.820 ^a	55.945 ^b	56.020 ^{ab}	0.212	0.0311
EE	76.323 ^b	79.575 ^a	79.830 ^a	0.730	0.0137
NFE	65.443 ^c	68.390 ^b	70.123 ^a	0.415	0.0001
Nutritive value					
TDN	64.050 ^c	66.438 ^b	67.840 ^a	0.288	0.0001
DCP	13.520 ^c	14.258 ^b	14.778 ^a	0.039	0.0001

^{a, b and c.} Mean within each row with different superscripts are significantly different (P < 0.05).

On the other hand, the digestibility of nutrients in laying hens declined when fed diets containing 14.6 % of *Hermetia illucens* (HI) larva meal (Laudadio *et al.*, 2012) or 17 % of HI larva meal (INRA, 2004), which was explained by the chitin content, contrary to the findings of our study. According to the results of these studies, there is a variation in insect protein digestion, which is influenced by many factors, such as the proportion of protein linked to chitin, as well as the kind and maturity of the insect entering ration (Finke, 2007).

There are three possible causes for the increased nutrient digestion in rabbit diets with VOM protein compared to the control diet (VOM₀). The first reason could be due to amino acid integration, mainly since all of the insects studied were high in other essential amino acids, especially lysine, tryptophan, and threonine, all of which are relatively low in many cereal proteins, making them a good source of amino acids (Rumpold and Schluter, 2013). In addition, it has a low anti-nutrient content (Inje *et al.*, 2018).

The second argument is that rabbits have the phenomenon of eating their droppings at dawn, which could be one of the reasons for the increase in digestion coefficients for many nutrients (Al-Mamary *et al.*, 2001), except fiber. Although this is an untested truth and may require further examination, it may aid in the digestion of re-ingested chitin-complexes found throughout the gastrointestinal tract.

The third explanation for the high coefficients of digestion associated with the inclusion of insect protein in rabbit diets, aside from fiber, is that the partial substitution of soybean meal protein by VOM protein, which was suitable up to 50% (VOM₅₀), resulted in a low chitin content in the diet (Longvah *et al.*, 2011). Because chitin is regarded as an indigestible fiber of the diet, and because rabbits are unable to secrete the chitinase enzymes (Finke, 2015; Tabata *et al.*, 2018), the digestion of fiber in the VOM groups was lower than in the control group (table 3), as chitin digestion in rabbits is dependent on microorganisms found only in the cecum, which have limited enzymatic activity (Tabata *et al.*, 2018).

Growth, feed and economic efficiency:

There are no significant differences in initial weights for rabbits in the different groups (Table 4). The final body weight (FBW) in all groups had more than tripled by the end of the study. In compared to the control group, the VOM₅₀ group had the greatest FBW, total weight gain (TWG), and daily weight gain (DWG) values ($P < 0.05$) at the end of the growth period. The daily body gain in rabbits fed the VOM₅₀ diet was 2 g/day, or 9.18 %, higher ($P < 0.05$) than in rabbits on the VOM₀ diet. The VOM groups demonstrated nonsignificant increase in growth rate (GR).

Many researchers have discovered that replacing fishmeal with silkworm pupae meal enhances broiler performance and profitability (Dutta and Dutta, 2012). Nandeesh *et al.* (1990) found that feeding worms up to 30% in common carp boosted the growth potential. Kowalska *et al.* (2021) found that partially substituting soybean meal with silkworm pupae and mealworm larvae meals in rabbit diets boosted body weight gains without affecting FCR. In addition, recent research by Schiavone *et al.* (2017) suggested that using *Hermetia illucens* larval meal as an alternate protein source to soybean meal in broiler chicken diets enhanced productive performance in terms of body weight gain, feed intake, and feed conversion ratio. Furthermore, when insect meal was used as a complete replacement for soybean meal in the diets of Japanese quail chicks, the weight gain was comparable to the control group (Hatab *et al.* 2020). Additional experiments by Strychalski *et al.* (2021) demonstrated that replacing soybean meal with silkworm pupae meal (SPM) or mealworm larvae meal (MLM) up to a 50% level can benefit a good result in rabbit production performance in terms of final body weight and daily body weight gains. Alternatively, Cullere *et al.* (2016) found that introducing defatted black soldier fly meal to the diets of growing broiler quails to replace 10 - 15% soybean meal had no negative impact on productive performance and mortality.

This positive response to the introduction of insect protein into rabbit diets could be attributed to the high feed intake (Inje *et al.* 2018) as well as the nutritional content of the insect meal for high biological value protein, which supports the optimal supply of essential amino acids (Khan *et al.* 2016), as well as the content of the insect protein for biologically active compounds as antioxidant agents, insulin regulators, and anti-inflammatory peptides (Acosta-Estrada *et al.*, 2021).

During the whole growth time, no mortality was detected. These findings are consistent with those of Hatab *et al.* (2020) who, reported no mortality in Japanese quail diets when insect meal was completely replaced with meat and bone meal.

The dietary treatment had no impact on the amount of dry matter consumed, which indicates that the diets examined had the same palatability. Incorporating insect protein into rabbit diets improved the feed

conversion (FC) rate significantly ($P < 0.05$) when compared to the control group. These FC values were comparable to those described (5.17 -11.32g) by Fakolade and Adetomiwa (2018), who fed weaner rabbits a graded amount of soybean seed meal.

Moreover, economic efficiency ranged from 1.787 in the control group to 2.274 in the VOM₅₀ group. However, differences in this feature are statistically significant ($P < 0.05$). Thus, replacing soybean meal in rabbit diets with the tested percentages (25 and 50%) of VOM meal increased the economic benefit by 12.87 and 27.25 %, respectively, compared to the control group. The findings of this study agree with those of Adeniji (2007), who noticed that insect meal diets were less expensive than meat and bone meal. Hatab et al (2020) identified that replacing 100% of meat and bone as the main source of animal protein in Japanese quail diets with insect meal made it more economically profitable than the control diet.

In this regard, it can be concluded that partial substitution of insects up to 50% of soybean in rabbit diets improved performance and economic return, while according to Kroeckel et al. (2012), high inclusion levels of Black Solider Fly lowered the palatability of the diet, protein digestibility, and growth performance of young turbot when compared to a control diet. However, it should be noted that some insects contain allergens that may pose a risk when consumed and should therefore be tested before consumption.

Table (4): Growth performance, feed efficiency, and economic efficiency of V-line rabbits fed the experimental diets.

Item	Experimental diet			±SEM	P. value
	Control	VOM ₂₅	VOM ₅₀		
<i>Growth performance</i>					
Initial weight (IW, g)	1.060	1.062	1.062	0.030	0.9989
Final weight (FW, kg)	3.021 ^b	3.117 ^{ab}	3.203 ^a	0.037	0.0060
Total weight gain (TWG, kg)	1.961 ^c	2.055 ^b	2.141 ^a	0.026	0.0001
Daily weight gain (DWG, g)	21.788 ^c	22.833 ^b	23.788 ^a	0.284	0.0001
Growth rate (%)	185.000	193.503	201.601	6.206	0.1594
Survival rate (%)	100	100	100	---	---
<i>Feed intake</i>					
DMI / h / d (g)	138.208	139.184	140.776	2.252	0.7208
TDN / h / d (g)	88.522 ^b	92.471 ^{ab}	95.502 ^a	1.503	0.0105
DCP / h / d (g)	18.686 ^b	19.845 ^a	20.804 ^a	0.324	0.0004
<i>Feed conversion (FC)</i>					
FC (DMI/ DWG)	6.346 ^a	6.096 ^{ab}	5.918 ^b	0.131	0.0423
FC (TDN/ DWG)	4.065	4.050	4.015	0.086	0.8905
FC (DCP/ DWG)	0.858	0.869	0.875	0.018	0.8433
<i>Economic efficiency</i>					
Price (LE) / kg diet ¹	4.432	4.426	4.420	---	---
Total feed cost / head	55.128	55.443	56.001	0.897	0.7857
Feed cost / kg WG	28.127 ^a	26.979 ^{ab}	26.156 ^b	0.581	0.0402
Total revenue / head ²	78.400 ^c	82.200 ^b	85.640 ^a	1.023	0.0001
Net return / head ³	50.273 ^c	55.221 ^b	59.484 ^a	1.474	0.0006
Economic efficiency ⁴	1.787 ^b	2.047 ^{ab}	2.274 ^a	0.093	0.0036

^{a and b}. Mean within each row with different superscripts are significantly differ ($P < 0.05$).

¹ Based on prices in the Egyptian market during the experimental period (2021).

² Total revenue (LE) /rabbit = Total weight gain × 40, assuming that the selling price of each kg of rabbit was LE 40.

³ Net revenue /rabbit (LE) = Total revenue - feed cost per kg gain.

⁴ Economic efficiencies = Net revenue / feed cost per kg weight gain.

Carcass Characteristics:

Results in Table (5) show the carcass characteristics and relative organ weight of different rabbit groups. The pre-slaughter weight of the VOM₅₀ rabbit group was 256.25 g higher ($P < 0.001$) than that of the control rabbit group. The increase in live body weights at the end of the experimental period was due to increasing VOM levels, which led to a similar increase in carcass weights (Kowalska et al., 2020). At the same time,

the levels of VOM used in the tested meals had no significant effect on carcass dressing or total edible giblets and heart weight for the entire trial. Additionally, the group of rabbits fed the VOM₂₅ and VOM₅₀ diets had significantly ($P < 0.05$) higher carcass weight, liver, kidney, and cecum length than the control group.

The higher protein and amino acid content of insect meal compared to soybean meal might lead to a rise in the relative weight of the carcass, liver, and kidney in groups fed VOM (Hatab et al, 2020). Similar results were reached by Kowalska et al. (2020). They revealed that feeding rabbits dried silkworm pupae and mealworm larvae meals at 4% inclusion level increased their final body weight and carcass meat content. In terms of carcass and organ weight gain, the present results match those of Bovera, et al. (2018), who fed broilers *Tenebrio molitor* larvae meal as a protein source, and Hatab et al, (2020), who reported the carcass features of growing Japanese quail chicks are unaffected by using insect meal protein as a replacement for MBM up to 100 %. However, Gasco et al., (2019) discovered that adding insect fat to rabbits' diets had no effect on carcass traits.

Table (5): Carcass traits and relative organs weight of V-line rabbits fed the experimental diets.

Item	Experimental diet			±SEM	P. value
	VOM ₀	VOM ₂₅	VOM ₅₀		
Pre-slaughter weight, (g)	3047.500 ^c	3167.500 ^b	3303.750 ^a	13.490	0.0001
Carcass weight, (g)	1650.500 ^c	1713.250 ^b	1763.750 ^a	12.274	0.0001
Carcass dressing, (%) ¹	54.159	54.088	53.386	0.4167	0.0001
Edible giblets, (%) ²	2.772 ^b	2.889 ^{ab}	2.837 ^a	0.024	0.0151
Total edible giblets, (%) ³	56.931	56.977	56.223	0.4042	0.0001
Liver, (g)	62.500 ^b	68.750 ^a	70.250 ^a	0.689	0.0001
Kidney, (g)	14.472 ^c	15.190 ^b	15.936 ^a	0.157	0.0001
Heart, (g)	7.498	7.562	7.538	0.126	0.9363
Cecum length, (cm)	32.876 ^c	34.562 ^b	36.250 ^a	0.452	0.0007

^{a and b}. Mean within each row with different superscripts are significantly different ($P < 0.05$).

¹ Carcass dressing (%) = Ratio between hot carcass weight (without head) to live weight.

² Edible Giblets %= (liver+ kidney + heart) / Pre-slaughter weight (g)*100

³ Total edible parts (%) = (carcass wt. + Edible Giblets)/ Pre-slaughter weight (g)*100

Caecal fermentative characteristics and microbiota:

In rabbits as herbivores, the large intestine environment is the primary site of bacterial fermentation in the digestive system (Jurgoński et al., 2014). In the caecal contents of VOM₂₅ and VOM₅₀ rabbits, total volatile fatty acids (VFA) were found to be significantly ($P < 0.05$) higher. However, caecal Ammonia-N concentration and pH were lower ($P < 0.05$) when compared to the control diet (Table 6). These values are within the normal range in healthy rabbits (Garcia et al. 2002). These results can be attributed to the fact that the control diet has higher fiber content (12.11 %) than the other two diets (11.96 and 11.80 %, respectively), in which the fiber content of the diet affects the concentration of total VFA acids (Garcia et al., 2002). The increase in total VFA concentrations could be due to microbial population modulation caused by the insect-based diet (Borrelli et al., 2017). The pH, total VFA, and Ammonia-N concentration values measured in rabbits in the present investigation (table 6) are similar to those found by Chrastinová et al. (2016) and Dabbou et al. (2020). Both caecal pH and VFA content are important factors in determining the degree and pattern of caecal fermentation, and thus serve as an indirect measure of caecal microbial activity (Polansky et al 2016). As it appeared in this study, the aerobic total count, *E. coli*, enterobacter and *Clostridium* spp (as a \log_{10}^{-1} CFU/ml) were significantly ($P < 0.05$) lower in rabbits fed VOM₂₅ and VOM₅₀ diets when compared to rabbits in the control group. However, in comparison with the control group, the *bacillus cereus* and *enterococcus* counts in rabbits fed the VOM diets appeared to be higher, with no significant differences. The present results agree with Józefiak et al. (2020). In comparison to the control group, dietary inclusion of VOM at a level of merely 50% of SBM protein induced a considerable reduction ($P < 0.05$) in yeast cell count. On the other hand, *Salmonella* and *Shigella* were not detected in any of the treatments. This finding prove that, a high concentration of total caecal VFA in rabbits exhibited a protective effect against enteropathogenic *Escherichia coli* infection (Peeters et al., 1995).

It was indicated that Lactobacilli (a probiotic bacteria) had been shown to enhance intestinal health, nutrient digestion, and animal growth by reducing pathogen infection levels. In addition, dietary insect meal could have the ability to operate as a prebiotic, and chitin is such a vital component of this activity.

However, the chitin content in insect meal could act as a substrate for the intestinal microbiota, therefore altering the fermentation processes (Borrelli et al., 2017). Accordingly, the current study implies that *Vespa Oriental* meal administration to rabbits in a limited amount may have a beneficial antimicrobial effect against infection (Yoon et al., 2018) by reducing harmful pathogen counts (Gasco et al., 2019). Therefore, the antimicrobial activity of VOM may be attributed to the presence of some bioactive compounds that may act on microbiota by inhibiting the growth of microbes (Yoon et al., 2018).

Table (6): Fermentation activity and microbiota counts (log⁻¹ CFU/ml) in the caecum of V-line rabbits fed the experimental diets.

Parameter	Experimental diet			±SEM	P. value
	VOM ₀	VOM ₂₅	VOM ₅₀		
Caecum activity					
pH Value	6.662 ^a	6.288 ^b	6.168 ^b	0.044	0.0001
NH ₃ -N (mg / 100 ml)	8.798 ^a	8.530 ^b	8.378 ^b	0.053	0.0004
TVFAs (ml Eq. / 100 ml)	9.212 ^c	9.520 ^b	10.080 ^a	0.041	0.0001
Microbial counts (log ⁻¹ CFU/ml)					
Aerobic total count	6.882 ^a	6.120 ^b	5.116 ^c	0.063	0.0001
Bacillus cereus	4.558	4.622	4.716	0.094	0.5082
Enterobacter	5.900 ^a	4.800 ^b	4.486 ^b	0.131	0.0001
Enterococcus	4.026	3.936	3.872	0.109	0.6184
E. Coli	7.218 ^a	4.548 ^b	3.962 ^c	0.090	0.0001
Clostridium spp.	2.508 ^a	1.960 ^b	1.672 ^c	0.055	0.0001
Yeasts	6.882 ^a	6.120 ^a	5.116 ^b	0.094	0.0067
Salmonella and Shigella	ND	ND	ND	-	-

^{a and b}. Mean within each row with different superscripts are significantly differ ($P < 0.05$).

Each value is an average of 3 observations.

TVFAs= Total volatile fatty acids, Number of bacterial cells per gram of cecum content (log¹⁰⁻¹ CFU/ml), CFU (Colony forming unite); ND =Not detected

Hematological parameters, liver and renal function:

The hematological parameters, liver and renal function of rabbits fed VOM compared to those fed SBM are illustrated in table (7). Hematology testing is well-known for its ability to detect changes in the nutritional, physiological, and pathological status of farm animals (Togun and Oseni, 2005) caused by diet and other variables (Afolabi et al., 2010). In the blood samples from rabbits fed a control diet, the concentration of haemoglobin (Hb), red blood cell count (RBC), mean cell volume (MCV) and mean cell haemoglobin (MCH) were significantly lower ($P < 0.05$) than those placed on the VOM₅₀ diet. The concentration of MCHC and white blood cell count (WBC) were not considerably ($P > 0.05$) different, indicating that introducing insect meal to rabbit diets had no deleterious effect. These findings are consistent with those of Hatab et al. (2020), who discovered that using insect meal protein as a partial replacement for soy bean meal has no effect on the haematological and serum biochemical indices of growing Japanese quail chicks. Similarly, Ekpo (2011) observed that insect enrichment diets had no significant influence on blood parameters in mice. Although the white blood cell count in rabbits administered VOM was not significantly higher, this indicates that these rabbits were more resistant to infection. It is widely known that animals with a sufficient number of white blood cells can produce antibodies and have a high level of immunity (Soetan et al., 2013), whereas those with a low number of white blood cells are susceptible to infection. Liver enzymes were not adversely ($P > 0.05$) affected, while renal function (creatinine and urea concentrations) was increased ($P < 0.05$) by VOM diets.

All determined enzymes values were within the normal range of values established by earlier studies for these parameters (Jenkins, 2008). This indicates that the rabbit liver cells are healthy, however when the liver cells are destroyed, the release of these enzymes are increased (Murray et al., 2012). In terms of renal function, rabbits fed the VOM₅₀ diet had substantially higher levels ($P < 0.05$) of creatinine and urea than rabbits fed the control diet. The increased of blood urea and creatinine concentrations in VOM₅₀ rabbits may thus represent higher protein intake than in rabbits fed control diets. Similar results were found in broiler

chickens with partial or entire substitution of soy bean meal lipid by *Hermetia illucens* with no significant variations in blood biochemical parameters (Schiavone et al., 2017; Schiavone et al., 2018). Li et al. (2016) observed the same results at varied levels of soybean meal replacement by *Hermetia illucens* larval meal in juvenile carp feed.

Table (7): Hematological parameters, liver and renal function of V-line rabbits fed the experimental diets.

Item	Experimental diet			±SEM	P. value
	VOM ₀	VOM ₂₅	VOM ₅₀		
Hematological parameters					
Haemoglobin (Hb, g/dL)	11.558 ^b	12.060 ^b	12.650 ^a	0.168	0.0043
Red Blood Cell Count (RBC, × 10 ⁶ /μL)	5.050 ^b	5.130 ^b	5.503 ^a	0.010	0.0236
Mean Cell Volume (MCV, fL)	69.088 ^b	70.940 ^b	74.203 ^a	1.091	0.0259
Mean Cell Hemoglobin (MCH, pg)	22.400 ^b	22.580 ^{ab}	23.570 ^a	0.212	0.0076
Mean Cell Hemoglobin Concentration (MCHC, g/dL)	30.900	30.480	31.080	0.499	0.6940
White Blood Cell Count (WBC, ×10 ³ /μL)	5.700	5.728	5.800	0.089	0.7251
Liver function					
Alanine Aminotransferase (ALT, IU/L)	42.333	42.668	44.333	0.913	0.3008
Aspartate Aminotransferase (AST, IU/L)	82.000	81.290	84.000	1.756	0.5497
Gamma-glutamyl transferase (GGT, IU/L)	5.708	5.773	5.893	0.192	0.7919
Total bilirubin (mg/dl)	0.973 ^b	0.978 ^b	1.080 ^a	0.021	0.0078
Renal function					
Creatinine (mg/dL)	0.690 ^b	0.730 ^b	0.888 ^a	0.690	0.0014
Urea (mg/dL)	27.668 ^b	32.333 ^a	34.668 ^a	1.434	0.0205

^{a and b}. Mean within each row with different superscripts are significantly different ($P < 0.05$).

These data could point to *Vespa Oriental* meals positively impacting rabbit metabolism and immunity. This could also be related to the higher bioavailability of essential amino acids in VOM, required for protein synthesis.

CONCLUSION

The findings of this study support the use of *Vespa Orientalis* wasp as a high-quality protein source for partial substitution of soybean meal in rabbit feed up to a 50% without adversely affecting growth performance, digestion parameters, or carcass organ characteristics.

Conflict of interest statement:

We declare that we have no conflict of interest.

REFERENCES

- Abou-Shaara, H (2017). Morphological aharacterization and wing description of *Vespa orientalis* queens. *Biotechnology in Animal Husbandry*. 33(2), 251-259.
- Acosta-Estrada, B.A., A, Reyes., C.M. Rosell., D. Rodrigo, and C.C. Ibarra-Herrera (2021). Benefits and Challenges in the Incorporation of Insects in Food Products. *Front. Nutr.* 8:687712. doi: 10.3389/fnut.2021.687712
- Abou El- Enain, H.T.; S.M. Abou- Lila and S.A. Mahmoud (1999): Studies on *Vespa ovientalis* fab attacking Honeybess colonies and control Bg modified traps Egypt. *J. Appl. Sci.*, 14(12).

- Abou-Shaara, H (2017). Morphological characterization and wing description of *Vespa orientalis* queens. *Biotechnology in Animal Husbandry*. 33(2), 251-259.
- Acosta-Estrada, B.A., A. Reyes., C.M. Rosell., D. Rodrigo, and C.C. Ibarra-Herrera (2021). Benefits and Challenges in the Incorporation of Insects in Food Products. *Front. Nutr.* 8:687712. doi: 10.3389/fnut.2021.687712
- Adeniji, A.A (2007). Effect of Replacing Groundnut Cake with Maggot Meal in the Diet of Broilers. *Intern. J. of Poultry Sci*, 6, 822-825. <https://doi.org/10.3923/ijps.2007.822.825>
- Afolabi, K. D., A.O. Akinsoyinu., R. Olajide., S.B. Akinleye (2010). Haematological parameters of the Nigerian local grower chickens fed varying dietary levels of palm kernel cake (p.247). *Proceedings of 35th Annual Conference of Nigerian Society for Animal Production*.
- Ahmed, S., M.A. Al Baki., J. Lee., D.Y. Seo., D. Lee, and Y. Kim (2021). The first report of prostacyclin and its physiological roles in insects. *Gen Comp Endocrinol* 2021; 301:113659. <https://doi.org/10.1016/j.ygcen.2020.113659>
- Al-Mamary, M., A. Molham., A. Abdulwali, and A. Al-Obeidi (2001). In vivo effects of dietary sorghum tannins on rabbit digestive enzymes and mineral absorption. *Nutrition Research*, Volume 21, Issue 10, October 2001, Pages 1393-1401. [https://doi.org/10.1016/S0271-5317\(01\)00334-7](https://doi.org/10.1016/S0271-5317(01)00334-7)
- Al-Sagheer, A.A., .H. Daader., H.A. Gabr, and E.A. Abd El-Moniem (2017). Palliative effects of extra virgin olive oil, gallic acid, and lemongrass oil dietary supplementation on growth performance, digestibility, carcass traits, and antioxidant status of heat-stressed growing NewZealand white rabbits. *Environmental Science and Pollution Research International*, 24 (7), 6807-6818.
- AOAC (1998) Official Method of Analysis. 15th Edition, Association of Official Analytical Chemists, Washington DC. ABSTRACT: Proximate and heavy metal analysis of five instant noodles samples was carried out using standard analytical methods.
- AOAC (2000). Association of official Analytical chemists. Official Methods of Analysis, 14th Ed. Published by the A. O. A. C. Washington, DC, USA.
- Baired Parker, A.C (1962). The occurrence and enumeration of micrococci and staphylococci in becon and on human and pig skin. *J. Appl. Bact.*, 25: 352-361.
- Belghit, I., N.S. Liland., R. Waagbø., I. Biancarosa., N. N. Pelusio., Y. Li and A. Krogdahl (2018). Lock, E.-J. Potential of insect-based diets for Atlantic salmon (*Salmo salar*). *Aquaculture* 2018, 491, 72–81.
- Berger, A, and J. Halver (1987). Effect of dietary protein, lipid and carbohydrate content on the growth, feed efficiency and carcass composition of striped bass, *Morone saxatilis* (Walbaum), fingerlings. *Aquaculture Research*, 18(4), 345-356.
- Bikker, P., M. van Krimpen., P. van Wikselaar., T. B. Houweling., N. Scaccia., J. van Hal. and A. López-Contreras (2016). Biorefinery of the green seaweed *Ulva lactuca* to produce animal feed, chemicals and biofuels. *Journal of Applied Phycology* 28, 3511–3525.
- Borrelli, L., L. Coretti., L. Dipineto., F. Bovera., F. Menna., L. Chiariotti., A. Nizza., F. Lembo, and A. Fioretti (2017). Insect-based diet, a promising nutritional source, modulates gut microbiota composition and SCFAs production in laying hens. *SCIENTIFIC Reports* | 7: 16269 | DOI:10.1038/s41598-017-16560-6
- Bosch, G., J.J.M. Vervoort, and W.H. Hendriks (2016). In vitro digestibility and ferment ability of selected insects for dog foods. *Animal Feed Science and Technology* 221: 174-184.
- Bosch, G., S. Zhang., D.G.A.B. Oonincx, and W.H. Hendriks (2014). Protein quality of insects as potential ingredients for dog and cat foods. *J. Nutritional Science*.
- Bovera F., R. Loponte., M.E. Pero., M.I. Cutrignelli., S. Calabrò, and Musco N, (2018). Laying performance, blood profiles, nutrient digestibility and inner organs traits of hens fed an insect meal from *Hermetia illucens* larvae. *Res Vet Sci*. 2018; 120:86–93.
- Cerritos, R (2009). *Insects as Food: An Ecological, Social and Economical Approach*, CAB Reviews: Perspectives in Agriculture, Nutrition and Natural Resources.

- Cheeke, P.R., M.A. Grobner, and N.M. Patton (1986). Effect of high fiber on the performance of rabbits. *Journal of Applied Rabbit Research*, 9(1): 25 - 30.
- Chrastinová L., K. Čobanová., M. Chrenková., M. Poláčiková., Z. Formelová, and A. Lauková (2016). Effect of dietary zinc supplementation on nutrients digestibility and fermentation characteristics of caecal content in physiological experiment with young rabbits. *Slovak J Anim Sci*. 2016;49:23– 31 <https://sjas.ojs.sk/sjas/article/view/158/146>
- Collavo, A., R.H. Glew., Y.S. Huang., L.T. Chuang., R. Bosse, and M.G. Paoletti (2005). House cricket small-scale farming. In: M.G. Paoletti, editor, *Ecological implications of mini livestock: Potential of insects, rodents, frogs and snails*. Science Publishers, Enfield, NH. p. 519–544.
- Conway, E.J (1958). *Micro-diffusion analysis and volumetric error* (4th ed.) The McMillan Co., New York.
- Cullere M., G. Tasoniero., V. Giaccone., R. Miotti-Scapin., E. Claeys, and S. De Smet (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. doi: 10.1017/S1751731116001270. [PubMed] [CrossRef] [Google Scholar]
- Dabbou, S., I. Ferrocino., L. Gasco., A. Schiavone., A. Trocino., G. Xiccato., Ana C. Barroeta., Sandra Maione., Dominga Soglia., I. Biasato., Luca Cocolin., F. Gai, and Daniele M. Nucera (2020). Antimicrobial Effects of Black Soldier Fly and Yellow Mealworm Fats and Their Impact on Gut Microbiota of Growing Rabbits. *Animals* 2020, 10, 1292; doi:10.3390/ani10081292
- Difco Laboratories Incorporated (1989). *Difco manual of dehydrated culture media and reagents for the microbiology*. Difco Lab., Detroit, Michigan, USA.
- Duncan D.B (1955). Multiple ranges and multiple F test. *Biometrics* 11: 1-42. doi:10.2307/3001478
- Dutta, A. S, and S.K. Dutta (2012). Growth of poultry chicks fed on formulated feed containing silk worm pupae meal as protein supplement and commercial diet. *J. Anim. Feed Res.* 3: 303-307.
- Eadie, J.M., P.N. Hobson, and S.O. Mann (1967). A note on some comparisons between the rumen content of barley fed steers and that of young calves also fed on high concentrate diets. *J. Anim Prod.*, 9: 247.
- Ekpo, K.E (2011). Nutritional and biochemical evaluation of the protein quality of four popular insects consumed in Southern Nigeria, *Arch. Appl. Sci. Res.* 3(2011) 428–444
- Fakolade, P.O, and A. A. Adetomiwa (2018). Performance and carcass characteristics of weaner rabbits fed wild sunflower (*Tithonia diversifolia*) inclusion in their diet. *International Journal of Development and Sustainability* Vol. 7 No. 8 (2018): 2216-2226
- FAO, (2011). *Food and Agriculture Organization of the United Nations (FAO), Rome, World Livestock–Livestock in food security*.
- FAO, (2013). *Food and Agriculture Organization of the United Nations 171, Edible insects. Future prospects for food and feed security*.
- FAO, (2014). *Food and Agriculture Organization of the United Nations. Insects to feed the World. In: Proceedings of the 1st International Conference. 14-17; Wageningen. The Netherlands*.
- Finke, M.D (2007). Estimate of chitin in raw whole insects. *Zoo Biol.* 26:105-15. doi: 10.1002/zoo.20123
- Finke, M. D (2013). Complete nutrient content of four species of feeder insects. *Zoo Biology*, 32(1), 27–36. doi: 10.1002/zoo.21012.
- Finke, M.D (2015). Complete Nutrient Content of Four Species of Commercially Available Feeder Insects Fed Enhanced Diets During Growth. *Zoo Biology*. 34:554–564. doi: 10.1002/zoo.21246
- Garcia, J., T. Gidenne., L. Falcao-e-Cunha., C. de Blas (2002). Identification of the main factors that influence caecal fermentation traits in growing rabbits. *Anim. Res.*, 51: 165- 173. doi:10.1051/animres:2002011
- Gariglio, M., S. Dabbou., I. Biasato., T. Maria., E. Capucchio., F. Colombino., F. Hernández., J. Madrid., S. Martínez., F. Gai., C. Caimi., Sara. B. Odon., M. Meneguz., A. Trocino., R. Vincenzi., L. Gasco, and

- A. Schiavone (2019). Nutritional effects of the dietary inclusion of partially defatted *Hermetia illucens* larva meal in Muscovy duck. *J Animal Sci Biotechnol* 10, 37. <https://doi.org/10.1186/s40104-019-0344-7>
- Gasco, L., S. Dabbou., A. Trocino., G. Xiccato., M.T. Capucchio., I. Biasato (2019). Effect of dietary supplementation with insect fats on growth performance, digestive efficiency and health of rabbits. *Anim Sci Biotechnol*. 2019b; 10:4. <https://doi.org/10.1186/s40104-018-0309-2>.
- Ghania, A. M. M (2007). Control of Honeybee Pests and Diseases Without the Use of Chemicals and Using of Natural Products.,176PP
- Ghosh, S., S. M. Namin., V.B. Meyer-Rochow., C. Jung (2021). Chemical Composition and Nutritional Value of Different Species of *Vespa* Hornets. *Foods*, 10, 418. <https://doi.org/10.3390/foods10020418>. <https://doi.org/10.3390/foods10020418>
- Goulet, G., P. Mullier., P. Sinave, and G.J.Brisson (1978). Nutritional evaluation of dried *tenebrio molitor* larvae in the rat. *Nutr. Rep. Int.* 18(1): 11–16.
- Hahn,T and A. Roth., E. Febel., M. Fijalkowska., E. Schmitt. And T. Arsiwalla (2018). New methods for high-accuracy insect chitin measurement. *J Sci Food Agric* 98:5069–5073.
- Hatab, M. H., N.S.Ibrahim., W.A. Sayed., E.M. Sabic (2020). Potential Value of Using Insect Meal as an Alternative Protein Source for Japanese Quail Diet Original Articles • Braz. J. Poult. Sci. 22 (01). <https://doi.org/10.1590/1806-9061-2017-0700>
- Huet, G., C. Hadad., E. Husson., S. Laclef., V. Lambertyn., M.A. Farias., A. Jamali., M. Courty., R. Alayoubi., I. Gosselin (2020). Straightforward extraction and selective bioconversion of high purity chitin from *Bombyx eri* larva: Toward an integrated insect biorefinery. *Carbohydr. Polym.* 2020, 228, 115382.
- Inje, O. F., A. H. Olufunmilayo., J. A. Audu., S. A. Ndaman, and E. E. Chidi (2018). Protein quality of four indigenous edible insect species in Nigeria. *Food Science and Human Wellness* 7:175–183
- INRA (2004). Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage: porc, volailles, bovins, ovins, caprins, lapins, chevaux, poissons. In: Sauvant D, Perez JM, Tran G, editors. 2ème édition revue et corrigée. Paris: INRA Editions; 2004. p. 301.
- Jenkins, J.R (2008). Rabbit Diagnostic Testing. *Journal of Exotic Pet Medicine*, 17, 4-15. <https://doi.org/10.1053/j.jepm.2007.12.003>
- Józefiak, D., A. Jozefiak., B. Kieronczyk., M. Rawski., S. Świątkiewicz., J. Długosz, and R.M. Engberg (2016). Insects – a natural nutrient source for poultry. *Annals of Animal Science* 16: 297-313.
- Józefiak, A., A. Benzertiha., B. Kierończyk., A. Łukomska., I. Wesołowska, and M. Rawski (2020). Improvement of Cecal Commensal Microbiome Following the Insect Additive into Chicken Diet. *Animals*, 10, 577; doi:10.3390/ani10040577
- Jurgoński, A., J. Juśkiewicz., Z. Zduńczyk., P. Matusevičius., K. Kołodziejczyk (2014). Polyphenol-rich extract from blackcurrant pomace attenuates the intestinal tract and serum lipid changes induced by a high-fat diet in rabbits. *Eur J Nutr.*;53(8):1603–13. <https://doi.org/10.1007/s00394-014-0665-4>.
- Kaya, M., N. Bağrıaçık., O. Seyyar, and T. Baran (2015a). Comparison of chitin structures derived from three common wasp species (*Vespa crabro* Linnaeus, 1758, *Vespa orientalis* Linnaeus, 1771 and *Vespula germanica* (Fabricius, 1793)). *Arch. Insect Biochem. Physiol.* 89, Issue 4 p. 204–217. <https://doi.org/10.1002/arch.21237>
- Kaya, M., V. Baublys., I. Šatkauskienė., B. Akyuz., E. Bulut and V. Tubelyte (2015b). First chitin extraction from *Plumatella repens* (Bryozoa) with comparison to chitins of insect and fungal origin. *Inter. J. of Biol Macromolecules*. 10.1016/j.ijbiomac.2015.04.066
- Khan, S., R.U. Khan., A. Sultan., M. Khan., S.U. Hayat and M.S. Shahid (2016) Evaluating the suitability of maggot meal as a partial substitute of soybean on the productive traits, digestibility indices and organoleptic properties of broiler meat. *J. of Anim. Physio and Anim Nutri.* 100(4): 649-56.

- Kim, H.U and J.M. Goepfert (1971). Enumeration and identification of *Bacillus cereus* in foods, 1, 24-hours presumptive test edium. *Appl. Microbiol.* 22: 581-587.
- Kowalska, D., A. Gugolek, and J. Strychalski (2020). Evaluation of slaughter parameters and meat quality of rabbits fed diets with silkworm pupae and mealworm larvae meals. *Ann. Anim. Sci.*, Vol. 20, No. 2 (2020) 551–564 DOI: 10.2478/aoas-2019-0080
- Kowalska, D., J. Strychalski., A. Gugolek (2021). The effect of silkworm pupae and mealworm larvae meals as dietary protein components on performance indicators in rabbits. *Rev Mex Cienc Pecu* 2021;12(1):151-162 <https://doi.org/10.22319/rmcp.v12i1.5455>
- Kroeckel, S., A.G.Harjes., I. Roth., H. Katz., S. Wuertz., A. Susenbeth. and C. Schulz (2012). When a turbot catches a fly: Evaluation of a pre-pupae meal of the Black Soldier Fly (*Hermetia illucens*) as fish meal Substitute-Growth performance and chitin degradation in juvenile turbot (*Psetta maxima*). *Aquac.*, 364, 345–352, doi: 10.1016/j.aquaculture.2012.08.041
- Laudadio, V., L. Passantino., A. Perillo., G. Lopresti., A. Passantino., R.U. Khan (2012). Productive performance and histological features of intestinal mucosa of broiler chickens fed different dietary protein levels. *Poult Sci.* 2012; 91:265–70.
- Lei, X.J., T.H. Kim., J.H. Park and I.H. Kim (2019). Evaluation of supplementation of defatted black soldier fly (*Hermetia illucens*) larvae meal in beagle dogs. *Ann. Anim. Sci.*, 19: 767–777.
- Li, L, H. Ji., B. Zhang., J. Tian., J. Zhou and H. Yu (2016). Influence of black soldier fly (*Hermetia illucens*) larvae oil on growth performance, body composition, tissue fatty acid composition and lipid deposition in juvenile Jian carp (*Cyprinus carpio* var. Jian). *Aquaculture*; 465:43–52.
- Lodder, J (1952). *The yeasts*. 1st Ed. Pup. Inc., N.Y.
- Longvah, T., K. Mangthya and P. Ramulu (2011). Nutrient composition and protein quality evaluation of eri silkworm (*Samia ricinii*) prepupae and pupae. *Food Chem.* 2011; 128:400 –3.
- Makkar, H. P. S.; G.Tran., V. Heuzé, and P. Ankers (2014). State-of-the-art on use of insects as animal feed. *Anim. Feed Sci. Technol.*, 197: 1-33. <https://doi.org/10.1016/j.anifeedsci.2014.07.008>
- Murray, R.K., D.A. Bender., K.M. Botham., P.J. Kennelly., V.W. Rodwell, P.A. Weil (2012). *Harpers Illustrated Biochemistry*, twenty ninth ed., McGraw –HillsCompanies, Inc, USA.
- Nandeeshha, M.C., B. Gangadhara and J.K. Maniseery (1990). Silk worm pupae oil as an additional energy source in the diet of common carp. *Cyprinus carpio*. *Asian Fisheries Science*, 12: 207-215.
- Narang, M.P and R. Lal (1985). Evaluation of some agro-industrial wastes in the feed of Jersey calves. *Agric Wastes*. 1985;13(1):15–21. [https://doi.org/10.1016/0141-4607\(85\)90008-3](https://doi.org/10.1016/0141-4607(85)90008-3).
- NRC, (2011). *Nutrient requirements of fish and shrimp*. National Research Council, National Academy Press, Washington DC, USA.
- Omran, N.S.M., M.H. Hussein., M.M. Khodairy, and A. M. Awad, A.M (2011). Predators of honeybee and its impact on activities of honeybee colonies under conditions of south valley, Egypt. *Res. J. of Agri and Biol Sci.* 7(1), 79-88.
- Ooninx, D.G.A.B. J. Van itterbeeck., M.J.W. Heetkamp., H. Van Den Brand., J.J.A. Van Loon and A. Van huis (2010). An exploration on greenhouse gas and ammonia production by insect species suitable for animal or human consumption. *Plos One* 5, 12.
- Park, B.S., K.H. U., W.K. Choi and S. Park (2017). Effect of feeding black soldier fly pupa meal in the diet on egg production, egg quality, blood lipid profiles and faecal bacteria in laying hens. *European Poultry Science* 81, 1-12.
- Peeters, J.E., L. Maertens., R. Orsenigo and M. Colin (1995). Influence of dietary beet pulp on caecal VFA, experimental colibacillosis and iota-enterotoxaemia in rabbits. *Anim Feed Sci Tech.* 1995; 51:123–39.
- Polansky, H and A. Javaherian (2016). 3-Ecosystems: MicroRNAs, Receptors, and Latent Viruses; Some Insights Biology Can Gain from Economic Theory. *Front. Microbiol.* 7:369. <https://doi.org/10.3389/fmicb.2016.00369>

- Porter, C. A and E.G. Jaworski (1965). Biosynthesis of chitin during various stages in the metamorphosis of *Prodenia Eridanus*. *J. Insect Physiol.*, 11: 1151-1160.
- Postage, J.R (1969). Viable counts and viability. In: methods in microbiology. Norris, J. R., Robbins, D.W. (eds), vol. 1. Academic Press, London, N.Y.: 611-628.
- Pretorius, Q (2011). The evaluation of larvae of *Musca Domestica* (common house fly) as protein source for broiler production. Thesis (MSc Agric (Animal Sciences)) – University of Stellenbosch.
- Ramos-Elorduy, J., J.M.P. Moreno., E.E Prado., M.A. Perez., J.L. Otero and OL. De Guevara (1997). Nutritional value of edible insects from the state of Oaxaca, Mexico. *J. Food Compost. Anal.* 1997, 10, 142–157.
- Rumpold, B.A and O.K. Schluter (2013). Nutritional composition and safety aspects of edible insects. *Mol Nutr and Food Res* 57:802–823.
- Sajomsang,W.; Gonil, P.(2010). Preparation and characterization of alpha-chitin from cicada sloughs. *Mater. Sci. Eng. C*, 30, 357–363.
- SAS, (2002). User's guide: Statistics, version 9. 4th Ed. SAS Ins., Inc., Cary., NC, USA.
- Schiavone, A., M. Cullere., M. De Marco., M. Meneguz., I. Biasato., S. Bergagna (2017). Partial or total replacement of soybean oil by black soldier larvae (*Hermetia illucens* L.) fat in broiler diets: effect on growth performances, feed-choice, blood traits, carcass characteristics and meat quality. *Ital J Anim Sci.* 2017; 16:93–100.
- Schiavone A., S. Dabbou., M. De Marco., M. Cullere., I. Biasato., E. Biasibetti (2018). Black soldier fly (*Hermetia illucens* L.) larva fat inclusion in finisher broiler chicken diet as an alternative fat source. *Anim.* 2018. <https://doi.org/10.1017/S1751731117003743>.
- Shockley,M and A.T. Dossee (2013). Insects for Human Consumption. [W:] *Mass Production of Beneficial Organisms* (ed. J. Morales-Ramos, M.G. Rojas, D. Schapiro-Ilan). Academic Press, pp. 617-652.
- Soetan, K.O., A.S. Akinrinde and T.O. Ajibade (2013). Preliminary studies on the haematological parameters of cockerels fed raw and processed guinea corn(sorgumbicolors), in: Proceedings of the 38th Annual Conference of the Nigerian Society of Animal Production.
- Strychalski, J., J. Juśkiewicz., D. Kowalska and A. Gugolek (2021). Performance indicators and gastrointestinal response of rabbits to dietary soybean meal replacement with silkworm pupae and mealworm larvae meals. *Archives of Animal Nutrition* 75(4):1-17. DOI:10.1080/1745039X.2021.1962171
- Tabata, Eri., A. Kashimura., A. Kikuchi., H. Masuda., R. Miyahara., Y. Hiruma., S. Wakita., M. Ohno., M. Sakaguchi., Y. Sugahara., V. Matoska., P. O. Bauer and F. Oyama (2018). Chitin digestibility is dependent on feeding behaviors, which determine acidic chitinase mRNA levels in mammalian and poultry stomachs. *SCIENTIFIC REPORTS*. 8:1461 | DOI:10.1038/s41598-018-19940-8.
- Togun, V. A and B.S.A. Oseni (2005). Effect of low level inclusion of biscuit dust in broiler finisher diet on pre-pubertal growth and some haematological parameters of unsexed broilers. *Res. Comm. Anim. Sci.*, 1(2):10-14.
- Trocino, A., J. Garcia., R. Carabano and G. Xiccato (2012). Role of soluble fiber in diets for growing rabbits: a review. *Proc. 10th World Rabbit Congress*. September 3-6, 2013 Sharm-El Sheikh- Egypt 453-471.
- Van Huis, A., V.J. Itterbeeck., H. Klunder., E. Mertens., A. Italloran., R.G. Mui and P.Vantomme (2013). *Edible Insects: Future Prospects for Food Security*, FAO Forestry Paper 171.
- Waterhouse, D.F., R. H. Hockman, and J.W. Mckellar (1961). An investigation of chitinase activity in cockroach and termite extracts. *J. Insect physiol.* ,6:96-112.
- Yang, X ., Y.Wang., Z. Lu., L. Zhai., J. Jiang., J. Liu, and H. Yu (2009). A novel serine protease inhibitor from the venom of *Vespa bicolor* Fabricius. *Comparative Biochemistry and Physiology Part B Biochemistry and Molecular Biology* 153(1):116-20. DOI:10.1016/j.cbpb.2009.02.010

- Yi, L., C.M.M. Lakemond., L.M.C. Sagis., V. Eisner-Schadler., A. van Huis., M.A.J.S. van Boekel (2013). Extraction and characterization of protein fractions from five insect species. Food Chem. 141:3341–8. doi: 10.1016/j.foodchem.2013. 05.115
- Yoon, B.K., J.A. Jackman., E.R.Valle-González., N.J. Cho (2018). Antibacterial free fatty acids and monoglycerides: biological activities, experimental testing, and therapeutic applications. Int J Mol Sci; 19 (1114). <http://doi.org/10.3390/ijms19041114>.
- Young,V.R., A. E. El-Khoury., C. A. Raguso., A. H. Forslund., L. Hambraeus (2000). Rates of Urea Production and Hydrolysis and Leucine Oxidation Change Linearly Over Widely Varying Protein Intakes in Healthy Adults. The J. of Nutrition, Vol. 130, Issue 4, P. 761–766, <https://doi.org/10.1093/jn/130.4.761>.

تأثير استخدام مسحوق حشرة دبور البلح محل كسب فول الصويا على النمو والاستفادة من الغذاء في ذكور الأرناب

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أجريت الدراسة الحالية بهدف تحديد تأثير الإحلال الجزئى لكسب فول الصويا بمسحوق دبور البلح على أداء النمو والهضم وبعض التغيرات فى قياسات الدم باستخدام ثلاث مستويات إحلال وهم صفر و 25 و 50% (VOM_0 و VOM_{25} و VOM_{50}) فى العلائق حيث تم توزيع عدد 30 ذكر من الأرناب بعمر 12 اسبوع وبمتوسط وزن بداية 1.06 كجم بالتساوى بين ثلاث مجموعات واستمرت التجربة لمدة 90 يوم. تشير النتائج إلى أن محتوى البروتين الخام فى مسحوق دبور البلح وكسب فول الصويا كان 76.84 و 43.76% على الترتيب. بالإضافة الى أن معاملات الهضم للبروتين كانت 74.65% و 76.07% وللمستخلص الخالى من الازوت 68.39 و 70.123% للعلائق ذات الإحلال 25% و 50% على الترتيب والتي كانت أعلى من مجموعة المقارنة (72.033 و 65.44%، على الترتيب). الزيادة اليومية فى وزن الجسم للأرناب التى تغذت على المجموعة VOM_{50} كانت أعلى بمقدار 9.18% عن تلك الأرناب التى تغذت على مجموعة المقارنة (VOM_0). أيضا الأرناب بالمجاميع المختبرة VOM_{25} و VOM_{50} كانت أعلى فى وزن الذبيحة والكبد والكلى وطول الأعور مقارنة بمجموعة VOM_0 . الأحماض الدهنية الطيارة كانت أعلى بصورة معنوية فى مكونات الأعور بمجموعة VOM_{25} و VOM_{50} بينما كان هناك إنخفاض فى قيم تلك المجموعتين من تركيز الأمونيا عند المقارنة بمجموعة VOM_0 . أظهرت المجموعة VOM_{50} تحسنا معنويا فى قياسات الدم ووظائف الكبد والكلى مقارنة بمجموعة المقارنة VOM_0 .

وبناء على نتائج هذه الدراسة يمكن ان نستخلص إمكانية استخدام مسحوق دبور البلح كمصدر بروتين بديل على الجودة محل كسب فول الصويا حتى مستوى إحلال 50% بدون وجود أى اثار سلبية على أداء الأرناب. وظهرت المجموعتين VOM_{25} و VOM_{50} قيم غذائية أعلى فى صورة مجموع المركبات الغذائية المهضومة (TDN) والبروتين المهضوم (DCP) مقارنة بمجموعة التحكم.