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THE USE OF ELECTRICAL STIMULATION TECHNIQUE TO INFLUENCE THE QUALITY AND QUANTITY OF ACCUMULATED FAT AND CHOLESTEROL IN DUCK MEAT

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Abstract

The use of electrical stimulation technique to influence the quality and quantity of accumulated fat and cholesterol in duck meat were the main aim of the present study. The device for measuring meat tenderness was designed at the department of Food Sciences, College of Agriculture, and University of Basra. In this experiment, thirty 12 weeks old local duck birds were used. Carcasses were exhibited to three electrical stimulation treatment groups with 10 birds per treatment. The treatments included the control (T1), the use of electrical stimulation with low voltage 110 V (intensity, 3.67) V/cm with a 1% saline concentration (T2), and high voltage 220 volts (intensity, 7.33) V/cm with 1% saline concentration (T3. The paper clarifies that electrical stimulation and gender have had a significant effect on all studied characteristics, as the electric intensity 7.33 volts / cm (220) volts and males showed a significant lower fat, lipase enzyme, cholesterol, triglycerides, high-density lipoprotein (HDL), and low-density lipoprotein (LDL) levels compared to the control treatment or females.

Keywords: Duck Meat, Lipase enzyme, fat, cholesterol

Introduction

Local ducks are one of domestic poultry types, which are raised in the southern marshes of Iraq. These birds are characterized by being of dual-purpose: for the production of eggs and meat. Their growth rates are slow, and the rate of feed conversion is low with high levels of fats and cholesterol in the blood and meat of their carcasses compared to chicken carcasses (Jafar *et al*., 2011). However, local ducks have the opportunity to become a source of meat production, although the consumer has become more interested in the nutritional composition of meat such as fats, cholesterol and fatty acids. One of the reasons for the slow increase in demand for duck meat is the opinion that duck meat contains high levels of fat and cholesterol in it, which can lead to an increased risk of coronary heart disease (Siri-Tarino *et al*., 2015). Therefore, information on fat, cholesterol and fatty acid content is required. The content of fats, cholesterol and fatty acids can be controlled through the nutrition source and oil content of animal feeding (Schivone *et al*., 2010) and the effect of genetics on the nutritional content of duck meat (Hermier *et al*., 2003). Duck meat has the advantage of containing high levels of unsaturated fatty acids that rarely cause nutritional problems, but when accumulated in the form of fat between muscle tissues, it could increase the possibility of consumer health risk of high levels of cholesterol due to the presence of the lipase enzyme (Davail *et al*., 2000). It is an enzyme produced from animal tissues such as fat tissue and muscles, and plays a significant role in regulating the level of fat precipitation and energy balance as it works to break down the triglycerides into fatty acids and glycerol. When fatty acids increase, it takes a space between muscles, in the abdominal cavity, and under skin (Tian *et al*., 2012).

Electrical Stimulation is the process of applying a voltage across the body of the bird immediately after being slaughtered and depleted, where a response occurs by the nervous and muscular systems of the voltage or amperage which leads to the occurrence physiological or biological changes in meat (Li *et al*., 1993).

Electrical stimulation has been studied as a way to reduce the time required for aging to prevent meat hardness. It has been recently used commercially. Electrical stimulation improves meat quality through chemical and physical changes, reduces cutting values, increases sarcomere length, and reduces the diameter of muscle fibers (Al-Asadi *et al*., 2018). Furthermore, there is a possibility of deboning within less than two hours of slaughtering, and in a manner equivalent to tenderness of the deboned and aged meat for 4 hours after slaughter, and then reducing the storage time to 50% or more, which leads to a reduction in the storage costs, as well as to strength required to remove feathers. Also, electrical stimulation reduces the microbial load on the flesh of carcasses (Young and Buhr, 2000), That's why the study aimed to use the technique of electrical stimulation to influence the quality and quantity of accumulated fat and cholesterol in duck meat.

Materials and Methods

The mechanism of the electrical stimulation device

The carcasses are suspended in the decentralized column, and then the column rotates for immersing the birds in the saline solution that has its concentration percentage 1. Then, the voltage converter determined the required voltages and the time was determined (one minute). To offer the carcasses to the electric field at a specific time by the timer, then after that, the machine will operate during the specified period and it will stop automatically at the end of the specified period then the eccentric shaft rotates for the purpose of raising the birds from the brine and then extracting them from the clips.

Calculation of electrical conductivity

According to the electrical conductivity of the following relationship

$$\sigma = \frac{IL}{VA} \quad \text{....(A)}$$

The distance between the electrodes (L), cross section area (A), voltage (V), current (I), and electrical conductivity (σ) (Young and Lyon, 1997).

Voltage and current measurement

Voltage and current are measured by Clamp meter Digital Voltage and current measurement: The power consumed is calculated by the following equation

$$P = V \times I \times t \quad ....(2)$$

Where **P** represents the power (kw), **t** represents the operating time (hr.) (Nilsson, 1986)

Device productivity

The device's productivity was calculated by dividing the number of electrically excavated birds by the stimulation time multiplied by 100 (Wing and Sastery, 1993)

1. Experiment treatments

In this experiment, thirty (30) birds comprising of local duck. The birds were 12 weeks-old, they were slaughtered manually and after the complete blood depletion period of 150 seconds. Then the feathers and internal organs were measurement removed manually. Carcasses were divided into three electrical stimulation treatment groups with 10 birds per treatment. The study treatments were as follow: the first treatment (T1) was control, the second treatment (T2) was the use of electrical stimulation with low voltage 110 V(intensity,3.67)V/cm with a 1% saline concentration, the third treatment (T3) was the use of electrical stimulation with high voltage 220 volts (intensity, 7.33) V/cm with 1% saline concentration. Traits were measured at 24 hours. The following tests were performed

2. Lipid profile level determination

Samples of local ducks meat were analyzed to determine cholesterol, triglycerides, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) levels. They were determined spectrophotometrically by using commercial kits. Fat was extracted with ethyl ether using a Soxhlet apparatus (AOAC 1990).

Estimating the efficacy of the lipase enzyme between the muscular tissues of the chest and calf of the local duck, according to the steps recommended by several kits.

3. Statistical Analysis

Data was statically analyzed by using Statistical Package of Social Science (SPSS). Factorial experiment with complete randomize design was used. Revised Least Significant Differences (RLSD) at 5% significant level (SPSS, 2016) compared means

Results

Figure (1) shows the effect of electrical stimulation and gender on the percentage of fat in the breast of male and female domestic ducks. It reflects an occurrence of a significant decrease in the percentage of fat in the two factors of electrical stimulation, as the percentage of fat in each of the second treatment (2T) and (3T) was (9.83 and 11.42) % respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05), as it approached (12.08)% and shows the effect of electrical stimulation and gender on the percentage of fat in the femoral thigh meat of the local male and female duck. It reflects a significant decrease in the percentage of fat in the two electrical stimulation factors, as the percentage of fat in each of the second treatment (2T) and the third treatment (3T) was (11.00, 12.00)% respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (13.00)%. The females showed a significant increase in the fat percentage (12.67) % (mg / 100g) compared to males, (11.33) %.

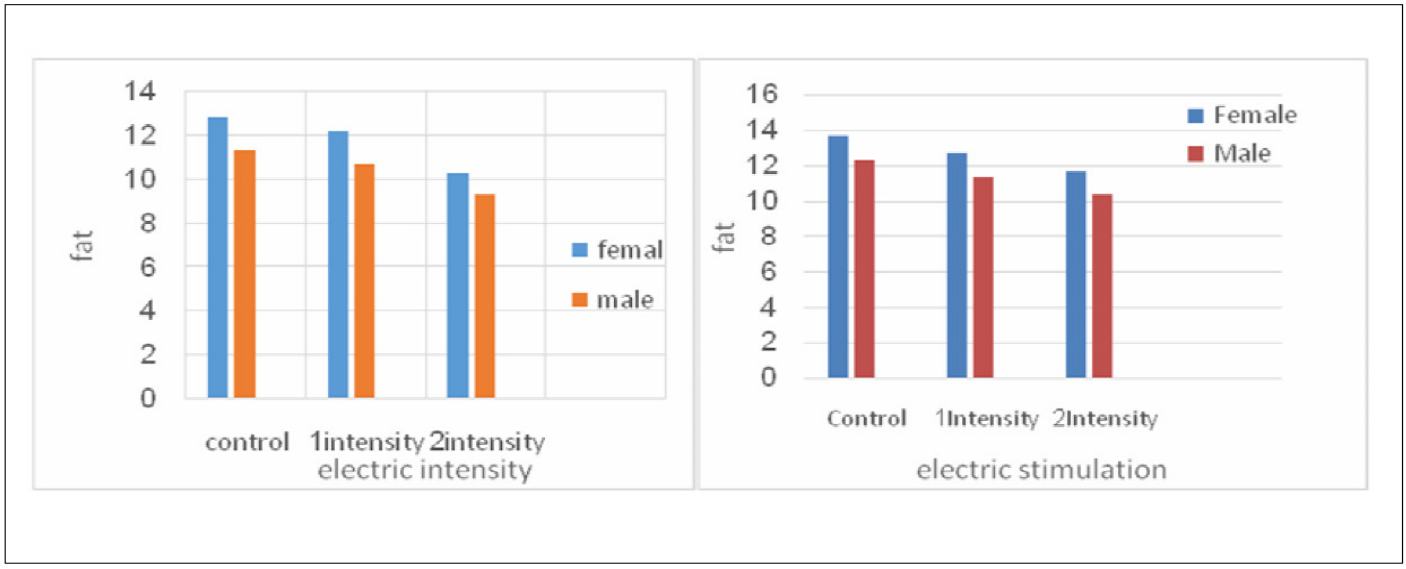


Figure (2) shows the effect of electrical stimulation and gender on the lipase enzyme ratio in the breast of male and female domestic ducks. It reflects a significant decrease in the lipase enzyme ratio in the two electrical stimulation factors, as the lipase enzyme ratio in both (2T) and (3T) was (1.58 and 2.06), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05), as it approached (2.50). The females showed a significant increase in the level of the Lipase enzyme, where it recorded (2.28) % compared to males at (1.82).and shows the effect of electrical stimulation and gender on the Lipase enzyme percentage in the thigh meat of the male and female domestic duck. It reflects a significant decrease in the Lipase enzyme percentage in the two electrical stimulation factors. The Lipase enzyme percentage in the third treatment (3T) was (3.08) decreased significantly compared with a control treatment (T1) that recorded a significant increase (P≤0.05), as it approached (4.17). The females showed a significant increase in the level of the Lipase enzyme, as it recorded (4.11) compared to males (3.00).

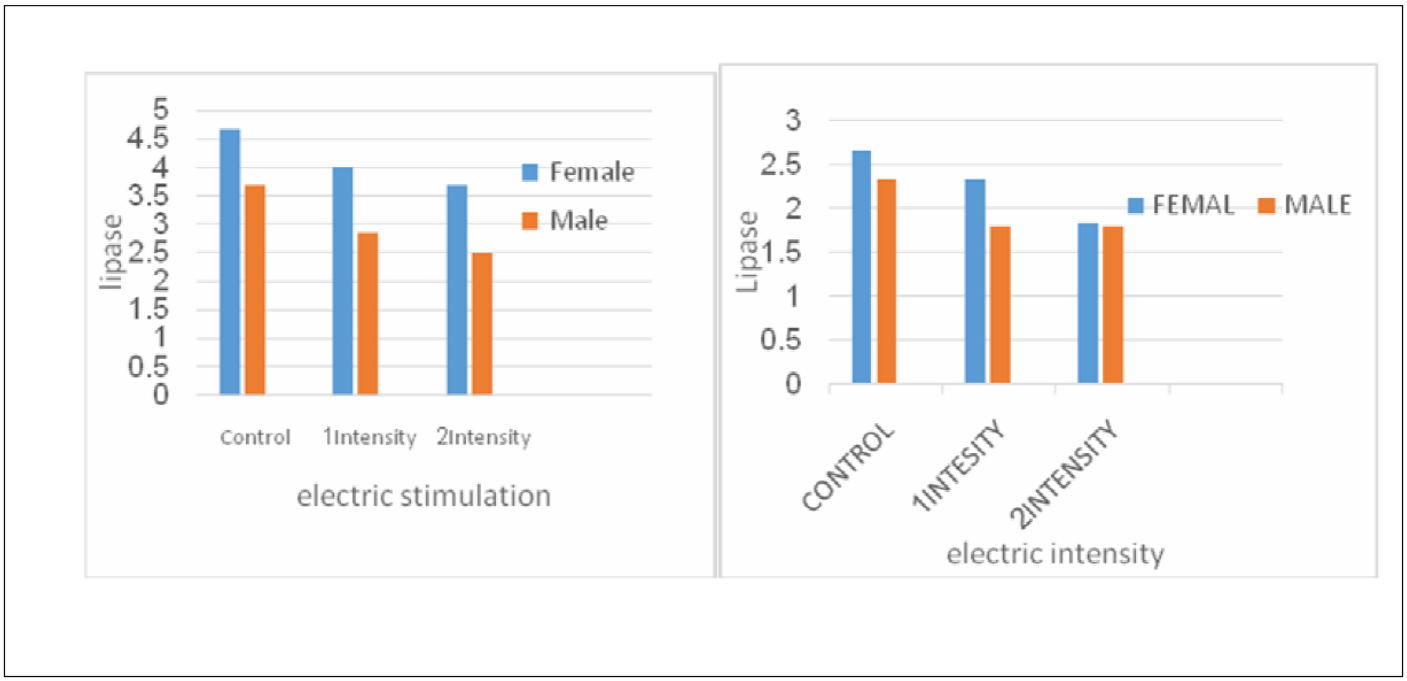


Figure (3) shows the effect of electrical stimulation and gender on the percentage of cholesterol in the breast of local male and female ducks. It reflects a significant decrease in the percentage of cholesterol in the two factors of electrical stimulation, as the ratio of cholesterol in each of the second treatment (T2) and the third treatment (T3) was (145.50 and 165.67 mg/100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (182.83) (mg/100g). Females showed a significant high percentage of cholesterol, as it recorded (163.33) (mg /100g) compared to males, (166.00 mg/100g) and shows the effect of electrical stimulation and gender on the percentage of cholesterol in the thigh meat of local male and female ducks. It reflects a significant decrease in the percentage of cholesterol in the two factors of electrical stimulation, as the percentage of cholesterol in each of the second treatment ((2T) and the third treatment (3T) was (153.50 and 172.00 mg /100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (188.17). Females showed a significant decrease in the percentage of cholesterol, as it recorded (168.67 mg/100g) compared to males, (173.78 mg /100g).

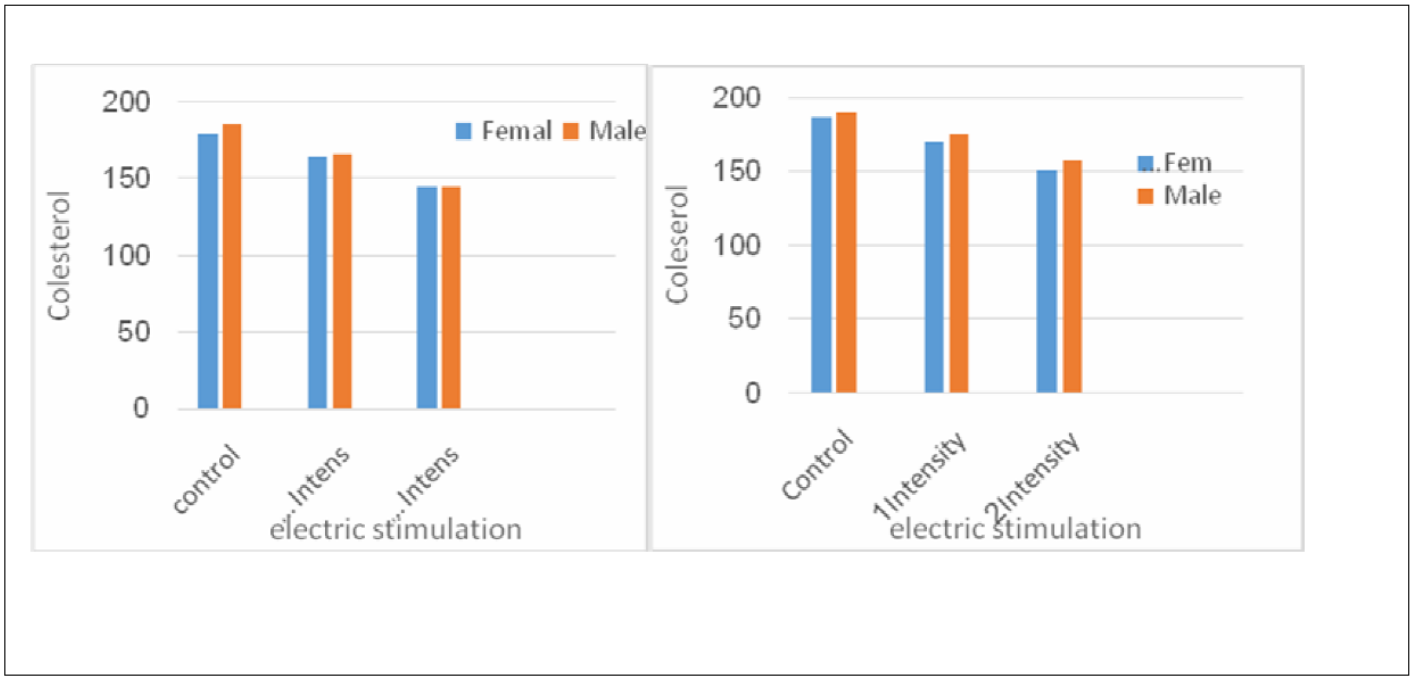
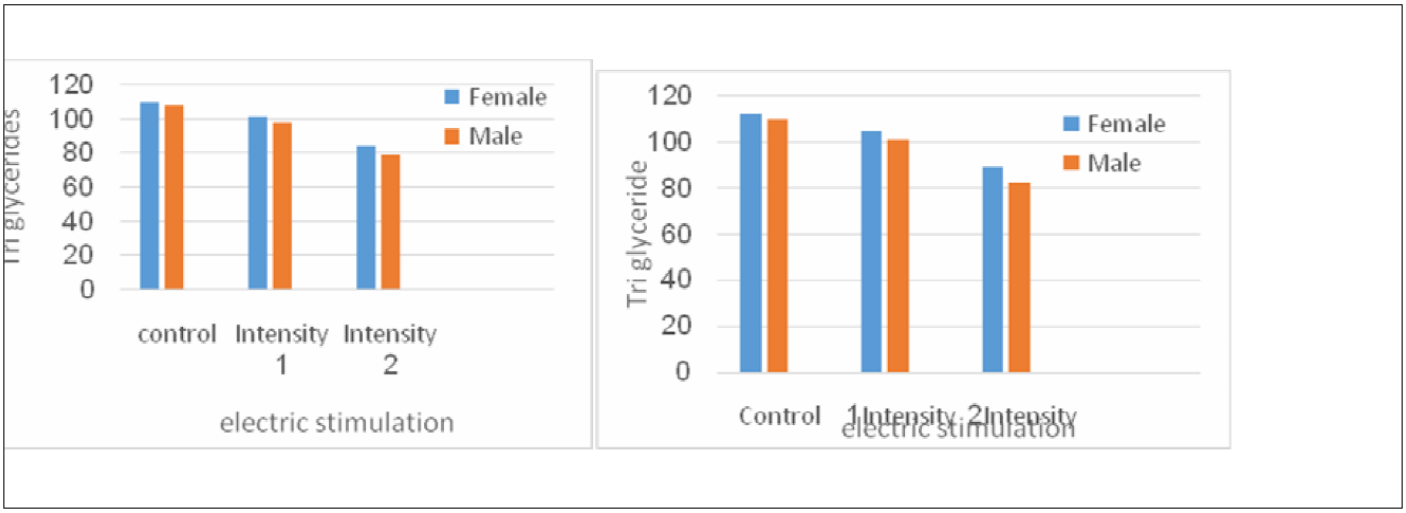
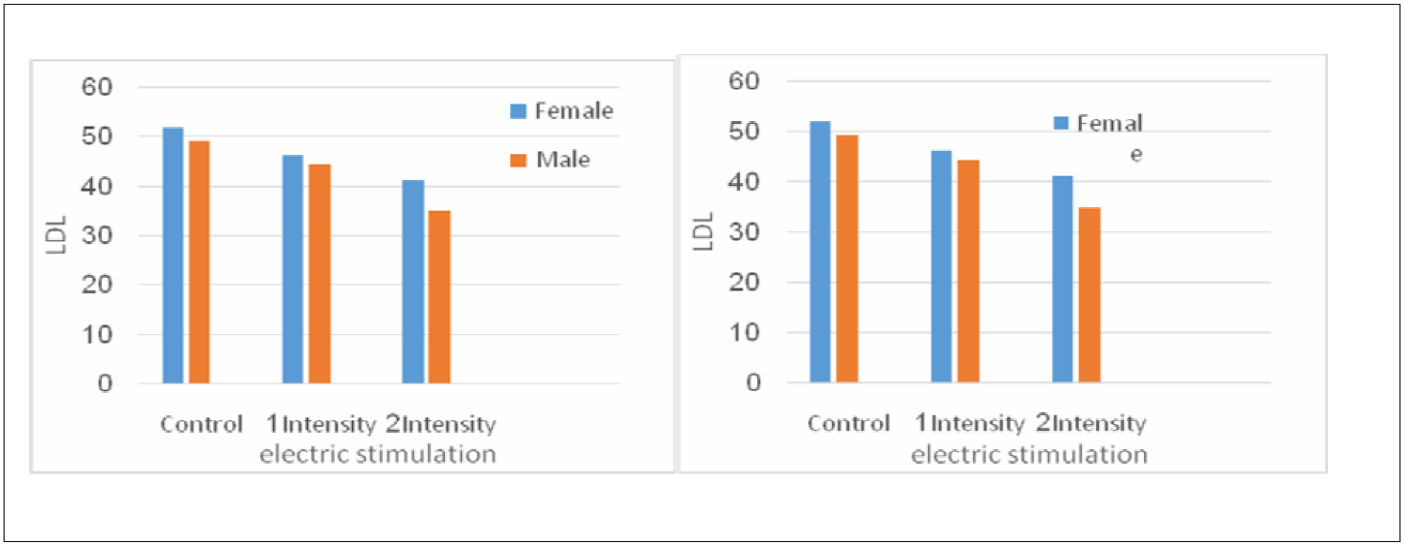


Figure (4) shows the effect of electrical stimulation and gender on the percentage of triglycerides in the breast of the local male and female duck. It reflects a significant decrease in the percentage of fat in the two factors of electrical stimulation, as the percentage of triglycerides in both the second treatment (2T) and the third treatment (T3) was (82.00, 99.50 mg/100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (109.00 mg/100g). Females showed a significant increase in the percentage of triglycerides, where it recorded (98.55 mg/100g) compared to males, (96.83 mg /100g) and shows the effect of electrical stimulation and gender on the percentage of triglycerides in the thigh meat of local male and female ducks. It reflects a

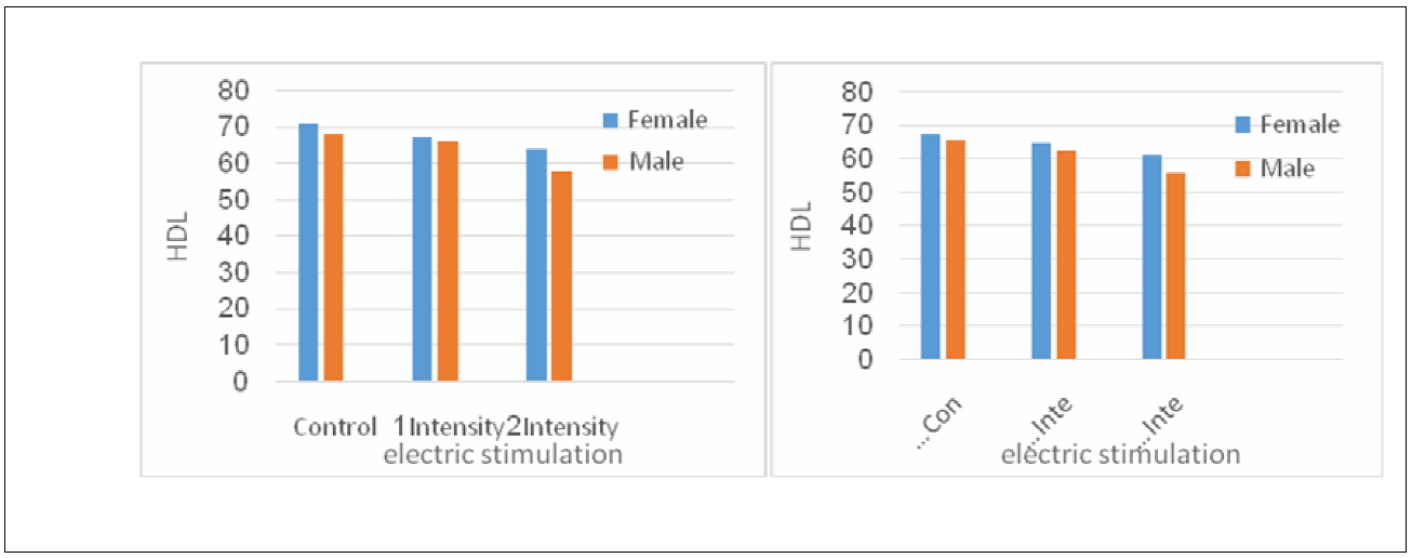
significant decrease in the percentage of fat in the two factors of electrical stimulation, as the percentage of triglycerides in both; the second treatment (2T) and the third treatment (3T) was (85.50 and 103.00 mg /100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (111.16) (mg /100g). Female showed a significant increase in the percentage of triglycerides, where it recorded (102.11) (mg /100g) compared to males, (97.67) (mg/100g).



Regarding figure (5), it shows the effect of electrical stimulation and gender in Low-density lipoprotein cholesterol (LDL) in the breast of the male and female domestic ducks. It reflects a significant decrease in LDL in the two factors of electrical stimulation as the ratio of LDL in both the second treatment (2T) and third treatment (T3) was (43.00 and 17.36 mg/100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (48.5 mg/100g). The females showed a significant increase in the triple LDL, as it recorded (22.44) (mg/100g) compared to males, (40.88) (mg/100g). and shows the effect of electrical stimulation and gender in Low-density lipoprotein cholesterol (LDL) in the thigh meat of the male and female domestic ducks. It reflects a significant decrease in LDL in the two factors of electrical stimulation as the percentage of LDL in both; the second treatment) (2T) and third treatment (T3) was (45.33, 17.38) (mg/100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05) as it approached (50.67) (mg /100g). The females showed a significant increase in the triple LDL as it recorded (55.46) (mg /100g) compared to the males (42.88) (mg/100g).



As to figure (6), it shows the effect of electrical stimulation and gender on the High-density lipoprotein cholesterol (HDL) in the breast of the male and female domestic ducks. It was noted that there was a significant decrease in HDL in the two factors of electrical stimulation, where the percentage of HDL in both the second treatment (2T) and third treatment (3T) was (63.83, 67.58) (mg/100g), respectively, compared to the control treatment (T1), which recorded a significant increase as it approached (66.67) (mg/100g). The females showed a significant increase in the triple HDL (67.64) (mg/100g) compared to males, (61.44) (mg/100g). and shows the effect of electrical stimulation and gender on the High-density lipoprotein cholesterol (HDL) in the thigh meat the male and female domestic ducks. It is noticeable that there was a significant decrease in HDL in the factors of electrical stimulation as the percentage of HDL In both, the second treatment (2T) and third treatment (3T) was (66.33,83.60) (mg/100g), respectively, compared to the control treatment (T1), which recorded a significant increase (P≤0.05), as it approached (69.33) (mg /100g). The females showed a significant increase in the triple HDL, where it recorded (22.67) (mg / 100g) compared to males, (63.77) (mg /100g).



Discussion

The paper clarifies that electrical stimulation and gender have had a significant effect on all studied characteristics, as the electric intensity of 7.33 volts/cm (220) volts showed a significant decrease in all studied characteristics compared to the control treatment. While males showed a significant decrease compared to the females for all studied characteristics. The reason behind this phenomenon may be due to the effect of the electric intensity, which endeavors to decrease the accumulation of fats and the number of fat cells in the fatty tissue, as there is a positive correlation between the accumulation of fats and the Lipase enzyme (Hermier, 1997).

This enzyme plays an important role in the breakdown of the triglycerides of fatty proteins stored in fatty tissues and the production of fatty acids and cholesterol. The Lipase enzyme is the main determining factor for regulating fats accumulation (Lie *et al*., 2004). A study conducted by Huang *et al*. (2016) made it clear that the activity of the Lipase enzyme in the thigh was higher than in breast of the two strains of chicken. Electrical stimulation reduces the pH while keeping the carcass temperature high immediately after slaughtering. It functions to tear the membranes of the Lysosomes tissues producing lysosomes enzymes to the Cytoplasm (Hmedawy *et al*., 2019). Besides, electrical stimulation operates to decrease the diameter of a muscular fiber, and then decrease percentage of accumulated fat (Apparao *et al.,* 2009).

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