

EFFECTIVENESS OF CAPRYLIC ACID AND YUCCA SCHIDIGERA EXTRACT ON PRODUCTIVE AND PHYSIOLOGICAL PERFORMANCE OF LAYING HENS

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SUMMARY

Caprylic acid (CA) and *Yucca schidigera* (YS) extract have much functional and nutritional properties that may have uses in poultry feeding. These beneficial effects include improvement of productive performance, egg quality immunity, hormones and other blood parameters. This study was conducted to evaluate the effects of dietary supplementation with different levels of CA with constant level of YS extract on productive performance, immunity status and some blood characteristics in laying hens. A total number of 120 *Lohmann Brown* hens 24 weeks old were used in this experiment. The hens were randomly distributed into 8 experimental groups and each group was divided into five replicates three hens each and dietary treatments can describe as follows : (T1): control diet (basal diet without supplement). (T2): basal diet with 100 mg/kg feed of *Yucca schidigera* extract. (T3): basal diet with 500 mg/kg feed of caprylic acid. (T4): basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 500 mg/kg feed of caprylic acid. (T5): basal diet with 1000 mg/kg feed of caprylic acid. (T6): basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 1000 mg/kg feed of caprylic acid. (T7): basal diet with 2000 mg/kg feed of caprylic acid. (T8): basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 2000 mg/kg feed of caprylic acid. Results showed that supplemented laying hen diets with CA and YS were significant differences and led to improve the BW, FI, FCR, egg production and egg mass among the dietary treatments. The egg quality parameters such as egg weight, yolk weight, albumin weight, eggshell weight, eggshell thickness, yolk index, shape index and yolk color in this study were not significantly affected by supplementation of layer chicken diets with different level of CA and YS. The concentration of serum glucose was significantly ($P < 0.05$) increased in all groups compared to control group. Also, the concentration of T_3 and T_4 hormones in serum was significantly ($P \leq 0.05$) increased as the level of CA increased in the layer diets with or without YS compared to control group. While, serum total cholesterol concentrations were significantly ($P \leq 0.05$) decreased as utilization level of CA increased either alone or with YS in the layer diets. The results of H/L ratio were significantly ($P \leq 0.05$) decreased as the level of CA increased in the layer chicken diets specially groups of T7 and T8. The rest of biochemical parameters such as serum IgG, serum total protein, serum albumin and serum globulin The results of these mentioned parameters in this study revealed that dietary inclusion of CA and YS significantly ($P \leq 0.05$) increased concentrations of that parameters as the level of CA increased in the hen diets. Therefore, it is recommended to apply both of CA and YS in layer chicken diets at levels studied without any adverse effect on productive and immunity status of layer hens.

Keywords: Laying hens, productive performance, caprylic acid and *Yucca schidigera*.

INTRODUCTION

In response to decreases in the therapeutic effectiveness of antibiotics for the treatment of bacterial infections in humans, several European countries have banned the use of dietary antibiotics for livestock and poultry (Simon *et al.*, 2003). As a result, there has been a lot of interest in discovering antibiotic growth promoter (AGPs) replacements in livestock feed (Park and Kim 2014; Zhang and Kim 2014). In particular, since the use of antibiotics in feeding has been banned, alternative compounds, such as caprylic acid and herbal plants, have increased in importance.

The poultry sector is continuously searching for new feed additives, to improve the feed efficiency and to appropriate nutrition provision to hen for optimal egg production. Medium chain fatty acids

(MCFAs) have specific nutritional, metabolic and antibacterial effects (Skřivanová *et al.*, 2011). Dietary supplementation with a microencapsulated organic acid blend including MCFAs can improve egg production, egg strength, Haugh units, calcium concentration, and faecal *Lactobacillus* and *E. coli* levels. *E. coli* levels in laying hens (Lee, *et al.*, 2015). Caprylic acid (CA) is a medium-chain fatty acid (MCHA) with eight carbon atoms, found naturally in human breast milk, bovine milk (Jensen, 2002) and in coconut oil (Sprong *et al.*, 2001). Both *in vitro* and fattening experiments have demonstrated that CA favorably influences the digestive tract (Bach and Babayan, 1982).

Some investigators have reported that caprylic acid can be used as anti-microbial activity against a wide range of microorganisms such as *Salmonella enteritidis* and *Campylobacter jejuni* in chicken caecal contents (Wang and Kim 2011) and *Escherichia coli* 0157:H7 in bovine rumen fluid (Annamalai *et al.*, 2004).

In a research on laying hens fed a diet added with caprylic acid, there was a favourable effect on egg weight and feed efficiency, as well as a decrease in serum and yolk cholesterol concentrations and *Escherichia coli* proliferation. (Wang and Kim, 2011). Medium-chain fatty acids (MCFAs) have been demonstrated to be viable replacements for in-feed antibiotics in farm animals due to their high antibacterial action against Gram-positive cocci and *Escherichia coli*. The combination of organic acids (OAs) and MCFAs has been shown to increase broiler nutritional digestibility, growth performance, *Lactobacillus* proliferation, and immunity. (Nguyen and Kim, 2020).

Foley (2021) found that using medium chain fatty acid in laying hen diets was significant improved feed intake and egg weight, and no significant differences were found for egg production, eggshell, breaking strength, eggshell percent, or Haugh unit.

Herbal plants and extracts are gaining popularity in animal and poultry production, as well as health care systems, due to their numerous positive uses such as stimulating growth and production, immune boosting effects, and health protection. (Dhama *et al.*, 2015). The *Yucca* plant or its extract is utilized as a natural additive, taste enhancer, and phytochemical additive for feed in the food and beverage sectors, as well as a phytochemical additive for feed in the animal industry.

The use of *Yucca schidigera* (YS) extract in poultry diets is a viable option for increasing feed effectiveness and performance. (Ayasan *et al.*, 2005). Saponins, the major chemical component of YS extract, present in steroidal form, but in other plants, such as *Quillaja saponaria*, they are present in triterpenoid form (Wang and Kim 2011). *Yucca* saponins have antibacterial characteristics that may function in conjunction with other antibacterial agents such as CA. (Wang *et al.*, 2000a, Wang and Kim, 2011).

Several researches have revealed *yucca*'s biological impacts and protective benefits, including anti-inflammatory, antioxidant, antibacterial, immunomodulatory, and health-promoting properties (Ashour *et al.*, 2014). *Yucca* is a medicinal plant native to the deserts. *Yucca* plant is employed in the pharmaceutical industry as a source of saponins, particularly steroidal saponins. Furthermore, the *yucca* plant contains a variety of polyphenolic compounds, including resveratrol and other phytochemicals such as yuccaols A, B, C, D, and E (Alagawany *et al.*, 2015).

The saponin components and numerous natural biosecurity compounds may be responsible for the positive effects of dietary supplementation with *yucca* on farm animal growth measures, feed consumption, and health condition (Piacente *et al.*, 2005). *Yucca* has been shown to lower NH₃ levels in chicken farms (Johnson *et al.*, 1981) and increase egg production (Ayasan *et al.*, 2005).

Supplementation of *Yucca schidigera* at level of (100 or 200 mg/Kg diet) to lead containing diet was significantly improved the Japanese quail performance parameters to be comparable with the control values. Also, fertility and hatchability at both levels (100 or 200) were improved compared with control group (Alagawany *et al.*, 2018).

On the other hand, Kutlu *et al.* (2001) and Kaya *et al.* (2003) demonstrated that *yucca* supplementation had no effect on productive performance in laying hens and quails, respectively. A steroidal saponin molecule with surface active characteristics and a glycocomponent molecule that binds ammonia are both present in *yucca* extract. Because of these advantages and benefits, researchers decided to employ the *yucca* plant or its derivatives in animal production applications. These advantages and benefits led investigators to use *yucca* plant or its products for animal production applications (Ayasan 2013; Sahoo *et al.*, 2015). The advantages and benefits of both caprylic acid and *yucca* plant led and encourage us to do this study. Therefore, the main objectives of the present study were to assess the effect of different levels of caprylic acid and *yucca* extract on the productive performance, egg quality criteria, and blood metabolites as well as immune response of laying hens.

MATERIALS AND METHODS

Experimental design and diets:

This study was conducted at Poultry Experimental Station belonging to Animal Production Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt, during the winter season from the first of January to the beginning of April 2018.

A total number of 120 *Lohmann Brown* (LB) hens 24 weeks old were used in this experiment. The hens were randomly distributed into 8 experimental groups and each group was divided into five replicates three hens each; three hens were housed per wire pen. The pens were equipped with a nipple drinker and trough feeders. The layer's house was provided with programmable lighting and suitable ventilation. Hens were maintained on a 16-h light +8-h dark cycle during the experimental period. Diets were created to accommodate the nutritional requirements of the Lohmann Brown management guide, which met or surpassed the guidelines of the NRC (1994). Isonitrogenous (18 percent CP) and isocaloric (2800 kcal of ME/kg feed) diets were used in the experiments. The trial phase lasted 12 weeks, from 24 to 36 weeks of age. Dietary treatments were as follows:

(T1): control diet (basal diet without supplement).

(T2): basal diet with 100 mg/kg feed of *Yucca schidigera* extract.

(T3): basal diet with 500 mg/kg feed of caprylic acid.

(T4): basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 500 mg/kg feed of caprylic acid.

(T5): basal diet with 1000 mg/kg feed of caprylic acid.

(T6): basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 1000 mg/kg feed of caprylic acid.

(T7): basal diet with 2000 mg/kg feed of caprylic acid.

(T8): basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 2000 mg/kg feed of caprylic acid.

The diets were prepared in a mash form. The formulation and composition of the basal diet is presented in Table (1).

Table (1): Shows the compositions and calculated analysis of experimental diet.

Ingredient	Quantity (Kg)
Ground yellow corn 8.8%	63.23
Soybean meal 44%	16.50
Corn gluten meal 60%	8.00
Monocalcium phosphate	1.51
Limestone	9.80
Premix ¹	0.30
Sodium Chloride (NaCl)	0.30
DL-methionine	0.19
L-lysine-HCl	0.17
Total (Kg)	100
Calculated analysis ²	
Crude protein%	17.97
ME. Kcal/Kg feed	2798
Calcium%	4.00
Available P.%	0.42
Lysine%	0.86
Methionine%	0.46
Methionine + Cystin%	0.77

¹Each 3Kg of vitamin and minerals mixture contain: Vit. A 10.000.000 IU, Vit. D3 2.000.000 IU, Vit. E 10.000 mg, Vit. K3 2.000 mg Vit. B1 1.000 mg, Vit. B2 5.000 mg, Vit. B6 1.500 mg, Vit B12 10 mg, Niacin 30.000 mg, Pantothenic acid 10.000 mg, Folic acid 1.000 mg, Biotin 50 mg, Choline chloride 500.000 mg, Copper 4.000 mg, Iodine 1.000 mg, Iron 30.000 mg, Manganese 60.000 mg, Zinc 50.000 mg, Cobalt 100 mg and Selenium 100 mg.

²According to NRC (1994).

Data collection and egg production:

Body weight (BW) was determined at the start and end of the experimental period. Feed consumption (FC) was measured as grammes of feed disappearance over 7 days divided by number of bird days corrected for mortalities, whereas feed conversion ratio (FCR) (kg feed/kg egg) was computed as the egg mass (EM) value divided by the quantity of feed eaten. To determine the egg masses (egg number egg weight), egg weight (EW) and egg number (EW) were recorded daily. Egg weight (EW) and egg number were recorded daily to determine the egg masses (egg number × egg weight).

Egg quality criteria:

The external and internal quality of the eggs was evaluated. Egg components were assessed on a monthly basis using ten fresh eggs from each treatment. Before cracking the eggs, they were weighed and their length and breadth were measured. The egg was gently cracked on a glass plate (35×25 cm) to assess both exterior and interior egg quality parameters. Yolk was separated from albumen, and eggshell was cleansed of any albumen that had adhered to it. The albumen weight was determined by subtracting the yolk and shell weights from the total weight of the egg. The ratio of egg width to length was used to compute egg shape indices (Awosanya *et al.*, 1998). Funk *et al.*, (1958) defined yolk index as average yolk height divided by yolk diameter (mm) after removing the yolk from the albumen. Yolk height was determined using a tripod micrometre set to the nearest 0.01 mm, and yolk diameter was determined using a vernier calliper set to the nearest 0.05 mm. The shell thickness of the eggs was measured using a micrometre to determine shell quality. Shell thickness was a mean value of measurements at three regions on the eggs (air cell, equator, and sharp end).

Blood sampling and laboratory:

At the end of the experimental period, blood samples withdrawn from 5 birds of each group and were taken randomly to blood analysis. Birds were fasted overnight before bleeding via jugular vein and blood was collected in unheparinized tubes to determine the blood profiles. Serum was separated and stored frozen at -20 °C until analyzed.

Differential white blood cells were determined according to the procedure outlined by Schalm *et al.* (1975). Serum total protein was determined according to Weichselbaum (1946). Albumin was measured according to Dumas, (1971). The globulin values were obtained by subtracting the values of albumin from the corresponding values of total proteins. Serum glucose was determined enzymatically by commercial kit purchased from Bio-Merieux (Motcyl Etios Charbon Mierels Rains/ France). Total cholesterol was colorimetrically determined in serum according to Zollner and Kirsch (1962). Serum Triiodothyronine (T3) and Thyroxine (T4) concentrations were analyzed by Radioimmunoassay (RIA) method using RIA kits (Amersham International Ltd., Amersham, United Kingdom). Serum immunoglobulin G (IgG) concentration was measured using single radial immuno diffusion technique, as described by Fahey and Mckelvey (1965).

Statistical analysis:

Data were subjected to analysis of variance using the General Linear Models procedure of SPSS software program package (SPSS, 2001, version 11.0). All percentages were first transformed to arcsine being analyzed to approximate normal distribution before ANOVA. Also, significant differences among means were determined by Duncan's multiple range test (Duncan, 1955) at 5% level of significant. Data were analyzed by one way method using the following model:

$$Y_{ij} = u + N_i + e_{ij}$$

Where Y_{ij} = the observed value, u = population means, N_i = the effect of treatment, e_{ij} = the standard error.

RESULTS AND DISCUSSION

Productive results:

Body weight, egg number, egg mass, feed intake and feed conversion ratio:

The effects of caprylic acid (CA) and *Yucca schidigera* (YS) extract supplementation in diet on body weight, egg number, egg mass, feed intake and feed conversion ratio of layer chickens during the experimental period are shown in Table (2). In general, the differences in body weight among the

experimental groups were significant. So, supplementation of layer chicken diets with different level of CA and YS led up to clear numerical increase but not significant in the body weights for groups 2, 3, 4, 5, 6 and 7. While, group 8 was significant ($P \leq 0.05$) higher in the body weight compared to control and other groups. The same trend was observed with the other parameters, where egg number, egg mass and feed conversion ratio were significantly ($P \leq 0.05$) improved for group of T8 which fed a basal diet with 100 mg/kg feed of *Yucca schidigera* extract + 2000 mg/kg feed of caprylic acid compared to the control and other groups. Group of T6 was recorded a higher in feed intake while group of T3 was recorded less in feed intake. Upon these results groups of T8 and T7 were the superior in all measurements mentioned above compared to the control group. The improvement in these parameters could possibly be due to better utilization of nutrients resulting in increased these parameters in the hens fed CA as (MCFAs) with YS in the diets.

Table (2): The effect of caprylic acid and *Yucca schidigera* extract supplementation in diet on body weight, egg number, egg mass, feed intake and feed conversion of laying chickens during the experimental period (24 – 36) weeks of age.

Treat.	Initial body weight (kg/bird) at 24 wk of age	Body weight (kg/bird) at 36 wk of age	Egg number (egg number/bird. day)	Egg mass (egg mass (g)/bird. day)	Feed intake (g/bird. day)	Feed conversion (g feed/1g eggs)
T1 (control)	1.566±0.0	1.621 ^c ±0.02	0.78 ^e ±0.04	46.79 ^c ±2.19	102.64 ^{ab} ±2.01	2.20 ^a ±0.01
T2	1.567±0.0	1.656 ^{abc} ±0.02	0.81 ^{de} ±0.02	47.30 ^{bc} ±1.38	103.64 ^{ab} ±2.10	2.20 ^a ±0.01
T3	1.563±0.02	1.630 ^{bc} ±0.02	0.87 ^{bcd} ±0.02	51.28 ^{ab} ±1.48	102.07 ^b ±2.08	2.00 ^d ±0.01
T4	1.570±0.0	1.655 ^{abc} ±0.02	0.89 ^{abc} ±0.01	52.79 ^a ±1.00	107.72 ^{ab} ±1.88	2.05 ^c ±0.01
T5	1.573±0.0	1.658 ^{abc} ±0.02	0.83 ^{cde} ±0.02	48.71 ^{bc} ±1.48	103.28 ^{ab} ±2.18	2.13 ^b ±0.01
T6	1.583±0.0	1.658 ^{abc} ±0.03	0.91 ^{ab} ±0.02	53.49 ^a ±1.25	108.91 ^a ±2.07	2.05 ^c ±0.01
T7	1.580±0.0	1.710 ^{ab} ±0.03	0.93 ^{ab} ±0.01	54.59 ^a ±1.00	106.83 ^{ab} ±2.25	1.97 ^e ±0.01
T8	1.580±0.0	1.715 ^a ±0.03	0.94 ^a ±0.01	55.10 ^a ±1.00	107.43 ^{ab} ±1.83	1.96 ^e ±0.01

Where: ($M \pm SE$) = Mean \pm Standard Error.

a, b and c = Means within the same column with different superscripts are significantly different ($P \leq 0.05$).

The betterment in feed conversion and significant increase in body weight gain may be due to a synergistic effect of chemical constituents present in *Yucca schidigera* extract such as steroidal saponins and phenolic compounds with CA. These chemical constituents have antimicrobial (Wang 2000a; Wang *et al.*, 2000b; Czczot *et al.*, 2003), antioxidant, anti-inflammatory, anti-carcinogenic, anti-fungal (Olas *et al.*, 2002; Olas *et al.*, 2003), and antiviral (Docherty *et al.*, 1999). The combined effects of these chemical constituents may have increased vitality. *Yucca schidigera* is a major source of natural saponins, which interfere with protozoa development by reacting with cholesterol in the parasite cell membrane, causing parasite death. Saponins have been shown in several studies to promote nutritional absorption by increasing intestinal permeability through membrane depolarization (Wang *et al.*, 1999 and Begum *et al.*, 2015). Based on their emulsifying properties (stabilizing water or oil emulsions) and their role in making monoglycerides more soluble, dietary supplementation with saponins will result in the emulsification of oil fats, promoting their digestion. Furthermore, medium chain fatty acids (MCFAs), which include caproic (C6), caprylic (C8), capric (C10), and lauric (C12) acids, have strong antimicrobial effects and are of nutritional interest because they are absorbed more quickly in the intestine and are used more effectively by animals than long-chain fatty acids. It has been shown that a combination of capric and caprylic acids (20–100 g/kg) can increase average daily growth while having no effect on average daily feed intake in weaned pigs during the first two weeks following supplementation (Rodas and Maxwell 1992).

The reason for the improvement in those parameters could be the direct antimicrobial effect of organic acids (OAs) and MCFAs, which could have resulted in the inhibition of intestinal bacteria, resulting in less bacterial competition with the host for available nutrients and a reduction in toxic bacterial metabolites as a result of lessened bacterial fermentation, resulting in the (Adil *et al.*, 2011). Furthermore, because of their direct delivery via portal circulation to the liver, MCFAs may be a rapidly accessible energy source for young animals, which may explain the observed improvement with the combination of OAs and MCFA supplementation (Odle 1997). MCFAs, like short chain fatty acids, exhibit antimicrobial properties (Skřivanová *et al.*, 2009). The increase in FCR might be attributed to greater nutrient utilisation,

which resulted in higher body weight growth in the birds fed a diet containing a combination of OAs and MCFAs. (Nguyen *et al.*, 2018 and Nguyen and Kim, 2020).

The increase in egg production seen in the medium chain fatty acid group might be attributed to increased nutrient absorption as a result of improved gut health and villi characteristics, since older laying hens are known to have poor gastrointestinal health (Sengor *et al.*, 2007).

Egg quality parameters:

The results of egg quality as affected by supplementation of CA and YS in layer diets are given in Table (3 and 4). The egg quality parameters such as egg weight, yolk weight, albumen weight, eggshell weight, eggshell thickness, yolk index, shape index and yolk color in this study were not significantly affected by supplementation of layer chicken diets with different level of CA and YS. These results may suggest that CA and YS had no beneficial effect on egg quality parameters of layer chickens fed different levels of CA and YS during the experimental period. But it is interesting to observe that increasing the level of CA in the diet increased the egg quality parameters mentioned above numerically but not significant as compared with the control group specially T8, T7 and T6. These results are agreeing with Yesilbag and Çolpan (2006) found that with incorporation of organic acid into the layer diets, the egg weight and egg quality parameters were not affected. In this context, another study displayed that the dietary organic acid supplementation did not significantly affect egg-weight and egg-quality parameters excluding egg weight which was improved by 9.08% (Youssef *et al.*, (2013).

Table (3): The effect of caprylic acid and *Yucca schidigera* extract supplementation in diet on egg weight, yolk weight, albumen weight and eggshell weight of laying chickens during the experimental period (24- 36) weeks of age.

Treatment	Egg weight (g)	Yolk weight (g)	Albumen weight (g)	Eggshell weight (g)
T1(control)	54.23±2.36	13.48±0.49	35.33±2.16	5.42±0.16
T2	56.80±0.86	13.65±0.30	37.33±0.69	5.82±0.40
T3	56.85±1.95	14.17±0.71	37.83±1.65	4.85±0.28
T4	58.80±0.64	14.58±0.56	38.28±0.51	5.93±0.22
T5	59.32±2.63	14.83±0.51	38.95±2.05	5.53±0.33
T6	59.45±2.25	14.03±0.64	39.70±1.47	5.72±0.27
T7	60.18±2.40	14.97±0.57	40.28±2.14	4.93±0.32
T8	60.19±2.35	14.50±0.37	40.37±1.94	5.32±0.13

Where: ($M \pm SE$) = Mean \pm Standard Error.

a, b and c = Means within the same column with different superscripts are significantly different ($P \leq 0.05$).

Table (4): The effect of caprylic acid and *Yucca schidigera* extract supplementation in diet on eggshell thickness, shape index, yolk index and yolk color of laying chickens during the experimental period (24 - 36) weeks of age.

Treatment	Eggshell thickness (mm)	Shape index	Yolk index	Yolk color
T1 (control)	0.312±0.01	0.75 ^{ab} ±0.01	0.41±0.04	10.67±0.21
T2	0.312±0.01	0.74 ^b ±0.02	0.42±0.03	10.85±0.18
T3	0.323±0.01	0.75 ^{ab} ±0.01	0.42±0.03	10.83±0.16
T4	0.332±0.01	0.75 ^{ab} ±0.02	0.40±0.03	11.02±0.25
T5	0.317±0.01	0.76 ^{ab} ±0.01	0.44±0.03	11.10±0.01
T6	0.317±0.01	0.79 ^a ±0.02	0.44±0.04	11.14±0.01
T7	0.327±0.01	0.75 ^{ab} ±0.01	0.43±0.04	11.12±0.01
T8	0.330±0.01	0.79 ^a ±0.03	0.44±0.02	11.20±0.01

Where: ($M \pm SE$) = Mean \pm Standard Error.

a, b and c = Means within the same column with different superscripts are significantly different ($P \leq 0.05$).

On the contrary, Kadim *et al.*, (2008) found that additional acetic acid resulted in a linear rise in external egg characteristics such as egg weight, egg length, egg diameter, and eggshell colour. Organic acid supplementation may increase the integrity of reproductive organs such as the shell gland in the oviduct, resulting in an improvement in eggshell colour. (Park *et al.*, 2009). The above studies suggested

that the improvement in eggshell quality might be a consequence of the increased mineral and protein absorption. The phenomenon of increased absorption is reflected in the increased calcium and protein deposits of the shell and contributes to improving the quality which may result in increased shell weight and thickness. The organic acid had a beneficial effect on calcium digestibility in layers. This may be because the addition of organic acids to the diet lowered diet acidity. Lowering the pH of the diet may enhance the solubility and absorption of minerals, improving the efficacy of calcium (Khan and Iqbal, 2016). Some investigations found that high ambient temperatures reduced the shell weight and thickness of layer eggs, which were considerably improved after organic acid feeding. (Soltan 2008 and Abbas *et al.*, 2013). It has been suggested that this response to organic acid may be influenced by factors such as dietary protein level, calcium level and the bird's metabolic rate (Kadim *et al.*, 2008).

Physiological results:

Serum constituents, serum hormones and serum IgG:

Blood constituents are usually related to the health situation. These constituents are important indices of nutritional and physiological status of poultry. The influence of supplemental CA and YS on some blood metabolites of layer hens are shown in Table (5). Results of serum glucose, serum hormones of T₃ and T₄ and serum cholesterol are presented in Table (5). The results of serum glucose revealed that there were significant differences in the serum glucose concentration among the experimental groups. The concentration of serum glucose was significantly (P<0.05) increased in all groups compared to control group. Moreover, it is noticed that the concentration of serum glucose increased as the level of CA increased in the diets either alone or when combined with YS. Also, the groups of T5, T6, T7 and T8 showed the highest levels of serum glucose concentration which was significantly higher (P<0.05) than control group (Table 5). These results may be attributed to low level of CA group has reduced feed intake and as a result, led to increasing the plasma concentrations of glucose. In addition, the increase of serum glucose concentration compared to control group may indicate an inefficiency of pancreatic function (Meglasson and Hazelwood, 1982).

Table (5): Display the effect of caprylic acid and *Yucca schidigera* extract supplementation in diet on blood parameters of laying hens at 36 weeks of age.

Treatment	Serum Glucose (mg/dl)	Serum T3 (ng/ml)	Serum T4 (ng/ml)	Serum Total Cholesterol (mg/dl)
T1(control)	184.00 ^d ±4.51	2.33 ^f ±0.09	5.43 ^e ±0.19	131.00 ^{ab} ±0.58
T2	215.33 ^c ±4.84	2.50 ^{ef} ±0.06	5.60 ^e ±0.12	133.33 ^a ±0.88
T3	212.67 ^c ±1.45	2.60 ^{de} ±0.06	6.27 ^d ±0.12	132.00 ^{ab} ±0.58
T4	223.67 ^b ±1.00	2.76 ^d ±0.09	6.86 ^c ±0.12	129.00 ^{abc} ±0.58
T5	233.00 ^a ±2.52	3.06 ^c ±0.09	6.93 ^{bc} ±0.19	125.66 ^c ±1.01
T6	235.00 ^a ±1.01	3.66 ^a ±0.09	7.52 ^a ±0.17	127.68 ^{bc} ±0.88
T7	235.32 ^a ±1.45	3.57 ^{ab} ±0.07	7.40 ^a ±0.06	121.03 ^d ±1.22
T8	234.33 ^a ±2.33	3.37 ^b ±0.09	7.31 ^{ab} ±0.06	125.01 ^{cd} ±0.58

Where: (M±SE) = Mean ± Standard Error.

a, b and c = Means within the same column with different superscripts are significantly different (P<0.05).

Results in Table (5) showed significant (P<0.05) elevation in serum concentrations of triiodothyronine (T₃) and thyroxine (T₄) hormones in the experimental groups supplemented with CA and YS either alone or in combination compared to control group. Moreover, the control group exhibited the lowest values in serum T₃ and T₄ hormones among the groups. Also, the concentration of T₃ and T₄ hormones in serum was significantly (P<0.05) increased as the level of CA increased in the layer diets with or without YS which mean that both of CA and YS had beneficial effect on the secretion of these hormones. These results may reflect that CA and YS improved the rate of metabolism for treated groups more than untreated one may be via increase the villi height, villi length and crypt length and width. This increment in villi height and crypt length and width can increase nutrients absorption due to increase of intestinal surface area for absorption (Ribeiro *et al.*, 2007; El-Shafei *et al.*, 2010 and 2013). The sole function of the thyroid gland is to make thyroid hormones. These hormones influence almost all tissues of the body where it increases cellular activity. The function of the thyroid therefore is to regulate the body's metabolism. It has an impact on heart rate, cholesterol level, body weight, energy level, muscular strength, skin condition, eyesight, mental state, and a variety of other factors. Furthermore, both T₃ and T₄ play an important role in physiological activity. Thyroid hormones play an important function in

boosting energy production; a lack of these hormones can cause severe tiredness (Hoffmann, 2003; Mareib and Hoehn, 2007). The thyroid gland synthesizes hormones which work within the body to regulate several functions including metabolism and growth. When the body experiences a deficiency in thyroid secretions, the metabolism slows causing low blood pressure and fatigue. In many cases thyroid function is responsive to herbal remedies and lifestyle changes (Hoffmann, 2003; Mareib and Hoehn, 2007). It is well known that thyroid hormones decreased during hot weather and are involved in the regulation of anabolic and catabolic pathways of protein, lipid and carbohydrate metabolism. On the other hand, in broiler chickens Piracicaba *et al.* (2009) discovered that the rise in T3 of broilers fed with coconut oil (CocO) diets in hot climate conditions may be related to increased energy availability and usage for an anabolic process for muscle growth in broiler chickens. It is demonstrated by an increase in growth rate and FCR during the first 1–21 days, as well as a decrease in liver and fat accumulation in the abdominal cavity of broilers given a CocO-supplemented diet. CocO is a rich source of medium chain fatty acids (MCFA) and saturated fatty acids (SFA) (6–12 carbon atoms) which can be absorbed directly into the portal system without re-esterification in intestinal cells (Piracicaba *et al.*, 2009 and Attia *et al.*, 2020). MCFA are exclusively and rapidly burned to produce energy (Attia *et al.*, 2020)). By contrast, long chain fatty acids (LCFA) is commonly found in most diets and are incorporated into chylomicrons after being absorbed in the intestine, where they are subjected to re-esterification, and then reach the bloodstream via the lymphatic system (Attia *et al.*, 2020).

Concerning to serum total cholesterol concentrations (Table, 5) were significantly ($P \leq 0.05$) decreased as utilization level of CA increased either alone or with YS in the layer diets. The group of T7 and T8 were recorded significantly ($P \leq 0.05$) lower values in total cholesterol in the serum of the layer chickens compared to control and other groups. The reduction in levels of the total cholesterol in serum was increased as CA level increased in the layer chicken diets. In this study, it is observed that the use of combined of CA as MCFAs with YS in the related studies may be more effective than individual adding of YS or CA. The obtained results revealed that CA and YS led to a profound reduction in intestinal cholesterol absorption and may accelerate the rate of fecal neutral sterol excretion. This may be indicating the potential modulatory role of YS on liver function mainly due to yucca saponins and phenolics that showed hypocholesterolemic, antioxidant, hypoglycemic, anti-inflammatory, immunostimulatory, antiviral, anticarcinogenic, and anti-mutagenic activities (Gupta, 2014; Alagawany *et al.*, 2016). According to Rao and Kendall (1986) powder and extracts of saponin-rich plants can affect the lipid metabolism of birds and other animals. Saponins decreased serum cholesterol levels in laying hens (Aslan *et al.*, 2004) and rabbits (Morehouse *et al.*, 1999). Saponins can form compounds with cholesterol, causing it to precipitate, and they can decrease hypercholesterolemia by changing the stability and size of cholesterol micelles, reducing their penetration into mucous membrane cells (Milgate and Roberts, 1995). Furthermore, saponins can decrease cholesterol absorption and promote the outflow of neutral sterols such as plant sterols, cholesterol, coprostanol, and bile acids in faeces (Jenkins and Atwal, 1994). Saponins can also degrade cell membranes and induce cholesterol loss. (Morehouse *et al.*, 1999). Furthermore, the presence of saponins can improve bile acid absorption and create high molecular weight micelles (cellulose saponin–bile acid complexes), preventing bile acid reabsorption and increasing cholesterol conversion to bile acids in hepatic tissue (Sidhu and Oakenfull, 1986). The reduction in cholesterol absorption reduced its hepatic content, which raised the activity of HMG-CoA reductase and increased the number of LDL receptors in the liver. (Harwood *et al.*, 1993 and Alagawany *et al.*, 2018). In addition to that, these results may suggest that the reduction in serum cholesterol may occurs by interfering both of CA and YS with the intestinal cholesterol absorption and inhibit cholesterol absorption. The small intestines are implicated in regulating cholesterol homeostasis through affecting cholesterol absorption. An inhibition of intestinal absorption results in lower levels of circulating cholesterol. Sitosterol, which acts directly at the gut level, reduces plasma cholesterol by decreasing intestinal fractional cholesterol absorption (Ntanios and Jones, 1999). According to Mathivanan and Edwin, (2012) the reduced serum cholesterol in the plant extract (*Andrographis paniculata*) might be attributed to increased activity of the enzyme catalase, which is involved in the esterification of cholesterol in the plasma. Furthermore, when yucca groups were compared to the control diet, cholesterol levels were lower. The disturbance in lipid profile may be attributed to increased biosynthesis and accumulation of cholesterol in liver and/or impaired biliary function (Ashour *et al.*, 2014). In addition to, the decreasing in serum cholesterol may be due to saponin in YS could inhibit cholesterol synthesis and enhance the catabolic pathway (Shi *et al.*, 2014). These findings are agreed with Pasaribu *et al.*, (2014).

The rest of biochemical parameters such as blood H/L ratio, serum IgG, serum total protein, serum albumin and serum globulin are listed in Table (6). When the data of the samples was examined, there were statistically significant ($P \leq 0.05$) differences between the groups in terms of blood H/L ratio, serum IgG, serum total protein, serum albumin and serum globulin concentrations. The results of H/L ratio were

significantly ($P \leq 0.05$) decreased as the level of CA increased in the layer chicken diets specially groups of T7 and T8. In this study, the inclusion of dietary CA and YS extract decreased the ratio of H/L in layer chickens blood. The reduction in the percentage of H/L in layer chicken fed higher level of CA with YS mean that these chickens were not under stress. The significant increase in H/L ratio for laying hens may be referred to heat and alimentation stress during summer season, which deteriorate blood cells synthesis (Oladele *et al.*, 2001 and Awad *et al.*, 2021). These findings are similar with Awad *et al.* (2021) who demonstrated a decrease in leucocytes and lymphocytes (%) during the summer season (June to August) of males Domyati ducklings. Moreover, results of Begum *et al.*, (2015) revealed that the immune related blood profile, WBCs and lymphocyte concentrations were enhanced by the effects of CA and Ys extract. However, the mechanism by which CA and Ys affects immune responses is completely unknown, although it has been stated that the gastrointestinal system and its associated lymphoid tissues play a crucial role in animal immune function (Insoft *et al.*, 2005). Willis *et al.* (2007) suggested that the bursa was the main lymphoid organ in broiler chickens; therefore, an increased relative weight of this organ may be associated with the increased blood lymphocyte counts.

The results of the serum IgG in this study revealed that dietary inclusion of CA and YS significantly ($P \leq 0.05$) increased IgG concentration as the level of CA increased in the hen diets. Groups of T6, T7 and T8 recorded higher ($P \leq 0.05$) values in IgG concentration in hen's serum compared to the control and other groups. Dietary supplementation of CA and YS revealed a positive impact on IgG level which is in accordance with Ashour *et al.*, (2014). Comparing to the control group, supplementation of diets with CA and YS linearly improved IgG level in serum of laying hens. In poultry production sector, it is the most important to enhance immune response to reduce or prevent infectious diseases. There are many different factors such as failure of vaccination; inhibit of antibiotics can induce immunodeficiency. Using immune enhancers is a key solution to improve immunity and to reduce susceptibility to infectious disease in poultry farms. Most medicinal plants, including yucca are rich in flavonoids extend the biological activity and could act as antioxidants, and may enhance immune functions (Acamovic and Brooker 2005). The addition of Yucca to layer diets may boost the immune system due to an increase in immunoglobulin concentrations in layers fed yucca treatments versus the control diet. To activate humoral immune response, it is anticipated that a lower dose of natural phytogetic feed additives will be required. (Alagawany *et al.*, 2016). These results may be due YS phenolic content that acts anti-inflammatory and antioxidant action (Cheeke *et al.*, 2006). Moreover, YS saponin content can provide some immunomodulatory effects (Oelschlager *et al.*, 2019). These results can be explained and discuss as follows, a natural product can act as an immunomodulator through stimulating, suppressing, or modulating the innate or the adaptive arm of the immune response (Patil *et al.*, 2013). Saponins derived from YS could increase the production of cytokines and trigger innate immunity (Song and Hu, 2009), and activate natural immunity as well as enhance antibody humoral and cellular immune responses or in the same sense, stimulate cellular and humoral immunity (Palatnik de Sousa *et al.*, 2004).

Alagawany *et al.* (2016) found that supplementing layer nutrition with yucca powder linearly and quadratically ($P < 0.001$) improved the IgG content. The authors concluded that supplementation of YS powder to layer diets could improve the immune system via improving levels of immunoglobulin compared with the control diet. So, the natural phytogetic additives in feeds at a lower dose may be required to activate a humoral immune response in poultry (Alagawany *et al.*, 2016). From the present study, it was obvious that dietary supplementation of YS improved the immune response, which was evidenced by the significant improvements in immunoglobulin (IgG). This could be probably due to the modulating effect of YS in liver functions including the level of globulin and the antioxidant power of YS. These effects are consistent with some previous reports on the positive effects of YS on immune functions, where YS saponins could enhance cellular and antibody humoral immune responses, stimulate the cytokines secretions, and activate the innate immunity (Palatnik de Sousa *et al.*, 2004). Supplementation of YS powder to broiler chicks stimulated the immune responses (cellular and humoral) (Su *et al.*, 2016). Similarly, YS powder improved IgG content in layer chicken (Alagawany *et al.*, 2016 and 2018).

IgG concentrations are indicators to reflect the humoral immunity situation in chickens. Our view in this point, the improvement in immunity of treated laying hens with CA and YS could be related to the inhibitory effects of CA and YS on gut pathogens. Also, both of CA and YS may be stimulates the immune system in many ways. It could be increases the number of stem cells in bone marrow and lymph tissue and encourages their development into active immune cells. It appears to help trigger immune cells from a "resting" state into heightened activity as Jiao *et al.* (1999) mentioned. As well, CA and YS may also enhance the body's production of immunoglobulin and stimulates macrophages and can help activation of T-cells and natural killer cells as Jiao *et al.* (1999); Thorne, (2003) and El-Shafei *et al.*

(2013) found with some other plants. Furthermore, YS contain varieties of chemical compounds that may have immune-enhancing functions.

On the other hand, there is limited information about the effects of MCFAs on the immune system metabolism in the organism. Saeidi *et al.* (2016) reported that MCFA did not cause a significant change in antibody levels in the body. However, some studies demonstrated that organic acids could stimulate the natural immune response in poultry.

Similarly, Houshmand *et al.* (2012) discovered that adding organic acids to the broiler's feed at 21 days of age resulted in substantial increases in antibody titers against Newcastle disease. However, by 42 days of age, there was no significant difference ($P > 0.05$) between treatments. Similarly, raising formic acid levels enhanced antibody titres against Newcastle disease in laying hens also increased by increasing the levels of formic acid (0.5–1.5 mL/L) (Abbas *et al.*, 2013). Furthermore, Emami *et al.* (2013) discovered that phytase and organic acid supplementation enhanced intestinal integrity and immunological response in broilers given diets deficient in accessible phosphorus. They found that broilers given a Phytase + organic acid diet had higher ($P < 0.001$) immunoglobulin G (IgG) levels in the first reaction, as well as higher ($P < 0.001$) total immunoglobulin and IgG levels in the secondary response, as compared to controls. In another study, Park *et al.* (2009) noticed that immunoglobulin-Y (IgY) levels significantly increased with the addition of organic acids in a layer diet of hens aged 75 weeks with production of 73.3%), and it appeared that adding organic acids to the feed influenced the digestive mucous membrane and improved the immune function.

Chickens produce immunoglobulins against almost all kinds of antigens including bacteria, virus and foreign substances in host defense. Antibodies interfere with the adhesion of pathogens to the intestinal wall and neutralize partially, or completely, their colonization potential (Rutter and Jones 1973; Moon 1981). Once pathogens enter the blood, antibodies induce hypersensitivity, activation of complement system and antibody-dependent cell cytotoxicity to facilitate the clearance of the pathogens. The total IgG in serum is thought to be related to the potential of specific humoral immune responses. Immunoglobulins in avian blood are transferred to the yolks of eggs to give passive immunity to the offspring (Rose and Orleans 1981). As such, the antibodies in eggs originating from the mother hen are used to protect the newly hatched chick from a variety of infectious diseases. The increased serum IgG concentration and IgY in egg yolk by feeding laying hens a n-3 PUFA-rich diet may provide a novel strategy to improve the health of hens and chicks, and thus increase poultry production. However, further experiments are required to better understand the effects of amount and ratio of dietary n-6 to n-3 PUFA, as well as of individual n-6 and n-3 fatty acids on the immune responses and the performance of chickens (Wang *et al.*, 2000c and Amer *et al.*, 2021).

In this study, CA and YS were used. However, more studies may be needed to verify the effects of such materials (CA and YS) on the immune properties of laying hens or in poultry in general.

Impact of different levels of CA with Ys supplementation in layer diets on total serum protein (TP), albumin (ALB) and globulin (GLOB) are presented in Table (6). Results of total serum protein, total albumin and globulin revealed that there were significant ($P \leq 0.05$) increase in TP, ALB and GLOB of treated groups compared with the control group. It is observed that the values of TP, ALB and GLOB were significantly increased as the level of CA with YS increased. The increased contents of TP, ALB, and GLOB in the serum of laying hens by inclusion of CA with YS in the hen diets indicated that the CA with YS affected protein metabolism, which is consistent with the observation of enhanced serum IgG. The increased serum concentration of ALB and GLOB status may be indicative of enhanced immune system as the serum concentration of ALB and GLOB proteins antioxidant status are regarded as the direct reference to the body immune function (Zhang *et al.*, 2013). Increment in serum protein concentration in treated groups as compared to the control group may be attributed to the hormonal regulation of protein metabolism, for example growth hormone increased the synthesis of cellular protein, glucocosteroids increased break down of most tissue proteins. The increasing of corticosterone hormone and glucocorticoids which are secreted by the adrenal cortex increased the quantity of protein in most tissues while decreased the amino acids concentration in the plasma, as well as decreased both liver protein and plasma proteins, or may be due to the decrease of thyroxin secretion, that thyroxin increases the rate of metabolism of all cells and, as a result indirectly affects protein metabolism (Guyton and Hall, 2006; Al-Daraji and Amen, 2011).

The increased serum protein of layers fed CA and YS are in general agreement with the effect of MCFA on improving nutrient absorption including protein. The present results confirmed this effect because the different fish oil and coconut oil sources increased chymotrypsin activity. The increased enzyme activity is associated with raising nutrient digestibility and thus, nutrient absorption (Chwen *et*

al., 2013 and Attia *et al.*, 2018 and 2020). Furthermore, the enhanced in total protein and albumin levels can be clarified by alpha-monolaurin's as medium chain fatty acids (MCFAs) role in improving the feed digestibility and protein level in the blood (Saleh *et al.*, 2021).

Table (6): Exhibits the effect of different levels of caprylic acid and *Yucca schidigera* extract on blood parameters of laying hens at 36 weeks of age.

Treatment	Blood H/L ratio	Serum IgG (mg/dl)	Serum Total Protein (g/dl)	Serum Albumin (g/dl)	Serum Globulin (g/dl)
T1(control)	0.28 ^{ab} ±0.01	8.34 ^c ±0.10	3.33 ^d ±0.01	1.14 ^c ±0.03	2.19 ^c ±0.02
T2	0.29 ^a ±0.01	9.43 ^{bc} ±0.40	3.56 ^{cd} ±0.06	1.21 ^b ±0.01	2.35 ^c ±0.07
T3	0.27 ^{abc} ±0.01	9.42 ^{bc} ±0.72	3.78 ^{bc} ±0.12	1.27 ^a ±0.01	2.51 ^{bc} ±0.11
T4	0.27 ^{abc} ±0.01	9.80 ^b ±0.32	3.74 ^{bc} ±0.05	1.24 ^{ab} ±0.01	2.50 ^{bc} ±0.05
T5	0.25 ^{cd} ±0.01	9.67 ^b ±0.33	4.00 ^{ab} ±0.22	1.21 ^{ab} ±0.02	2.79 ^{ab} ±0.20
T6	0.26 ^{bc} ±0.02	11.25 ^a ±0.37	3.99 ^{ab} ±0.12	1.22 ^{ab} ±0.02	2.77 ^{ab} ±0.12
T7	0.23 ^{de} ±0.01	11.01 ^a ±0.15	4.03 ^{ab} ±0.11	1.20 ^b ±0.03	2.83 ^{ab} ±0.09
T8	0.22 ^e ±0.01	11.13 ^a ±0.28	4.34 ^a ±0.09	1.24 ^{ab} ±0.01	3.09 ^a ±0.08

Where: ($M \pm SE$) = Mean ± Standard Error.

a, b and c = Means within the same column with different superscripts are significantly different ($P \leq 0.05$).

Concentration of globulin is used as an indicator for measuring immunity response. Also, the improvement in bird immunity could be related to the inhibitory effects of CA and YS on gut system pathogens. Globulins, a significant protein family, are an important source of protein found in animal fluids, including enzymes, antibodies, and fibrous and contractile proteins found in blood plasma (Attia *et al.*, 2006). α - and β -globulins are transport proteins, serve as substrates upon which other substances are formed, and perform other diverse functions (Attia *et al.*, 2017).

CONCLUSION

In conclusion, the results of this study indicate that feeds supplemented with CA and YS improved laying hens productive performance and physiological parameters. In addition, layers fed with diet supplemented with CA and YS improved all blood serum parameters investigated, such as improved production of T3 and T4 hormones, improved IgG and globulin values which reflect better immunity for these hens compared to control group. The effect of addition of CA and YS were obviously clear and was more pronounced with increasing level of CA in the diets. Therefore, it is recommended to apply both of CA and YS in layer chicken diets at levels studied without any adverse effect on productive and immunity status of layer hens.

However, we see that the nutritionist and physiologists should consider some important issues such as the type and age of birds, their gastro-intestinal tract microbial ecology, pH and buffering capacity of nutritional ingredients, immunity, hormonal, and antioxidant status. It seems that further study is still necessary to recognize the exact effect of CA and YS in different stages of poultry life.

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فعالية حمض الكابريليك ومستخلص اليوكا شيدجيرا على الأداء الإنتاجي والفيسيولوجي للدجاج البياض

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يحتوي حمض الكابريليك (CA) ومستخلص اليوكا شيدجيرا (YS) على العديد من الخصائص الوظيفية والغذائية والتي لها العديد من التأثيرات الإيجابية في تغذية الدواجن، ومن هذه التأثيرات - تحسين الأداء الإنتاجي، وتحسين جودة البيض، وتحسين الحالة المناعية والهرمونات ومقاييس الدم الأخرى للطيور.

أجريت هذه الدراسة لتقييم تأثير الإضافات الغذائية بمستويات مختلفة من CA مع مستوى ثابت من مستخلص YS على الأداء الإنتاجي وحالة المناعة وبعض خصائص الدم في الدجاج البياض، تم استخدام عدد 120 دجاجة من سلالة لوهمان البني عند عمر 24 أسبوعاً في هذه التجربة، تم تسكين الدجاج البياض في بطاريات سلكية حيث تم توزيع الدجاجات عشوائياً على 8 مجموعات تجريبية وقسمت كل مجموعة إلى خمس مكررات وكل مكررة أحتوت على ثلاث دجاجات، وكانت معاملات التجربة على النحو التالي: (T1): العليقة الكنترول بدون أى إضافات، (T2): العليقة الكنترول مع إضافة 100 مجم / كجم من مستخلص يوكا شيدجيرا، (T3): العليقة الكنترول مع إضافة 500 ملجم / كجم من حمض الكابريليك، (T4): العليقة الكنترول مع إضافة 100 ملجم / كجم من خلاصة اليوكا شيدجيرا + 500 ملجم / كجم من حمض الكابريليك، (T5): العليقة الكنترول مع إضافة 1000 مجم / كجم من حمض الكابريليك، (T6): العليقة الكنترول مع إضافة 100 ملجم / كجم من خلاصة اليوكا شيدجيرا + 1000 ملجم / كجم من حمض الكابريليك، (T7): العليقة الكنترول مع إضافة 2000 مجم / كجم من حمض الكابريليك، (T8): العليقة الكنترول مع إضافة 100 مجم / كجم من خلاصة يوكا شيدجيرا + 2000 مجم / كجم من حمض الكابريليك.

أوضحت النتائج أن علائق الدجاج البياض المضاف إليها كل من حمض الكابريليك CA و مستخلص اليوكا شيدجيرا YS أدت إلى تحسين وزن الجسم، والغذاء المستهلك، ومعامل تحويل الغذاء، ومعدل إنتاج البيض، وكتلة البيض مقارنة بالمعاملة الكنترول، لم تتأثر قياسات صفات جودة البيض في هذه الدراسة مثل وزن البيضة ووزن الصفار ووزن البياض ووزن قشرة البيض وسمك قشرة البيض ودليل الصفار ومعامل شكل البيضة ولون الصفار معنوياً نتيجة إضافة كل من CA و YS بمستويات مختلفة على علائق الدجاج البياض، لوحظ زيادة تركيز مستوى الجلوكوز في سيرم الدم معنوياً في جميع المجموعات مقارنة بمجموعة الكنترول، كما ارتفع تركيز مستوى هرموني T3 و T4 في سيرم الدم معنوياً بزيادة مستوى CA في علائق الدجاج البياض مع أو بدون YS مقارنة بمجموعة الكنترول. بينما انخفض تركيز مستوى الكوليسترول الكلي في سيرم الدم معنوياً بزيادة مستوى CA بمفرده أو مع YS في علائق الدجاج البياض، أيضاً انخفضت قيم نسبة H / L معنوياً بزيادة مستوى CA في علائق الدجاج البياض خاصة مجموعات T7 و T8. بالنسبة لباقي القياسات البيوكيميائية مثل Igg، والبروتين الكلي لسيرم الدم، وألبومين سيرم الدم والجلوبولين؛ أظهرت النتائج في هذه الدراسة أن إضافة كل من CA و YS على علائق الدجاج البياض أدى إلى زيادة في تركيزات تلك القياسات؛ لذلك، نوصي بإضافة كل من CA و YS في عليقة الدجاج البياض بالمستويات الموجودة في هذه الدراسة دون أى تأثير سلبي على الحالة الإنتاجية والمناعية للدجاج البياض.