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NUTRITIONAL MODIFICATION to ALLEVIATE HEAT STRESS and ENHANCE PRODUCTIVE PERFORMANCE of JAPANESE QUAIL SUBJECTED to HIGH AMBIENT TEMPERATURE

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ABSTRACT: This study was conducted to examine the effect of substituting 15, 20, 25 and 30 % of energy supplied by corn in a control diet with energy from by-product of palm oil extraction (POE) to enhance productive performance and combat heat stress of Japanese quail. A total of 375, 7-d old Japanese quail chicks were randomly distributed following a completely randomized design into 5 treatment groups (N = 75 chicks/group). Each treatment having three replications (n=25 chicks/ replicate). Results indicated that live weight and gain differed significantly ($P \leq 0.05$) among treatment groups. While feed intake, protein and energy intake insignificantly affected. However, FCR recorded the best values for birds fed diet inclusion different levels of POE compared with control group. No mortalities observed among the treatments along the experimental period. Moreover, there were improvements for most hematological and biochemical parameters due to feeding POE. Therefore, lipid profile significantly ($P \leq 0.05$) decreased, when POE increased in the diets. The findings showed that the histomorphometric parameters significantly ($P \leq 0.05$) improved due to feeding POE. The highest economical efficiency observed for groups fed diets inclusion different levels of POE. Therefore, on the basis of the current results, we concluded that adding by-product POE up to 30% to the quail diets has no adverse effect on their productive performance or physiological status as well as the addition of POE gets higher economic efficiency.

Key words: by- product palm oil extraction, growth performance, Japanese quail**.**

INTRODUCTION

The Japanese quail is an additional source of animal protein for human consumption, where quail kept for both commercial and scientific purposes (Raji et al., 2015). However, heat stress is one of the most important environmental stressors challenging poultry production in tropical countries (Afrin et al., 2016). Clearly, Akbarian et al. (2016) indicate that heat as a stressor of poultry has been studied extensively for many decades; it affects poultry production as a worldwide basis and has a significant impact on well-being and production. Because it is expensive to cool poultry houses, methods are focused mainly on nutritional modifications. Therefore, there are various nutritional strategies, manipulations or feeding practices that have been used to be helpful in reducing and overcome the negative impact of heat stress (Suganya et al., 2015). On the other hand, corn is one of the major energy ingredients in poultry diets and heat increment yielding from digestion is higher. The use of oil in substitution of carbohydrates is justified by the fact that fats, among all ingredients, has lowest heat increment (9%), as compared to protein (26%) (Ribeiro and Lagana, 2002). Red palm oil is the only vegetable oil with a balanced composition of saturated and unsaturated fatty acids both in processed and unprocessed forms and it contains carotenoids, phosphatides, sterols, tocopherols and trace metals (Aboua et al., 2009). Also, it contains 50% saturated fatty acids, 40% monounsaturated fatty acids and 10% polyunsaturated fatty acids (Eqbal et al., 2013). In this context, Zulkifli et al. (2003) reported that providing diets containing high levels of palm oil enhanced growth performance and survivability of heat-stressed broiler chickens. Also, Htin et al. (2007) indicated that the addition 8% of palm oil is optimum for alleviating the adverse effects of heat stress and improved body weight of broiler chickens. However, POE is a by-product of palm oil extraction and can be used as a cheap source for formulating poultry diets where, there is need to improve the scientific knowledge for utilizing low cost locally available agro-industrial by-products to reduce the feed cost. As feed constitutes 60-70 % of the total cost of production, any attempt to reduce the feed cost may lead to a significant reduction in the total cost of production. Unfortunately, there is a lack of enough information concerning the effects of use by-product POE on the performance of Japanese quail under high environmental temperature. Therefore, the principal objective of this study was to evaluate the effects of by-product POE supplementation on growth performance, some blood constituents, gut health, fatty acid compositions as well as economical efficiency.

MATERIALS AND METHODS

Site and the aim of study:

This study was conducted at the Experimental Poultry Research Station at the Faculty of Agriculture, Al-Azhar University, Naser City, Cairo, Egypt, during summer season. The main objective of this study was to evaluate the effects of addition different levels of by product palm oil extraction (POE) on productive performance, some blood parameters, digestibility, small intestinal histomorphological parameters as well as economical efficiency of Japanese quail reared under high environmental temperature.

Birds, husbandry and experimental procedure:

In total, 500, 1-d old chicks of Japanese quail were purchased from local market and raised together during the first 7th d of age to avoid any mortalities occurred during the first life of age. A basal diet containing nutrient requirements was given to the chicks from arrival until 7 d of age. At the end of the 7th d of age a total number of 375 chicks were selected and were randomly distributed into 5 treatment groups containing 75 birds each. Each treatment was represented by 3 replicates each with 25 birds. Chicks were assigned to five feeding regimes as follows: T1 (control diet, contained corn as the main energy source without added POE), T2) control diet supplemented with 15% POE, T3) control diet supplemented with 20% POE, T4) control diet supplemented with 25% POE and T5) control diet supplemented with 30% POE respectively. All diets were formulated to be isocaloric and isonitrogenous (NRC, 1994). Both diets and water were offered *ad libitum* along the experiment duration. Chicks housed in batteries, which were provided by incandescent bulbs with 22 lx of light intensity. Birds were reared under similar environmental, managerial and hygienic conditions. Birds were submitted to heat stress, where the temperature and relative humidity were constant in the cages, were they 35±1°C and 65% ± 2% RH as averages along the experimental period.

Measurement and analysis:

Prior to feeding, body weight was individually weekly measured. Body weight gain, feed intake, feed conversion ratio (g feed /g gain), protein intake, energy intake, protein and energy efficiency ratio and mortality rate were also recorded. At the end of experiment 3 mL of blood were obtained from 6 birds (3 male and 3 female) for each treatment alone, which divided into two samples in Eppendorf tubes. One was heparinized test tube by using Ethylenediamine tetraacetate acid (EDTA) as an anticoagulant to study blood hematological parameters immediately after blood collection. The other was non-heparinized to determine other biochemical constituents including total lipid (Zollner and Kirsch, 1962), total cholesterol and triglycerides, (Allain et al., 1974), LDL and HDL (Lopes-Virella et al., 1977), ALT and AST (Murray, 1984 a,b) by using a standard commercial diagnostic kit made in Egypt by Diamond Company, Stanpio, Laboratory Pasteur Lab. Serum separated and stored at -20°C until analyses. Samples of diets were taken to carry over the routine chemical composition according to standard methods of the Association of Official Analytical Chemists (AOAC, 2012) as shown in Table 1. For analysis of fatty acid compositions, fatty acid methyl esters were prepared according to the method of Christie (2003). Fatty acid composition was trans esterified into their corresponding fatty acid methyl esters (FAMEs) using methanolic NaOH and boron triflouride (BF3) with methanol as described by the AOAC (2012).The FAMEs were quantified by Shematizu Gas Chromatograph Series 2010 equipped with a 2010+Sautosampler (Japan,) and interfaced with a FID. The GC was equipped with a temperature programmable column. The column phase was Supplco DB-Wax (carbowax) with the following dimensions: 30 m long, 0.25 mm i.e. with a 0.25μm phase thickness. Helium was used as a carrier gas with flow rate of 40 mL/min. One μL was injected using the inlet in a split mode. The head pressure was set at 2 psi, and the split vent flow was 7 mL/m. The injector temperature was 250°C. The column flow rate at 2 psi was 0.68 mL/m. The column temperature was maintained at 200°C for10°C/s and was held at 260°C for 80 min. The detector was operated in the selected ion monitoring mode. Fatty acids were identified by retention times obtained from the FAME standards (Sigma Company, St. Louis, MO). For histopathological examination different tissue samples from duodenum, jejunum, and ileum were taken from either male or female and fixed in 10% neutral formalin. Then the tissues were routinely processed, dehydrated, cleared in xylene and embedded in paraffin wax. Tissue sections of 4µm thickness were stained with Hematoxylin and eosin and examined for histopathological alterations. For digestibility trial, 15 males were randomly selected and divided into 5 uniform groups on the basis of body weight. Birds were housed in cage equipped with a wire-mesh floor and removable aluminum tray at the bottom to facilitate the collection and record of spilled food. Dried samples were then ground through a mill equipped with a 1-mm screen to ensure a homogeneous mixture. Digestibilities of nutrients and AME were determined using the feed and excreta chemical analyses. Triplicate 1.0 g samples of feed and excreta were analyzed for gross energy (GE) using an adiabatic oxygen bomb calorimeter (Parr Instruments, 6400). The digestibility was calculated according to the following equation:

Digestion coefficient% = Nutrient intake (g) – Fecal nutrient content (g)) / Nutrient intake (g) ×100.

However, the calculation of apparent metabolizable energy (AME) was computed as the following equation reported by Cole and Haresign (1989).

$$\text{AME/g of feed} = \frac{(F_i \times GE_f) - (E \times GE_e)}{F_i}$$

Where Fi is the feed intake (g); E is the excreta output (g); GE f is the gross energy/ g of feed; and GE e is the gross energy /g of excreta. At the end of experiment, the economical efficiency was also calculated. The price of experimental diets was calculated according to the price at local market of the Egyptian market at the time of the experiment.

Statistical Model:

Data analysis was performed using General Linear Models (GLM) procedure of SPSS software program package (SPSS, 2010), version 16.0. All data were analyzed based on a completely randomized design using one way ANOVA. All percentages were first transformed to arcsine being analyzed to approximate normal distribution before ANOVA. All obtained data were analyzed by using the following Model:

$X_{ijk} = M + \alpha_i + e_{ijk}$

Where, M = General mean, α_i = Effect of by-product POE level, $\mathbf{e_{ijk}}$= Stander error for observations.

RESULTS

The macronutrients and fatty Acid profiles of by-product POE vs., experimental diets

Table 2 shows the macronutrients and fatty acid profiles of by-product POE compared with the experimental diets. As can be seen, from the present result POE has high gross energy, where it found 9.600 Kcal /g, while the AME was 8.561 kcal /kg. The gross energy of diets was found to be 4054.7, 4282.3, 4470.7, 4570.0 and 4791.3 kcal /kg. However, the values of AME were 2913.3, 2922.3, 2926.0, 29237.7 and 2927.5 respectively. It is observed that POE has balanced ratio between saturated (∑SFA %) and unsaturated (∑USFA %) fatty acid. The value of ∑SFA % was 49.527 % vs., 47.643 for ∑USFA %. However, the value of mono unsaturated fatty acid (∑MUF %) was 45.552 vs., 2.091% of polyunsaturated fatty acid (∑ PUFA %). It is interesting to note that, when experimental diets inclusion different levels of by- product POE there were an increase of either ∑SFA % or ∑USFA %, where the highest values recorded for diet inclusion 30% followed in descending order by diets inclusion 25, 20, and 15% , respectively.

Growth performance

Table 3 summarizes the effect of dietary treatments on growth performance of Japanese quail. Results indicated that the initial body weight at 7 d of age was similar among the experimental groups reflecting insignificant differences at start. However, body weight at 28 d of age was significantly higher ($P \leq 0.05$) for birds fed diets inclusion 15 and 20% by-product POE, followed in descending order by control group or those fed 25 and 30% by-product POE. However, at the end of experiment, (42 d of age), the body weight exhibited significantly ($P \leq 0.05$) higher values for birds fed diet supplemented with 15, 20 and 25% POE, followed by those fed 30% and control one. Body weight gain was also markedly ($P \leq 0.05$) improved by the inclusion of POE in the diets for all periods of experiment. The highest values of gain observed for birds fed diet inclusion 15, 20 and 25% POE compared with those fed 30% or control one. In contrast insignificant differences were recorded in feed intake, protein and energy intake for different periods of experiment due to inclusion POE. Concerning, FCR calculated during 7-28 d of age, the analysis of variance indicated that there was insignificant differences detected among the experimental groups. While, during the later periods (29-42 and 7-42 d of age), FCR recorded ($P \leq 0.05$) best values for birds fed diets inclusion POE compared with control group. Moreover, the present results indicated that protein and energy efficiency ratio insignificantly affected by the dietary treatments during the first period of experiment (7-28 d), while during the periods 29-42 and 7-42 d of age the analysis of variance indicated that there were pronounced ($P \leq 0.05$) improvements of both traits due to feeding diets inclusion POE compared with control group. Clearly, throughout the trial, no quail died; therefore the survival was 100% among all the dietary treatments. It is observed, the addition of by-product POE to the diet resulted positive effects on growth performance of quail exposed to high environmental temperature.

Blood constituents

Results of blood constituents including hematological and biochemical parameters of birds as affected by dietary treatments are illustrated in Table (4). Results indicated that the values of RBCs count, MCH, WBCs count, hetrophil % and ALT insignificantly affected by the dietary treatments. In contrast, the values of MCV, lymphocyte %, H/L ratio, Hgb and HCT% were significantly ($P \leq 0.05$) affected when inclusion of POE compared with control group. Regarding with the biochemical traits, the analysis of variance indicated that there were marked ($P \leq 0.05$) decreases of lipids, triglycerides, LDL and VLDL for birds fed diets inclusion of POE, where the more pronounced decreases detected for group fed high level 30%, followed by those supplemented with 25, 20, 15% POE and control one. While, the values of HDL significantly ($P \leq 0.05$) increased with the increase POE in the diets. The value of AST exhibited significantly ($P \leq 0.05$) high values for bird's fed diet inclusion 30% POE, followed in descending ordered for those fed 25%, 15%, POE, control and 20 % POE.

Intestinal histomorphometric parameters

The effects of dietary treatments on intestinal histomorphometric parameters for both male and female are shown in Tables (5 and 6) and illustrated in Figures 1 and 2 (a, b, c, d, e). The histomorphometric analysis of duodenum indicated that male fed 15% POE promoted high ($P \leq 0.05$) villus height in comparison with other POE treatment or control group. While, crypt depth of duodenum exhibited high ($P \leq 0.05$) value for birds fed control diet, followed in descending order by those fed 15%, 30%, 20% and 25% POE diets, respectively. Also, villus height in jejunum recorded significantly ($P \leq 0.05$) higher value for male fed 15 % POE compared with other dietary treatment or controls one. However, crypt depth of jejunum male showed the highest value when fed diet inclusion 30% POE, while the lowest value recorded for those fed 20% POE. The villus height and crypt depth recorded for male ileum cut indicated that the highest values observed for birds fed 20% POE compared with other treatments or control group. Concerning the data of former traits recorded for females the analysis of variance indicated that the villus height and crypt depth of duodenum and jejunum recorded significantly ($P \leq 0.05$) higher values for those fed 30% POE, compared with other dietary treatments. Furthermore, the villus height and crypt depth of ileum intestinal of female showed the highest values for birds fed 25%, while the lowest recorded for those fed 30% POE. In general, it is interesting to note that the addition of POE in diets have distinctive impacts on the development of intestine histomorphological parameters.

Digestibility and AME

Results of the effect of diets inclusion different levels of POE on digestibility are presented in Table (7). From the present results it is interesting to note that the increasing amounts of POE in the diets significantly ($P \leq 0.05$) increased the digestibilities of nutrients including, CP, EE and CF. However, AME was also increased with increasing levels of POE supplementation.

Economical efficiency

Results of the economical efficiency of the experimental diets are presented in Table (8). The data indicated that quails fed different levels of POE recorded lower feed cost and higher economical efficiency compared with quails fed control diet. It is clearly indicated that the addition of POE in diet of quail reared under high temperature resulted higher economical efficiency than those fed control diet.

DISCUSSION

Macronutrients and fatty acid profiles of by- product POE vs., experimental diets

Results of macronutrients including GE, AME, CP and fatty acid compositions of POE compared with control diet indicate that POE has high GE and AME (AOCS Lipid Librar, 2013); while, no CP detected in POE. The GE and AME of experimental diets decreased when blend POE in the diets. It is interesting to note that POE contains approximate proportions of each saturated and unsaturated fatty acid, where the highest saturated fatty acid was relatively palmitic acid (C16:0) compared with other saturated fatty acid. The fatty acid compositions are an important criterion to evaluating the use of fat in the intensive feeding of poultry (Burlikowska et al., 2010). Whereas, the highest level of unsaturated fatty acid was oleic acid

(C18:1) compared with other unsaturated fatty acid. The addition of POE in the diets significantly rise the level of single saturated and unsaturated fatty acid, and subsequently increased ∑SFA and ∑UFA%. It is noteworthy; POE contains balanced proportions of both saturated and unsaturated fatty acid. The finding are accordance with Aboua et al. (2009) who showed that palm oil is the only vegetable oil with a balanced composition of saturated and unsaturated fatty acids both in processed and unprocessed forms and it contains carotenoids, phosphatides, sterols, tocopherols and trace metals. Also, Eqbal et al. (2013) found that red palm oil contains 50% saturated fatty acids, 40% monounsaturated fatty acids and 10% polyunsaturated fatty acids. However, we hypothesized that randomization of palm oil would increase its digestibility, in particular that of its C16:0 components.

Growth performance

The present study investigated the effects of inclusion POE on performance of quail. It is observed that no health problems occurred during the trial due to dietary supplementations. Therefore, in this study reported herein, there was marked increase in weight and gain with each increment of POE inclusion. Clearly demonstrated that, birds fed with POE had the highest body weight and gain at 21, 35 and 42 d and the differences were significant compared to control group. The improvement may be attributed to reduce the passage rate of the digesta through the gastrointestinal tract, which allows a better absorption and better utilization, and improved absorption of vitamin A, vitamin E and Ca (Latshaw, 2008). However, the addition of POE as a source of free fatty acids has a main effect on optimum lipid metabolism and subsequent increased body weight. This result confirmed previous findings indicated that high fat diet alleviates the detrimental effects of heat stress on performance, and providing diets with high levels of palm oil enhanced growth performance and survivability of heat-stressed broiler chickens (Zulkifli et al., 2003). It is of interest to mention that feed intake, energy and protein intake were unaffected, when inclusion POE in the diets under the condition of present study. This might be due to birds being able to be trained to adjust their intake of high dietary fat to meet the requirements for dietary fat or energy according to ambient temperature. This confirmed by Htin et al. (2007) who indicated that the feed consumption was not significantly different among groups of broiler chickens which fed diet inclusion palm oil, sunflower oil, fish oil and coconut oil from 21 to 27 and 28 to 34 days of age. In contrast the finding showed that, the addition of POE has positive effect on FCR compared with control one. This may be due to essential fatty acids and unsaturated fatty acids, where reduce the feed passage rate of fatty acids through the digestive system can play a major role in improving FCR, which allows a better absorption of all nutrients present in the diet. Also, the addition of fat to diets, besides supplying energy, improves the absorption of fat-soluble, vitamins, diminishes the pulverulence, where increased the digestibility of fat (Wiseman et al., 1998) and improved use of dietary ME (Nitsan et al., 1997). In this connection, Htin et al. (2007) indicated that broilers fed palm oil diet showed significantly better FCR than those fed control and coconut oil diets. From the previous results it is observed that protein and energy efficiency ratio insignificantly affected during the period 7-28d of age, while they were significantly improved during the later periods of experiment. This result has been similar with Zulkifli et al. (2007) who observed that diets without added fat have lower energetic efficiency (lower energy gain and higher energy losses) with respect to those with added fat. Moreover, the inclusion of fats in the diets increases the palatability of the rations and improves the energy efficiency (Nitsan et al., 1997). On the other hand feeding diets inclusion of POE prevents mortality resulting from the heat challenge. It is observed that chicks remained healthy during the experiment, where there are no mortalities recorded along the experiment. This finding is accordance with Zulkifli et al. (2003) who indicated that providing diets containing 91.1 g/kg of palm oil decreased mortality of heat-stressed broilers. In general, Obua and Obua (2001) showed that palm oil could be included in the diet of broiler up to 30-40% supplementation, without adverse effect on the performance.

Blood constituents

Blood parameters are good indicators of physiological, pathological and nutritional status of an animal and changes in hematological parameters have the potential of being used to elucidate the impact of nutritional factors. For example, haemtological studies are useful in the diagnosis of many diseases as well as investigation of the extent of damage to blood (Togun et al., 2007). With hematological exams, it is possible to qualitatively and quantitatively measure changes in the red and white blood cell fractions as well as changes in cell morphology that can assist in the diagnosis of several diseases and pathologies (Fudge, 1997). However, the lack of adequate data on the role of POE in altering blood parameters in poultry requires further research. In present study, it is observed most hematological parameters significantly improved due to adding POE in the diets at 42 d of age. The RBCs number, being an index of the oxygen transfer capacity of the blood, is used as an indicator of health in birds (Sergent et al., 2004). Low RBCs number can indicate illness and associated with reduction in body mass (Artacho et al., 2007), might also be a sign of anaemia, since RBCs production depends on the nutritional status. In the present results RBC's count, which is within the physiological rang and insignificantly affected by the addition of POE in the diet, which could be explained by the normal blood values for a normal growth of birds. However, the values of MCV and MCHC indicated that birds fed POE have higher value than those recorded for control, while MCH insignificantly affected. The finding indicated that, WBCs insignificantly affected due to inclusion POE in the diets. Since WBCs from the basis of the immune system of an organism, their elevated numbers (Leukocytosis) are symptomatic of stress syndrome and inflammatory processes (Norris and Evans, 2000). The ratio of the most numerous leukocytes in birds, i.e. the hetrophil/ lymphocytes ratio (hereafter H/L) is often used as a stress indicator in birds (Maxwell, 1993). It increases in response to various stressors, including infectious diseases, parasite infestation, food or water deprivation, temperature extremes and psychological disturbance, thus unlike the corticosterone level in blood, it is not so rapidly affected by handling or blood sampling stress (Davis et al., 2008). In this study, H/ L ratio significantly decreased with duration of heat exposure, reflecting no stress or problems occurred due to the addition of POE in the diet. In this respect, Htin et al. (2007) showed that chicks fed diet contain palm oil had significantly lower H/L ratio than those of chicks fed diet contains sunflower oil, fish oil and control following heat exposure. However, hematocrit (HCT %) and hemoglobin (Hgb) are an important indicator of hematological status in birds. The improvements for both traits due to feeding POE may attribute to alteration in the fluidity and composition of the plasma cell walls. The present results indicated that inclusion level of POE in diets decreased the concentrations of lipid profile including total lipids, total cholesterol, triglycerides, LDL, VLDL, while HDL significantly increased. From the present results, it becomes clear that feeding diets inclusion POE greatly decreased lipids profile, this may attributed to the presence of polyunsaturated fatty acids from direct deposit from the diet (more likely) or conversion from precursors by de novo synthesis (desaturation and elongation) in the liver and tissue. Occasionally, red palm oil is rich in plant sterols which competitively block cholesterol uptake, reducing dietary cholesterol uptake and thereby contributing to reducing plasma cholesterol levels (Carr et al., 2002). In this connection, Guyton and Hall (1996) showed that increased serum HDL is able to decrease the negative effect of high blood cholesterol. The findings of Svedova et al. (2008) observed that serum total cholesterol and HDL-cholesterol concentrations decreased and increased, respectively, in laying hens fed a diet containing 3% linseed oil. However, the present study indicated that AST significantly increased for birds fed different levels of POE, but the level was in a normal range, while ALT insignificantly affected. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) are tissue enzymes that catalyses the transfer of amino and keto groups between alpha-amino acids and alpha-keto acids hence they are called transferase (Stroev and Makarova, 1984). In this study, the result showed a significant increase ($P<0.05$) in the activity of AST, while ALT insignificantly affected. Both enzymes were studied to evaluate liver malfunctions and used in diagnosis and monitoring of hepatic injury. Liver enzymes levels are usually raised in acute hepatoxicity, but tend to decrease with prolonged intoxication due to damage to the liver (Obi et al., 2004).

Intestinal histomorphometric parameters

In fact, intestinal morphology is a main indicator of gut health and its functional status. Intestinal histomorphometric data showed that the quail fed POE had higher villi and deeper crypts in duodenum, jejunum and ileum than control, where the addition of POE provoked increase of the intestinal mucosa. Villus height and surface area can be considered as indicators of nutrients' absorption capacity. The results of present study showed that inclusion of POE can improve histomorphometric parameters, may attributed to an increased villus height is paralleled by an increased digestive and absorptive function of the intestine due to increased absorptive surface area, expression of brush border enzymes and nutrient transport systems (Amat et al., 1996). This can partly explain the mechanism for previously described positive effects of POE on body weight and performance. However, small intestine, especially crypt and villi of the absorptive epithelium, play a significant role in the final phase of nutrient digestion and absorption (Wang and Peng, 2008). In addition, the absorption of nutrient takes place via intestinal villi with a height range from 0.5 to 1.5 μm (Julendra et al., 2012). Shorter villi and deeper crypts have been reported in some conditions, such as the presence of toxins and the increase of pathogenic bacteria in the intestinal lumen, which are related to fewer absorptive functions and more secretory cells (Nain et al., 2012). The finding is agreed with Xia et al. (2004) who indicated that longer villus could be considered as an indicator of an active functioning of intestinal villi. Also, increased villi height provides more surface area for nutrients absorption. The information obtained in this study demonstrates that parameters of nutrient digestibility can be useful tools for assessing intestinal health conditions and, when associated with intestinal histomorphometry values, amplify the possibilities of understanding the function of the gastrointestinal tract when facing heat stress challenges. Awad et al. (2009) showed that villus condition is a common criteria measurement for investigation of the effects of nutrition on gut physiology. On the contrary, reduction in villus height can reduce nutrient absorption due to the decrease in the intestinal surface area for absorption. Thus, reduction in nutrient absorption, decreased resistance to disease and lower growth performance and increase in secretion of gastrointestinal tract are the negative consequences of deeper crypt and shorter villi (Xu et al., 2003). Therefore, our results are in accordance with Abdulla et al. (2016) who found that the duodenum and jejunum of birds fed sunflower oil and palm oil showed greater villus height compared with those fed linseed oil in both the starter and finisher phases. Clearly, it is observed that supplementation of POE in the quail diet markedly improved gut health by enhancing duodenal villus height and wider crypt depth.

Digestibility

There has been considerable interest in the use of POE to enhance nutrient digestibility in quail. In this study, it also notice that birds fed diet inclusion POE have a significantly higher digestibility compared with the control group. However, the addition of POE would increase the digestibility of CP, EE and CF, this attributed to POE reduces the passage rate of the digesta in the gastrointestinal tract, which allows a better absorption of all diet nutrients (Palmquist, 2002). It is appeared that, there was a significantly higher fat digestibility when addition POE, this could be attributed to high energetic efficiency of POE. The results of the current research also demonstrated an increase of AME with the increase of POE addition; this may be due to POE releasing molecules bound to be utilized for energy. Dietary POE still improves energy utilization but through mechanisms not accounted for by the AME procedure. We hypothesized that randomization of palm oil would increase its digestibility, in particular that of its C16:0 components. Generally, the addition of POE to diets, besides supplying energy improve the absorption of fat soluble vitamins, provides varying quantities of the essential fatty acids, diminishes the dustiness, improves the palatability of the diets by reducing the passage rate of the digested nutrients in the gastrointestinal tract (Baiao and Lara, 2005).

Economical efficiency

On the economics point of view, due to the high cost of dietary energy in the Middle East, it is important to continually evaluate the source as well as the level of energy in practical type diets. The proportion of corn in monogastric tropical diets ranges from 50 to 70%, which implies that increasing cost of corn as is being currently experienced due to low level of production and higher consumption rates by man and agro-industries. In Egypt, the bulk of the feed cost arises not only from protein concentrates such as soybean meal but also from the corn, which is the main energy concentrate. There is constant need to search for cheaper sources of energy ingredients which attract less competition between human and livestock/agro-industries. One of advocated alternative for partial replacement of corn in animal diets is the processed addition of POE in diets. Nevertheless, data presented in Table 7, indicated that both net revenue and economical efficiency markedly increased by the inclusion of POE in diets compared with control group. It is clearly, observed that, POE inclusion diet exhibited the best economic efficiency value, and may attribute to the high body weight gain and the best FCR ratio. Subsequently, the addition of POE in quail diet lowered fed cost and improved economical efficiency. Results obtained by Htin et al. (2007) found that on the economics point of view, although the mortality rate of the palm oil group was eight times higher than their control counter parts, the extra body weight gain (418 g) and superior FCR of the former can be sufficient to compensate for the higher mortality rate. However, Ibrahim et al. (2014) indicated that broiler chickens fed diets inclusion palm oil exhibited the best economical efficiency value which being 103.61%, followed by those of distillated fatty acids diet (102.54%), fatty acids diet (97.1%) and finally the dry fat diet (96.34%).

CONCLUSION AND APPLICATIONS

In summary, based on the obtained results, it might be concluded that the addition of POE significantly improved either performance or physiological status. Therefore, feeding Japanese quail on diets inclusion different levels of POE increased economical efficiency and alleviating the adverse effects of heat stress.

Table (1): The Ingredients and chemical compositions of experimental diets.

Ingredients	Substitution by-product POE levels (%)				
	T1 (0%)[1]	**T2 (15%)**	**T3 (20%)**	**T4 (25%)**	**T5 (30%)**
Ground yellow corn (8.5%)	55.570	37.665	29.860	23.776	17.211
Soybean meal (44%)	30.40	33.70	26.350	25.0	25.82
Gluten (62%)	9.0	6.600	10.0	10.0	10.0
Wheat bran (15.7%)	1.730	12.395	22.104	27.561	31.279
By product POE	-	5.870	7.827	9.783	11.740
Calcium carbonate ($CaCo_3$)	1.20	1.0	1.0	1.0	1.0
Di-calcium phosphate ($CaHPO_4$)	0.90	1.7	1.70	1.70	1.7
Sodium chloride (Na Cl)	0.3	0.3	0.30	0.3	0.3
DL- Methionine	0.07	0.10	0.102	0.08	0.09
L- Lysine (Hcl)	0.33	0.17	0.257	0.30	0.360
Premix[2]	0.50	0.50	0.50	0.50	0.50
Total (Kg)	100.00	100.00	100.00	10.00	100.00
Calculated diet compositions:					
CP (%)	24.34	24.21	24.29	24.0	24.0
ME (Kcal/kg)	2912	2934	2942	2937	2949
EE (%)	2.56	7.30	9.25	10.90	12.55
CF (%)	3.70	4.70	5.04	5.55	5.92
Ca (%)	0.80	0.89	0.90	0.91	0.91
Available phosphorous (%)	0.30	0.48	0.46	0.47	0.44
Lysine (%)	1.30	1.30	1.30	1.30	1.30
Methionine (%)	0.50	0.50	0.50	0.50	0.50
Methionine + Cystine (%)	0.90	0.90	0.92	0.91	0.91
Chemical diet compositions:					
CP (%)	24.13	24.26	24.30	24.09	24.04
Gross energy (Kcal/kg)	4054.7	4282.3	4470.7	4570.0	4791.3
EE (%)	3.02	7.50	9.22	10.93	12.60
CF (%)	3.77	4.71	5.09	5.59	5.96
Price cost /kg (E.P)[3]	3.27	2.88	2.87	2.75	2.71

1= Control group

2- Each 3 kilogram of mineral and vitamin premix contains: Vit. A 12000000IU;Vit. D3 2200000IU;Vit. E 10000IU;Vit. K 2000 mg;Vit. B1 1000 mg; Vit. B_2 4000 mg; Vit. B12 10mg;Vit. B6 1500 mg; Niacin 20000 mg; Pantothenic acid 10000 mg; Folic acid 1000mg;Biotin 50 mg; Cholin chloride 50000mg;Copper 10000mg; Iodine 1000mg; Iron 3000mg;Zinc 5000mg; Manganese 5500 mg and Selenium10mg.

3= Egyptian pound

Table (2): Macronutrients and major fatty acid profile (% of methyl esters) of by-product PO compared with experimental diets

Items	Substitution by-product POE levels (%)					
	POB[1]	T1[2] (0%)	T2 (15%)	T3 (20%)	T4 (25%)	T5 (30%)
Macronutrients						
Gross energy (Kcal/Kg)	9600	4054.7	4282.3	4470.7	4570.0	4791.3
AME (Kcal/Kg)[3]	8561*	2913.3	2922.3	2926.0	2923.7	2927.5
CP (%)	-	24.13	24.26	24.30	24.0	24.04
SFA(%)[4]						
Caproic (C6:0)						
Caprylic (C8:0)	1.120	1.122	1.170	1.201	1.208	1.222
Capric (C10:0)	0.190	0.201	0.235	0.255	0.265	0.281
Lauric (C12:0)	0.220	0.233	0.270	0.291	0.303	0.309
Myristic (C14:0)	15.407	15.420	15.493	15.502	15.510	15.512
Palmitic (C16:0)	6.154	6.170	6.207	6.287	6.291	6.299
Stearic (C18:0)	16.194	16.201	16.303	16.335	16.392	16.400
Behenic acid (C22:0)	8.215	8.235	8.273	8.301	8.323	8.330
Arachidic acid (20:0)	1.039	1.126	1.190	1.195	1.210	1.215
		1.080	1.190	1.212	1.222	1.429
USFA (%)[5]						
Palmetoleic (C16:1)	0.988	1.277	1.299	1.303	1.332	1.341
Oleic (C18:1)	1.246	38.171	38.191	38.213	38.239	38.242
Linoleic (C18:2)	38.145	1.516	1.523	1.550	1.571	1.580
Linolenic (C18:3)	1.515	0.530	0.559	0.601	0.622	0.630
Vaccinic acid (C18:1 ω7)	0.526	5.222	5.278	5.301	5.318	5.326
Gadolic acid (C20:1)	5.211	0.630	0.642	0.650	0.676	0.680
Erucic (C22:1)	0.625	0.335	0.371	0.380	0.391	0.401
Eicosapentenoic acid	0.325	0.040	0.133	0.140	0.178	0.189
(EPA) C20:5	0.035	0.018	0.098	0.148	0.162	0.166
Docosahexaenoic acid	0.015					
(DHA) C22:6						
∑SFA (%)	49.527	49.788	50.394	50.579	50.724	50.997
∑UFA	47.643	47.739	48.094	48.286	48.489	48.555
∑MUFA	45.552	45.635	45.781	45.847	45.956	45.990
∑PUFA	2.091	2.104	2.313	2.439	2.533	2.566
Other unknown %	2.83	2.473	1.512	1.135	0.787	0.448

1- POE = by-product Palm oil extraction

2-Contro diet, 3-AME = Apparent metabolizable energy calculated using the method described by Sibbald (1976), 4-SFA = Saturated fatty acid, 5-USFA = Unsaturated fatty acid

Table (3): Productive performance of Japanese quail fed diets inclusion different levels of by- product POE (Means ±SE).

Items	Substitution by-product POE levels (%)					
	T1(control)	**T2 (15%)**	**T3 (20%)**	**T4 (25%)**	**T5 (30%)**	**Sig.**
BW[1]						
7 d	30.27±0.02	30.28±0.02	30.29±0.01	30.31±0.02	30.32±0.01	NS
28 d	148.09^{b}±0.99	153.28^{a}±2.11	152.56^{a}±0.16	143.57^{c}±0.19	141.62^{c}±0.32	*
42 d	193.53^{c}±1.40	208.92^{a}±1.14	206.41^{a}±1.12	205.64^{a}±1.14	199.76^{b}±0.64	*
Gain						
7-28 d	117.81^{ab}±1.02	123.0^{a}±2.11	122.27^{ab}±0.17	116.58bc±3.44	111.29^{c}±0.31	*
29-42 d	45.44^{b}±0.61	55.64b±1.42	53.85^{c}±1.04	62.07^{a}±0.99	58.14^{b}±0.37	*
7-42 d	163.25^{b}±1.42	178.64^{a}±1.12	176.12^{a}±1.13	178.65^{a}±1.15	169.43^{b}±0.71	*
FI[2]						
7-28	317.43±8.46	306.67±1.06	300.39±1.27	296.47±1.07	299.6±4.96	NS
29-42	272.22±8.33	261.75±3.28	262.38±7.31	259.70±3.05	254.41±3.9	NS)
7-42	589.65±1.35	568.42±1.38	562.77±2.0	556.17±1.28	554.01±1.70	NS
FCR[3]						
7-28 d	2.69±0.07	2.49±0.07	2.45±0.10	2.54±0.09	2.69±0.04	NS
29-42 d	5.99^{a}±0.24	4.71^{b}±0.17	4.87^{b}±0.09	4.18^{c}±0.10	4.37^{bc}±0.08	*
7-42 d	3.61^{a}±0.11	3.18^{b}±0.08	3.19^{b}±0.09	3.17^{b}±0.07	3.27^{b}±0.05	*
PI[4]						
7-28 d	76.57±2.06	74.40±2.59	72.99±3.10	71.50±2.82	72.02±1.19	NS
29-42 d	65.69±2.02	63.50±0.80	63.76±1.77	62.56±0.73	61.16±0.97	NS
7-42 d	142.26±3.25	137.90±3.35	136.75±4.87	133.56±3.08	133.18±1.93	NS
EI[5]						
7-28 d	924.03±2.46	896.18±3.11	878.95±3.73	866.88±3.13	872.24±1.45	NS
29-42 d	792.47±2.43	764.86±9.58	767.74±2.14	759.36±8.92	744.90±1.15	NS
7-42 d	1716.5±3.93	1661.04±4.63	1646.69±5.87	1626.24±3.75	1617.14±3.52	NS

Continue Table (3):

PER[6]						
7-28 d	1.54±0.04	1.65±0.04	1.68±0.06	1.63±0.09	1.54±0.02	NS
29-42 d	0.69^{d}±0.03	0.87^{c}±0.03	0.84^{c}±0.14	0.99^{a} ±0.02	0.95 ^{ab}±0.02	*
7-42 d	1.15^{b}±0.03	1.30^{a}±0.03	1.29^{a}±0.04	1.31^{a}±0.03	1.27^{a}±0.02	NS
EER[7]						
7-28 d	12.77±0.37	13.73±0.39	13.95±0.55	13.48±0.66	12.69±0.19	NS
29-42 d	5.52^{d}±0.21	7.27^{bc}±0.15	7.02^{c}±0.13	8.17^{a}±0.35	7.80^{ab}±0.21	*
7-42 d	9.52^{b}±0.29	10.75^{a}±0.29	10.71^{a}±0.32	10.79^{a}±0.25	10.40^{a}±0.16	*
MO %[8]	0	0	0	0	0	-

^{a,b,c} ...Rows means with different superscripts differ significantly at * P ≤0.05

1-BW (g) =Body weight, 2-FI= Feed intake (g/bird /week), 3-FCR =Fed conversion ratio (g feed/g gain), 4-PI= Protein intake (g/bird), 5-EI= Energy intake (Kcal/bird), 6- PER= Protein efficiency ratio calculated as weight gain divided by protein intake (Kamran et al., 2008), 7- (EER= Energy efficiency ratio calculated as weight gainx100/total ME intake (Kamran et al., 2008), 8-MO=Mortality rat

Table (4): Blood constituents of Japanese quail at the end of experimental period fed diets inclusion different levels of by- product POE (Means ±SE).

Parameters	Substitution by-product POE levels (%)					
	T1 (control)	T2 (15%)	T3 (20%)	T4 (25%)	T5 (30%)	Sig.
Hematological traits						
RBCs (M/µL)[1]	3.32±0.2	3.34±0.3	3.63±0.4	3.89±0.14	3.65± 0.2	NS
MCV(fL)[2]	$85.82^{c}\pm1.3$	$87.99^{abc}\pm1.2$	$88.90^{ab}\pm0.3$	$86.27^{bc}\pm0.7$	$89.08^{a}\pm0.3$	*
MCH(pg)[3]	30.16±0.8	31.87±1.2	30.73±0.9	32.12±0.9	31.81±0.6	NS
MCHC (g/dL)[4]	$39.03^{c}\pm0.6$	$40.37^{b}\pm0.7$	$41.11^{a}\pm0.8$	$41.44^{a}\pm0.9$	$41.80^{a}\pm0.9$	*
WBCs (K/ µL) [5]	8.29±0.3	8.21±0.3	8.32±0.4	8.19±0.5	8.43±0.1	NS
Hetrophil (%)	29.73±0.4	29.01±0.4	30.30±0.5	29.08±0.4	29.93±0.4	NS
Lymphocyte (%)	$60.70^{b}\pm1.6$	$62.5^{ab}\pm0.4$	$65.45^{a}\pm0.5$	$67.45^{a}\pm3.2$	$68.71^{a}\pm0.8$	*
H/L ratio [6]	$0.48^{a}\pm0.04$	$0.46^{b}\pm0.02$	0.46b±0.06	$0.43^{c}\pm0.04$	$043^{c}\pm0.1$	*
Hgb (g/dL)[7]	$14.28^{b}\pm1.0$	$14.23^{b}\pm0.6$	$15.33^{ab}\pm0.7$	$15.96^{ab}\pm0.4$	$17.28^{a}\pm0.6$	*
HCT (%) [8]	$37.73^{b}\pm1.1$	$40.68^{a}\pm0.6$	$40.58^{a}\pm0.8$	$40.75^{a}\pm0.6$	$41.26^{a}\pm0.5$	*
Biochemical traits						
T.L (mg/ dL)[9]	$834.45^{a}\pm7.3$	$764.72^{b}\pm9.4$	$704.42^{c}\pm1.8$	$646.80^{d}\pm40.5$	$570.40^{e}\pm1.2$	*
T. TGR (mg/ dL)[10]	$159.44^{a}\pm4.6$	$143.87^{b}\pm4.1$	$141.50^{b}\pm6.1$	$122.23^{c}\pm3.0$	$104.23^{d}\pm4.4$	*
T.COL (mg/ dL)[11]	$195.12^{a}\pm4.2$	$166.28^{b}\pm2.3$	$160.47^{b}\pm1.5$	$137.72^{c}\pm3.3$	$121.39^{d}\pm2.2$	*
HDL (mg/ dL)[12]	$42.15^{d}\pm0.8$	$46.95^{c}\pm2.0$	$54.10^{b}\pm1.5$	$63.68^{a}\pm1.0$	$66.35^{a}\pm1.6$	*
LDL (mg/dL)[13]	$149.88^{a}\pm0.6$	$135.54^{b}\pm3.3$	$111.75^{c}\pm3.9$	$94.82^{d}\pm2.1$	$75.54^{e}\pm2.9$	*
VLDL (mg/dL)[14]	$71.93^{a}\pm2.0$	$63.72^{b}\pm2.8$	$60.3^{bc}\pm2.2$	$55.43^{c}\pm2.1$	$48.06^{d}\pm2.4$	*
AST (U/L)[15]	$35.16^{bc}\pm1.8$	$34.50^{bc}\pm2.3$	$31.83^{c}\pm1.4$	$40.66^{ab}\pm2.0$	$42.83^{a}\pm2.7$	*
ALT (U/L)[16]	28.50±2.5	29.33±2.2	28.0±1.9	33.50±2.5	33.16±2.7	NS

[a,b,c]Rows means with different superscripts differ significantly at * $P < 0.05$

1-RBCs = red blood cells, 2-MCV= mean corpuscular volume, 3-MCH=Mean corpuscular hemoglobin 4- MCHC = Mean corpuscular hemoglobin concentration 5- WBCs = while blood cells, 6-H/L = Hetrophil/ Lymphocyte ratio, 7- Hgb= hemoglobin, 8-HCT= Hematocrit, 9-TL=Total lipids, 10-T.TGR=Total triglycerides, 11- T.COL=Total cholesterol, 12- HDL=High density lipoprotein, 13-LDL= Low density lipoprotein, 14-VLDL= Very low density lipoprotein, 15-AST= Aspartate Aminotransferase, 16- ALT=Alanine Aminotransferase

Table (5): Intestinal histomorphological parameters of male Japanese quails fed diets inclusion different levels of by- product POE (Means ±SE).

Substitution by-product POE levels (%)	Duodenum		Jejunum		Ileum	
	villus height (µm)	Crypt depth (µm)	villus height (µm)	Crypt depth (µm	villus height (µm)	Crypt depth (µm)
T1 (control)	600.85^{e} ±2.88	293.44^{a} ±1.73	651.37^{b} ±0.57	111.41^{d} ±0.57	412.60^{b} ±1.15	95.33^{d} ±0.57
T2 (15%)	1062.28^{a} ±1.15	238.42^{b} ±1.73	720.50^{a} ±2.88	207.75^{b} ±1.15	287.93^{e} ±1.15	116.55^{b} ±1.15
T3 (20%)	948.86^{b} ±4.61	170.72^{d} ±2.88	458.55^{e} ±1.15	89.05^{e} ±0.57	756.24^{a} ±0.57	136.01^{a} ±0.57
T4 (25%)	682.43^{c} ±1.15	129.41^{e} ±0.57	508.04^{d} ±0.57	117.02^{c} ±0.57	386.53^{c} ±0.57	108.76^{c} ±1.15
T5 (30%)	618.35^{d} ±1.73	189.88^{c} ±0.57	607.79^{c} ±0.57	236.75^{a} ±0.57	314.53^{d} ±1.15	78.44^{e} ±0.57
Overall means	782.55 ±5.01	204.37 ±1.51	589.25 ±2.53	152.40 ±1.56	431.57 ±4.50	107.0 ±5.20
F. value	622.3	133.8	528.6	802.7	380.7	642.13
Sig.	*	*	*	*	*	*

[a,b,c] Column means with different superscripts differ significantly at * P <0.05

Table (6): Intestinal histomorphological parameters of female Japanese quails fed diets inclusion different levels of by- product POE (Means ±SE).

Substitution by-product POE levels (%)	Duodenum		Jejunum		Ileum	
	villus height (µm)	**Crypt depth (µm)**	**villus height (µm)**	**Crypt depth (µm)**	**Villus height (µm)**	**Crypt depth (µm)**
T1 (control)	881.84^{d} ±0.57	168.36^{d} ±1.37	666.65^{d} ±3.46	130.49^{b} ±0.57	521.53^{d} ±0.57	113.49^{c} ±.57
T2 (15%)	485.73^{e} ±2.88	194.55^{c} ±2.30	713.96^{c} ±1.73	98.91^{d} ±0.57	600.43^{b} ±1.15	129.27^{b} ±1.15
T3 (20%)	1215.74^{b} ±2.90	101.76^{e} ±13.44	808.35^{b} ±4.61	106.36^{c} ±0.57	554.64^{c} ±0.57	106.36^{d} ±0.57
T4 (25%)	961.60^{c} ±0.58	250.97^{b} ±0.57	642.56^{e} ±1.15	49.82^{e} ±0.57	652.46^{a} ±1.15	137.31^{a} ±1.15
T5 (30%)	1276.95^{a} ±1.10	321.10^{a} ±1.15	886.27^{a} ±0.57	137.31^{a} ±1.15	399.00^{e} ±0.57	98.91^{e} ±0.57
Overall means	964.4 ±7.52	207.35 ±1.98	743.56 ±2.43	104.58 ±8.26	545.61 ±2.28	117.07 ±3.82
F value	622.3	334.8	136.7	223.9	124.7	346.30
Sig.	*	*	*	*	*	*

^{a,b,c} Column means with different superscripts differ significantly at * P <0.05

Table (7): Trail digestibility of Japanese quail fed diets inclusion different levels of by- product POE (Means ±SE).

Parameters	Substitution by-product POE levels (%)					
	T1 (control)	T2 (15%)	T3 (20%)	T4 (25%)	T5 (30%)	Sig.
FI (g)[1]	76.33^{a}±0.66	73.74^{b}±0.25	72.96^{b}±0.95	70.64^{c}±0.16	69.65^{e}±0.18	*
EW(g)[2]	40.66^{c}±0.66	42.14^{c}±0.11	45.06^{b}±0.41	45.24^{b}±0.68	47.37^{a}±0.62	*
MWN (g)[3]						
CP	18.41^{a}±0.16	17.56^{b}±0.06	17.73^{b}±0.23	16.95^{c}±0.04	16.74^{c}±0.04	*
EE	2.30^{f}±0.02	5.40^{e}±0.02	6.72^{c}±0.09	7.72^{b}±0.02	8.77^{a}±0.02	*
CF	2.58^{c}±0.29	3.47^{b}±0.02	3.71^{ab}±0.05	3.92^{a}±0.01	4.12^{a}±0.02	*
MWE (g)[4]						
CP	5.29^{a}±1.13	4.23^{ab}±0.10	3.94^{ab}±0.04	3.28^{b}±0.06	3.34^{b}±0.03	*
EE	1.06^{d}±0.03	2.02^{c}±0.04	2.09^{c}±0.03	2.27^{b}±0.03	2.61^{a}±0.02	*
CF	1.61^{d}±0.008	1.87^{c}±0.008	1.90^{bc}±0.01	1.96^{ab}±0.008	1.98^{a}±0.01	*
DC(%) [5]						
CP	65.84^{c}±0.72	76.35^{b}±0.55	77.77^{b}±0.18	80.61^{a}±0.43	80.01^{a}±0.13	*
EE	53.70^{c}±1.10	62.49^{b}±0.66	68.91^{a}±0.60	70.61^{a}±0.38	70.22^{a}±0.27	*
CF	43.79^{d}±0.71	45.97^{c}±0.07	48.84^{b}±0.44	49.95^{b}±0.18	51.64^{a}±0.06	*
GE [6]						
in diets	4054.7^{e}±2.24	4282.3^{d}±4.09	4472.0^{c}±1.76	4570.0^{b}±6.08	4791.3^{a}±4.97	*
in excreta	2144.7^{d}±1.27	2396.0^{c}±1.30	2504.7^{b}±5.0	2571.0^{b}±1.98	2740.0^{a}±4.58	*
AME[7]	2913.3^{bc}±3.31	2907.2^{c}±2.48	2926.0^{ab}±7.09	2923.7^{ab}±4.70	2927.5^{a}±5.0	*

^{a,b,c} Rows means with different superscripts differ significantly at * $p < 0.05$

1-FI=Feed intake, 2-EW=Excreta weight, 3- MWN= Mean weight of nutrients in feed (g), 4-MWE= Mean weight of nutrients in excreta (g), 5- DC (%) = Digestion coefficient (%), 6-GE (kcal/Kg DM) = Gross energy, 7-AME (kcal/g) =Apparent metabolizable energy

Table (8): The economical efficiency of the experimental diets.

Items	T1 (control)	T2 (15%)	T3 (20%)	T4 (25%)	T5 (30%)
I BW (g/bird)[1]	30.27±0.02	30.28±0.02	30.29±0.01	30.31±0.02	30.32±0.01
FBW (g/bird)[2]	193.53±1.40	208.92±1.14	206.41±1.12	205.64±1.14	199.76±0.64
FI (g/bird/period)[3]	589.65±1.35	568.42±1.38	562.78±2.0	556.17±1.28	558.06±1.70
Feed cost (kg /LE)	3.27	2.88	2.87	2.75	2.71
Feed cost (LE/chick)[4]	1.79	1.64	1.62	1.53	1.51
Price of chick at 7 d (LE) [5].	1.75	1.75	1.75	1.75	1.75
Cost of husbandry (LE)[6]	1.0	1.0	1.0	1.0	1.0
Total cost (LE/chick)	4.54	4.39	4.37	4.28	4.26
Sale price of one bird (LE)[7]	10.0	10.0	10.0	10.0	10.0
Net revenue (LE)/ bird)[8]	5.46	5.61	5.63	5.72	5.74
REE [9]	120.26	127.79	128.83	133.64	134.74
% control	100	106.26	107.13	111.13	112.04

1-IBW= Initial body weight
2-FBW=Final body weight
3-FI=Feed intake
4-Accodring to the price of different ingredients available in Egypt at 2014
5-Fixed cost
6-Cost of husbandry comprise price of labor, light, drugs and etc.
7-Price of one bird at marketing = 10 LE.
8-Net revenue per unit total cost
9- REE= Relative economic efficiency, assuming that the relative economical efficiency of control group equals 100%.

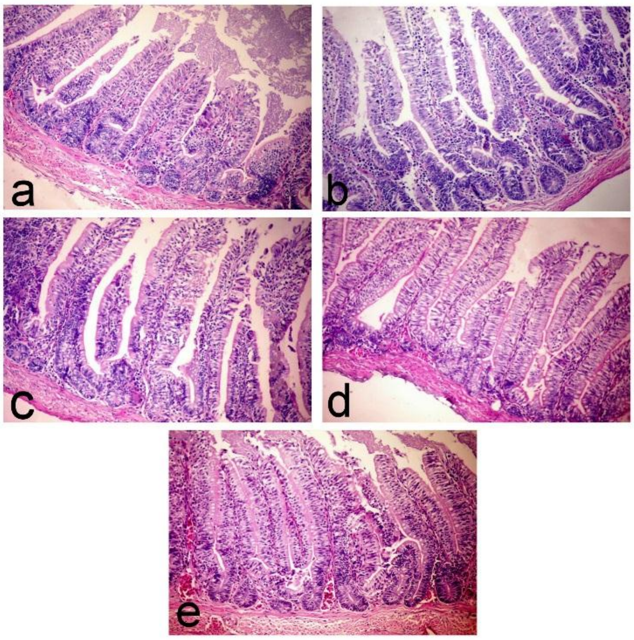

Figure (1): Photomicrograph of intestinal villus and crypt depth of male quails (a) control group, (b) 15% by-product POE, (c) 20% by-product POE , (d) 25% by-product POE and (e) 30% by-product POE (H&E, 10X)

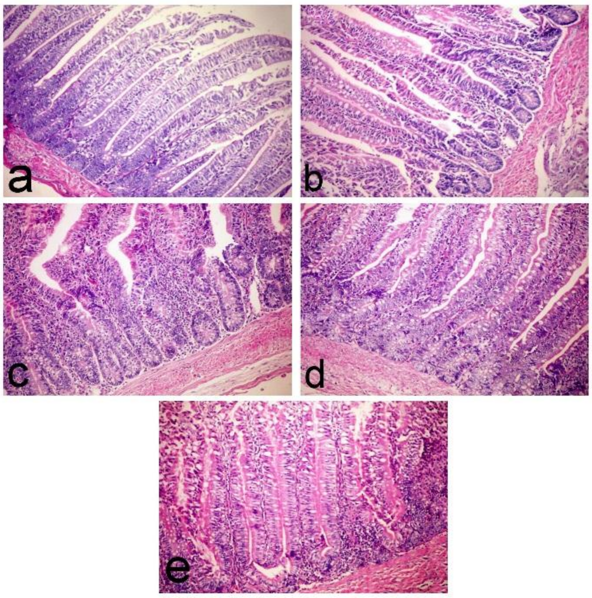

Figure (2): Photomicrograph of intestinal villus height and crypt depth of female quails (a) control group , (b) 15% by-product POE, (c) 20% by-product POE, (d) 25% by-product POE and (e) 30% by-product POE (H&E, 10X)

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الملخص العربى

التعديل الغذائى لتخفيف الإجهاد الحراري وتعزيز الأداء الإنتاجي للسمان الياباني المعرض لدرجة الحرارة العالية

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اجريت هذه الدراسه بغرض بحث آثار استبدال 15 ، 20 ، 25، 30٪ من الطاقة التي توفرها الذرة من المنتج الثانوي لاستخراج زيت النخيل لتعزيز الأداء الإنتاجي ومكافحة الإجهاد الحراري فى السمان الياباني . استخدم عدد 375 كتكوت عمر اسبوع وقسمت عشوائيا إلى 5 مجموعات (75 كتكوت / مجموعة). كل معاملة احتوت على ثلاثة مكررات (25 كتكوت / مكرره). وكانت المجاميع على النحو التالي: T1) عليقه الكنترول (دون أي اضافات)، T2) عليقه الكنترول مع 15٪ من المنتج الثانوي لاستخراج زيت النخيل ، T3) عليقه الكنترول مع 20٪ من المنتج الثانوي لاستخراج زيت النخيل ، T4) عليقه الكنترول مع 25٪ من المنتج الثانوي لاستخراج زيت النخيل ، (T5عليقه الكنترول مع 30٪ من المنتج الثانوي لاستخراج زيت النخيل. من عمر 7 يوم إلى عمر 42 تعرضت جميع الطيور للإجهاد الحراري حيث كان متوسط درجة الحرارة والرطوبة 35 ± 1 درجة مئوية ، 65٪ ± 2٪ رطوبه نسبيه على طول التجربة. وأظهرت النتائج أن الوزن الحي والمكتسب اختلف معنويا بين مجموعات التجربه، حيث سجلت أعلى القيم للطيور التي تغذت على المنتج الثانوي لاستخراج زيت النخيل مقارنة مع مجموعة الكنترول. بينما لم يتاثر استهلاك الغذاء، والبروتين والطاقه الماكوله معنويا بين المجموعات التجريبيه. سجلت نسبة تحويل الغذاء أفضل القيم للطيور التي تغذت على المستويات المختلفة من المنتج الثانوي لاستخراج زيت النخيل مقارنة بمجموعه الكنترول. وعلاوة على ذلك لم يكن هناك نفوق بين المجموعات على طول الفترة التجريبية. كان هناك تحسن معنوى لمعظم الصفات الدموية والكيميائية نتيجه التغذيه على المنتج الثانوي لاستخراج زيت النخيل، حيث انخفضت نسب الدهون بسبب زيادة المنتج الثانوي لاستخراج زيت النخيل في العلائق. اظهرت النتائج ان المقاييس الهستولوجيه للامعاء تحسنت معنويا نتيجه اضافه المنتج الثانوى لزيت النخيل. وعلاوة على ذلك فإن أعلى كفاءة اقتصادية لوحظت بالنسبة للمجموعات التي تغذت على العلائق المحتويع على المنتج الثانوي لاستخراج زيت النخيل. لذلك واستنادا على النتائج الحالية خلصنا إلى أن إضافة المنتج الثانوي لاستخراج زيت النخيل حتى 30٪ إلى علائق السمان لا يؤثر سلبيا على أدائها الإنتاجي أو الحاله الفسيولوجيه فضلا عن ان إضافة المنتج الثانوي لاستخراج زيت النخيل ادى الى الحصول على اعلى كفاءة اقتصادية .