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EFFECT OF GUM ARABIC ON EGG PRODUCTION AND SOME BLOOD CONSTITUENTS OF LAYING HENS UNDER HOT SUMMER CONDITIONS IN EGYPT

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ABSTRACT

The present study aimed to investigate the effects of inclusion of Gum Arabic (GA) levels in laying hen diets on egg production, egg quality and some blood parameters under summer conditions in Egypt.

One hundred and twenty Mamourah hens of 28 weeks of age were allotted at random among four experimental groups (30 birds in each group). The first group was fed the control diet , while groups 2, 3 and 4 were fed on the control diet included with 0.5, 1.0 or 1.5% of Gum Arabic for 12 weeks during summer season.

The results revealed that productive performance as final body weight, egg production, and feed conversion were significantly improved ($P \leq 0.05$) by different levels of GA inclusion in the diets, while, feed consumption and egg weight were slight increased by GA inclusion compare with the control group. Egg shell % and shell thickness were highly significant ($P \leq 0.05$) in groups fed diets included with Gum Arabic compared to the control group. Significant ($p \leq 0.05$) increase in Ca and P were also noticed in blood plasma and egg yolk. Increasing the level of the Gum Arabic (from 0.5 – 1.5 %) in laying hen diet significantly ($p \leq 0.05$) reduced plasma cholesterol concentration and consequently eggs with lowered yolk cholesterol were obtained. The concentration of total protein, albumin, globulin, calcium and phosphorus in the plasma were significantly ($P \leq 0.01$) higher in groups fed diets included with GA especially group 4 which containing 1.5 % Gum Arabic.

Evidently, it is concluded that GA inclusion in laying hen diets could improve egg production, final body weight, egg shell thickness and some blood constituents in Mamourah hens under high ambient temperature in Egypt.

Keywords: Gum Arabic, Laying hen, Performance, blood constituents and egg quality

INTRODUCTION

Environmental stressors exert their effects on the productive and reproductive performance and the well-being of the domestic animals as poultry species (De Basilio *et al*., 2002). One of the major obstacles and limiting factors of poultry production during Egyptian summer months is the high ambient temperature. Hot ambient temperature, above the zone of thermo-neutrality for domestic fowl have adverse effects on feed intake, feed efficiency, egg production and egg shell quality (Abu-Dieyeh, 2006; Kocaman *et al*., 2006; and Ramnath *et al*., 2007). Also heat stress causes alterations in serum lipids (Sands and Smith, 2002), and thus can affect health make poultry production difficult and uneconomical.

Several methods are available to alleviate the negative effects of high environmental temperature on poultry performance. Because it is expensive to cool poultry buildings, such methods are focused mostly on dietary manipulation. The dietary characteristics (level of nutrients or the type of ingredients) can modulate the susceptibility of birds to infectious challenges (Klasing, 1988).

Today they used natural sources as growth promoters, like probiotics, prebiotics; they are altering the intestinal microbiota and immune system to reduce colonization by pathogens in certain conditions (Patterson and Burkholder, 2003). Gum Arabic (GA) is the dried exudates obtained from the stems and branches of either acacia seyal or acacia sengal. It has ability to increase number of probiotics bacteria and enhancing immune system, it contains soluble dietary fibers with more than 85% of its weight as soluble fermentable fractions (Nasir *et al*., 2004). Sabahelkhier *et al*., (2009) found that feed intake and egg shell thickness increased by supplementation of graded levels of gum Arabic in the basal laying hen diet. Abd-Razig *et al*. (2010) and El-khier *et al*. (2010) found significant decreases in serum cholesterol, triglycerides, but with no significant differences in high density protein (HDL). So, The present study aimed to investigating the effects of Gum Arabic levels to alleviate the adverse effects of high ambient temperature on egg production traits, some egg quality traits and some blood constituents of laying hens during high ambient temperature in Egypt.

MATERIALS AND METHODS

The current study was conducted in Gemeza Poultry Research Station and the biochemical analysis was done in laboratories of Animal Production Research Institute (APRI) during the period from (1/6 - 23/8/2015).

One hundred and twenty local laying hens (Mamourah) were divided into four groups, each group was assigned for one treatment. G1 fed basal diet with no GA (as control) , however, G2, G3 and G4 fed diets contained 0.5, 1.0 and 1.5 % GA , respectively. The composition of the experimental diets are summarized in Table 1. Each group contained 30 hens (28 weeks of age). The birds were individually caged in metal galvanized cages in an open house, Photoperiod was 17 hours daily and the average temperature in the house was 34.5±3.5 °C. Fresh water was automatically available all the time by stainless steel nipples for each cage.. The experiment lasted 12 weeks. Birds were kept under the same managerial and hygienic conditions. Gum Arabic (*Acacia senegal L*) was obtained from the SAVANNA companies Group (Processing Gums, Juices and Confectionery), Khartom Sudan. (Specification: appearance colour-off white ,

appearance from –powder, purity , 98.14 ± 0.65 %). Gum Arabic was analyzed for the crude protein, moisture content, crude fiber, crude fat and crud ash percentage according to the methods of A.O.A.C.(2005). It contained, 15% moisture, 2.0 % CP, 0.0% EE , 0.0% CF, 4.4% ash and 78.6 % NFE. Metabolism Energy (ME) for Gum Arabic measured according to Scott *et al*. (1976) equation (ME= 53+38 (% crude protein + 2.25x % ether extract + 1.1 x nitrogen free extract (NFE).

Table (1) Composition and calculated analysis of the experimental diets

Ingredients (%)	Control	Gum Arabic		
		0.5%	1.0%	1.5%
Yellow corn	64.94	64.44	64.00	63.40
Soybean meal (44%)	23.50	23.30	23.25	23.33
Wheat bran	1.74	1.94	1.93	1.95
Gum Arabic	0.00	0.50	1.00	1.50
Limestone	7.63	7.63	7.63	7.63
Di calcium phosphate	1.51	1.51	1.51	1.51
Nacl	0.30	0.30	0.30	0.30
Premix[1]	0.30	0.30	0.30	0.30
Dl-Methionine	0.08	0.08	0.08	0.08
Total	100	100	100	100
Calculated analysis[2]				
CP, %	16.8	16.28	16.23	16.22
ME (kcal/kg diet)	2725	2724	2725	2725
Crude fiber %	3.26	3.26	3.26	3.26
Available phosphorus %	0.40	0.40	0.40	0.40
Calcium %	3.30	3.30	3.30	3.30
Lysine %	0.81	0.81	0.81	0.81
Methionine %	0.34	0.34	0.34	0.34
Methionine +Cystine %	0.62	0.62	0.62	0.62

[1]Eash kg of vitamin and minerals contained: vitamin.A, 10000 IU; vitamin D_3, 2000 IU; vitamin Vitamin E, 10mg; Vitamin K_3,1mg; vitamin.B_1, 1mg; vitamin. B_2, 5mg; vitamin.B_6, 1.5mg; vitamin. B_{12}, 10mcg; Niacin, 30mg; Pantothenic acid, 10mg; Folic acid, 1mg; Biotin, 50µg; Choline, 260mg; Copper, 4mg; Iron; 30mg; Manganese, 60mg; Zn, 50mg; Iodine, 1.3mg; Se, 0.1mg and Cobalt, 0.1mg.

[2] According to Feed Composition Tables for animal & poultry feedstuffs used in Egypt (2001).

Measurements:

Performance and egg quality traits:

Hens were weighed individually at the beginning and the end of the experiment. Mortality was recorded. Feed consumption was recorded at 7-d intervals. Feed consumption was recorded at the beginning and the end of the experiment and calculated as grams per hen per day. Feed conversion ratio was calculated as gram of feed per gram of egg. All of the eggs were collected and weighted individually to determine the egg weight. Using these values, egg production and egg mass were calculated. Egg quality was determined for 3 consecutive days at the end of the trial. Fifteen eggs were collected randomly from each replicate. Each egg was weighed and shape index was calculated in percentages according to the formula of (egg length)/(egg width) . Shell thickness was measured in 3 different parts (upper and lower ends and middle) by a micrometer. Yolk color was determined according to the Roche Yolk color fan. Haugh unit = 100 x log (AH + 7.57 - 1.7 x EW $^{0.37}$) where AH, albumin height and EW, egg weight. Calcium and phosphorus in egg yolk were determined by method of Chapman and Pralt, (1961), while cholesterol and triglyceride in egg yolk were determined by the method of AOAC (2005).

Blood sampling and plasma constituents:

Blood samples were collected randomly from each group (9 samples/group) at 40 week of age. Bloods were collected from the hen's wing by using sterilizing syringes in heparinized tubes. Plasma were separated by centrifugation at 3000 rpm for 10 minutes and stored in ependorf tubes at -20^{o}C until analysis. Plasma total protein measured according to Gornal et al. (1949), albumin was measured according to Dumas and Biggs (1971). Plasma globulin was calculated by the difference between plasma total protein and albumin. Plasma cholesterol was measured according to Allain et al. (1974), triglycerides were measured according to Fassati and Prencipe (1982), calcium was measured according to Gindler and King (1972), phosphorus was measured according to El-Merzabani et al. (1977) while AST and ALT according to methods described by Kapalan and Pesce (1996).

Statistical analysis:

Data were analyzed using the one-way ANOVA test of (SAS, 2000). In the case of significant means ($P< 0.05$), Duncan multiple range test was used to determine treatment differences.

Model: Xij = µ+Ti+eij

Where: Xij = Any observation,
µ = Overall mean
Ti = Treatments (i = 1, 2,…and 4)
eij = Experimental error

RESULTS AND DISCUSSION

Performance of laying hens:

Data for productive performance are summarized in Table 2. Results indicated that initial body weight did not differ significantly among the treatments indicating the complete randomization of distribution of birds into the experimental groups. However, final body weight of laying hens at the end of the experimental period was significantly increased by GA inclusion in the diets (Table 2). All GA levels significantly ($P \leq 0.05$) increased hens final body weight compared with the control group and the heaviest weights were recorded for that of 1.5 % GA . These results are in agreement with those of Abd- Razig *et al*. (2010) who reported significant increasing in body weight of hen from supplementation of graded levels of Gum Arabic in laying hens.

Generally, Gum Arabic could improve intestinal function or gut health (e.g., increased villi height, uniformity, and integrity) via a receptor analog mechanism (strongly binding to, and decoying pathogens away from, the sugar coated intestinal lining) or via agglutination of gum arabic by different bacterial strains (Spring *et al*., 2000)

An analysis of the production characteristic data is shown in Table 2. It was observed that GA inclusion at 0.5, 1.0 or 1.5% in laying hen diets caused a significant improve in egg production % compared with the control group. When GA was added up to 1.5% in laying diets showing the high values of egg production during the whole experimental period. These finding are inline with results that obtained by McNaughton (1978). Whereas, GA inclusion in laying hen diets had slight increase in egg weight during the whole experimental period. Similarly, Kelly and Tsai (1978).

The GA caused slight increase in feed intake compared to the control during the experimental period. The insignificant differences in feed intake indicate the positive effect of Gum Arabic was due to feed utilization. Feed conversion (FC) means were improved ($P \leq 0.05$) due to Gum Arabic inclusion in laying hen diets. The hens fed GA up to 1.5% in the diet had significantly ($P \leq 0.05$) better FC means during the total period. Similar trends were reported by Abd- Razig *et al*. (2010). The mortality rate decreased with the inclusion of GA in the diet compared to control group which recorded the highest rate of mortality. This might be due to that natural prebiotic (GA) creates suitable environment for probiotics to grow and help eliminate toxins, fats and balance out bad bacteria thus, enhance the immune system, which secure body to be less prone to sickness and severe as energy booster. This result was in agreed with Gibson and Roberfroid, (1995), Marinho *et al*, (2007) and Rays *et al*. (2009), and savage *et at*. (1996) that reported prebiotics may enhance health by stimulating antibody production.

The main reason for the decreased egg production of the control group may be due to the decrease in feed intake. At high temperatures, birds increase their respiration rate to regulate heat loss through water evaporation from their lungs (Okela *et al*., 2003). This panting behavior increases CO2 loss from lungs and partial pressure of CO2 in blood was reduced causing a decrease in HCO3 concentrations due to the increase in HCO3 excretion with a reduction of H+ excretion by the kidneys to maintain the acid-base balance in the bird. Lowered H+ concentration raises the level of blood plasma pH, a leading to respiratory alkalosis (Borges *et al*., 2007). This acid-base imbalance alters Na:Cl ratio thus reduces feed consumption (Naseem *et al*., 2005).

Table 2: Effect of Gum Arabic on body weight, feed intake and egg production traits of Mamourah layers.

Items	G1 0.0% GA	G2 0.5% GA	G3 1.0% GA	G4 1.5% GA	SEM	p-value
Initial body weight	1406.7	1443.3	1410.0	1435.0	8.463	0.363
Final body weight	1496.7^{b}	1540.0^{b}	1550.0^{b}	1616.7^{a}	15.248	0.013
Change of body weight %	+6.01^{c}	+6.28^{c}	+9.02^{b}	+11.23^{a}	0.692	0.001
Egg production (%)	43.93^{b}	53.23^{ab}	55.78^{a}	55.89^{a}	1.954	0.05
Egg weight (g)	49.07	50.00	50.20	50.46	0.257	0.254
Feed intake (g/hen/day)	108.66	109.0	110.3	113.0	1.225	0.650
Feed conversion (g feed/g egg)	5.07^{a}	4.10^{b}	3.97^{b}	4.01^{b}	0.159	.011
Mortality (%)	3.33	0.00	0.00	0.00		

a, b. c. d Means in the same row bearing different letters, differ significantly (P≤ 0.05).

Egg quality:

Analysis of the egg quality data is shown in Table 3. No significant variance was found in egg yolk %, egg albumen%, Haugh unit, yolk index and egg shape index when hens fed diet contained different levels of GA compared with those of hens fed a basal diet. While, Groups fed diets GA inclusion in laying hen diets showed significantly ($P< 0.05$) increased egg shell % and shell thickness compared with control group under hot ambient temperature .

The increase in egg shell % and egg shell thickness during hot ambient temperature for treatments fed Gum Arabic inclusion in the diet in the present study could be due to the increase of plasma calcium and phosphorus concentration as shown in Table 4. These results in general agreement with those obtained by EL-Khier *et al*. (2009) who found that inclusion of GA in the diet significantly ($P \leq 0.05$) improved thickness of egg shell which may be due to the increased calcium and phosphorus concentration in

blood serum. The reduction in shell thickness may result from reduce feed intake and insufficient intake of nutrients such as calcium due to insufficient HCO3 level to form CaCO3 due to excess expiration of CO2 or both. The reduction in egg weight (Bollengier-Lee *et al*., 1998) and shell thickness (Yardibi and Türkay, 2008) reflects the detrimental effects of heat stress on egg shell %.

Table 3: Effect of Gum Arabic on Some egg quality traits at 40 weeks of age of Mamourah layers.

Items	G1 0.0% GA	G2 0.5% GA	G3 1.0% GA	G4 1.5% GA	SEM	p-value
Egg yolk (%)	29.17	30.05	30.98	30.93	0.453	0.504
Egg albumen (%)	59.12	55.98	54.84	54.58	0.755	0.102
Egg shell (%)	11.69^{b}	13.96^{a}	14.17^{a}	14.48^{a}	0.402	0.021
Haugh unit	78.72	78.50	79.50	80.10	3.381	0.523
Yolk index	42.18	46.81	43.22	43.80	0.876	0.303
Egg shape index	75.81	73.42	77.97	76.73	0.996	0.476
Shell thickness (mm)	0.342^{b}	0.384^{a}	0.385^{a}	0.390^{a}	0.623	0.0001
Yolk color	5.66	5.33	5.66	5.66	0.148	0.859

a, b. c. d Means in the same row bearing different letters, differ significantly (P≤ 0.05).

Blood biochemical parameters in laying hens :

The data obtained for the values of blood plasma constituents are shown in Table (4). The results revealed that the concentration of plasma total protein, albumen, globulin, calcium and phosphorus were significantly (P≤ 0.05) higher in groups fed diets included with Gum Arabic especially group (4) compared with the control group during hot ambient temperature. These results are agreements with Hassan and Ragab (2007) who observed that prebiotic supplementation in the laying hen diets significant increases in serum total protein and albumin concentration compared with the hens fed a basal diets.

The effects of GA in layers diets on blood constituents are shown in Table 4. Inclusion of 0.5%, 1.0% and 1.5 % gum Arabic in the laying hen diets decreased plasma cholesterol compared to the control group (86.66, 84.97 and 80.71 versus 139.86 mg/dl) this result is agree with El-kheir (2009) who found that GA decreased serum cholesterol which may be due to the interference with dietary cholesterol absorption. These results confirmed by Abd-Razig *et al*. (2010), El-khier *et al*. (2010) who found that inclusion of GA at 1.5% in layer diet significantly reduced serum cholesterol. The findings in the present study are also consistent with those reported by Kelley and Tsai, (1978), they noticed that GA reduces serum cholesterol in rats, suggesting that GA inter with dietary cholesterol absorption. Al-Othman *et al*., (1998), observed that GA (soluble dietary fiber) effective in lowering the total plasma cholesterol level .

In the current experimental diets contained 0.5%, 1.0 % and 1.5% GA recorded the lower levels of plasma glucose (199.66, 122.33 and 100.86 mg/dl) compared with control group (218.03 mg/ dl). Similarly, Wadood *et al*. (1989) who found that Gum Arabic significantly decrease glucose and creatinine concentration. In the current study, plasma albumin, globuline , phosphorus and calcium concentration were significantly increased by Gum Arabic inclusion in laying hen diets. Kawase *et al*. (2007) found that GA inclusion caused to improve efficiency of Ca absorption in rats.

In the current study AST, ALT and creatinine concentration decreased for hens fed 1.0% and 1.5% GA. These results are in agreement with those of Suliman *et al*. (2000) . It is well known that GA is fermented by intestinal bacteria leading to formation of various degradation products, such as short chain fatty acids (Bliss *et al*., 1996). Matsumoto *et al*., (2006) reported that serum butyrate concentrations were increased with GA in healthy subjects and this may have a role in the claimed salutatory effect on creatinine clearance.

Table 4: Effect of Gum Arabic on some blood constituents at 40 weeks age in Mamourah laying hens.

Items	G1 0.0% GA	G2 0.5% GA	G3 1.0% GA	G4 1.5% GA	SEM	p-value
Total protein (mg/dl)	3.69^{c}	4.18^{c}	5.11^{b}	5.76^{a}	0.252	0.0001
Albumin (m g/dl)	1.83	1.87	1.86	2.03	0.094	0.920
Globulin (m g/dl)	1.85^{b}	2.30^{b}	3.25^{a}	3.73^{a}	0.235	0.0001
AST (U/L)	344.00^{a}	269.40^{b}	263.86^{b}	226.76^{b}	14.463	0.005
ALT (U/L)	36.70^{a}	16.79^{b}	15.55^{b}	13.33^{b}	3.176	0.004
Cholesterol (mg/dl)	139.86^{a}	86.66^{b}	84.97^{b}	80.71^{b}	9.152	0.036
Calcium (mg/dl)	6.46^{b}	9.80^{b}	15.14^{a}	18.19^{a}	1.466	0.001
Phosphorus (mg/dl)	3.14^{b}	4.26^{a}	4.71^{a}	4.76^{a}	0.220	0.004
Creatinine (mg/dl)	1.09^{a}	0.643^{b}	0.620^{b}	0.616^{b}	0.063	0.0001
Glucose (mg/dl)	218.03^{a}	199.66^{a}	122.33^{b}	100.86^{b}	16.102	0.001
Triglycerides (mg/dl)	520.70^{a}	338.60^{b}	198.76^{c}	85.05^{c}	51.30	0.0001

a, b. c. d Means in the same row bearing different letters, differ significantly (P≤ 0.05).

Concerning the concentrations of AST, ALT, present study revealed that AST and ALT significantly decreased in groups fed Gum Arabic in comparison with the control group.

Plasma triglyceride was decreased by included GA in laying hen diets compared to the control group. This result is agreement with results obtained by AbdelWahed *et al*. (2010). Topping *et al*. (1985) who found that GA inclusion resulted significant decrease in serum triglyceride.

Table 5 show a significant ($p \leq 0.05$) decrease in cholesterol and triglycerides concentration in the egg yolk with increasing the Gum Arabic levels in the laying hen diet. This decrease in yolk cholesterol may be due to the decrease in plasma cholesterol of the laying hens (Table 4). These results are agreement with McNaughton (1978) and Abd-Razig *et al*. (2010). Calcium and phosphorus contents in egg yolk were showed the highest percentage by GA inclusion in the diet especially, 1.5 % GA compared with the control group . This increase in Ca and P is may be due to the observable increase in both minerals in blood plasma (Table 4). Mee and Gee, (1997) reported that Gum Arabic may improve absorption of Ca and possibly other minerals . However, Kawase *et al*.,(2007) found that the efficiency of Ca absorption in rats was improved by using 1.5% GA .

Table 5: Effect of Gum Arabic on yolk cholesterol, calcium and phosphorus of Mamourah layers.

Items	G1 0.0% GA	G2 0.5% GA	G3 1.0% GA	G4 1.5% GA	SEM	p-value
Cholesterol (mg/dl)	12.16^{a}	11.04^{b}	10.95^{b}	10.72^{b}	0.172	0.0001
Triglycerides (mg/dl)	63.2^{a}	63.2^{a}	57.2^{b}	50.4^{b}	0. 302	0.03
Calcium (mg/dl)	15.65^{a}	16.06^{ab}	17.16^{b}	19.29^{c}	0.452	0.0001
Phosphorus (mg/dl)	16.02^{b}	16.68^{b}	18.72^{a}	19.50^{a}	0.444	0.0001

a, b. c. d Means in the same row bearing different letters, differ significantly ($P \leq 0.05$).

In conclusion, the best results were obtained with 1.5 % GA inclusion in the diet, which reducing the negative effects of heat stress on egg production, egg quality, and some plasma metabolites of laying hen reared under Egyptian summer conditions.

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تأثير الصمغ العربى على الأداء الإنتاجى وبعض صفات الدم للدجاج البياض تحت ظروف الصيف الحارة فى مصر

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أجريت هذة الدراسة لمعرفة تأثير الصمغ العربى على الأداء الأنتاجى وجودة البيض وبعض مكونات الدم للدجاج البياض المحلى تحت ظروف الجو الحار . وقد استخدم ١٢٠ دجاجة من سلالة المعمورة عمر ٢٨ أسبوع وتم توزيعها فرديا فى أقفاص بطريقة عشوائية الى أربعة مجاميع (كل مجموعة تحتوى على ٣٠ دجاجة) واستمرت التجربة لمدة ١٢ أسبوع . وتم تغذية الطيور على أربعة علائق كالأتى :-

١- عليقة اساسية بدون أضافات.

٢- عليقة تحتوى على ٠.٥% صمغ عربى .

٣- عليقة تحتوى على ١.٠% صمغ عربى .

٤- عليقة تحتوى على ١.٥ % صمغ عربى .

وأظهرت النتائج الأتى :-

أضافة ١.٥% صمغ عربى الى عليقة الدجاج البياض أدت إلى حدوث زيادة معنوية فى وزن الجسم النهائى وزيادة نسبة التغير فى وزن الجسم . كما أدت أضافة مستويات الصمغ العربى إلى زيادة فى صفات إنتاج البيض فى حين لم يكن هناك تأثر معنوى على أستهلاك العلف ووزن البيض . و لم تتأثر صفات جودة البيض بأضافة الصمغ العربى فى العلف ما عدا وزن القشرة وسمك القشرة والتى زادت معنويا بالمقارنة بمجموعة الكنترول . وأدت أضافة الصمغ العربى الى عليقة الدجاج البياض الى زيادة معنوية فى بعض مكونات الدم (البروتين الكلى – الجلوبيولين- الكالسيوم – الفوسفور) وإنخفاض فى بعض قيم الدم (الكوليسترول- أنزيمات الكبد- الكرياتنين- الجليسريدات الثلاثية) بالمقارنة بمجموعة الكنترول. وهناك تأثير معنوى لأضافة الصمغ العربى على خفض نسبة كل من الكوليسترول والجليسريدات الثلاثية فى صفار البيضة كما أدى أضافة الصمغ العربى الى زيادة الكالسيوم والفوسفور فى صفار البيض .

ونستخلص من النتائج الى أن أضافة الصمغ العربى وخاصة المستوى العالى (١.٥%) أدى الى تحسين معظم الصفات الأنتاجية و وزن القشرة وسمكها و بعض مكونات الدم للدجاج البياض المحلى (سلالة المعمورة) خلال موسم الصيف فى مصر .