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Different Eggs Portions from Commercial Layers and Local Chickens Affected Differently, the Levels of Blood Lipids, and Abdominal and Liver Fat in Treated Wistar Rats

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Abstract

The presented study investigated whether egg portions from commercial layers and local chickens may have different effects on the levels of blood lipids and visceral fat in consumers using Wistar rats as an experimental model. Prepared egg portions included the whole egg (mixture of Egg white + yolk), Egg white and egg yolk. Then, 35 rats were randomized into seven groups (n = 5). **Group 1** (control) received tap water. **Groups 2, 3 and 4** received by gavaging 10mg/gBW of the commercial layer sourced whole egg, egg yolk and Egg white respectively. **Groups 5, 6 and 7** consumed the same amount of similar egg portions from local chickens. Also, all groups were maintained on broiler mash and adlib water (without restriction). Treatment covered 28 days, then, rats were sacrificed after sedation in ether. Blood was collected to analyze blood lipids. The abdominal fat and Liver were dissected and weighed. Hepatic fat infiltration was assessed by histological examination.

Rats eating the whole egg from either the commercial layer or local chickens had their abdominal fat and Liver's weights increased significantly compared to the control. Also, rats eating the whole egg or only the egg yolk from either commercial layers or local chickens showed a significantly elevated serum TG, HDL-C and LDL-C compared to the control. Moreover, the effects caused by the commercial layer egg fractions exceeded significantly those caused by egg portions from local chickens. Moreover, the rats' Liver histology indicated numerous fat-infiltrated, enlarged hepatocytes in rats that were orally gavaged by the whole egg or only the yolk from commercial layers. Also, regardless of the egg source, the egg white showed no significant effects on visceral fats and blood lipids of the treated rats.

In conclusion, feeding the egg whites had no significant effect on the visceral fat and blood cholesterol of the treated rats. However, the whole egg or egg yolk from commercial layers exceeded significantly similar egg portions from local chickens in increasing the levels of viscera fat and blood cholesterols in the treated rats.

Keywords: viscera fat, cholesterols, chicken, eggs, egg white, egg yolk

1. Introduction

Chicken eggs fall in the group of animal-sourced foods that contribute significantly to nourishing the growing human population worldwide (Réhault-Godbert *et al*., 2019). What makes chicken eggs a fascinating special diet is their moderate content of calories while being rich in minerals, vitamins, protein, antioxidants, saturated fat and cholesterol, distributed in different egg fractions (the Egg York and Egg white) (Jennifer *et al.*, 2005, Griffin 2016). Despite the tremendous nutritional benefits offered by chicken eggs (Griffin 2016), there are debates on whether overconsumption can be unhealthy due to their richness in saturated fat (Rouhani *et al*., 2018). There are growing arguments on the chicken egg's probable contribution to cardiovascular risk factor incidences in consumers which drives the need for more studies in this area. While some studies associate chicken egg overconsumption with the possibility of cardiovascular risk factor occurrences (Rianne *et al*., 2001; Rouhani *et al*., 2018; McNamara 2000; Shim and Seo 2021); other authors report differently (Blesso 2015; Knopp *et al*., 1997; Chairuk 2021; Cassondra *et al*., 2019; DiMarco *et al*., 2017). One of the presumed risk factors associated with chicken egg overconsumption is viscera fat accumulation (viscera obesity) and hyperlipidemia (Dala *et al*., 2012, Shim and Seo, 2021). Visceral obesity can be a risk factor for insulin resistance, hyperglycemia and type 2 Diabetes Mellitus (Jung *et al*., 2016). Also, hyperlipidemia can be a risk factor for atherosclerosis, hypertension and other cardiovascular diseases (Dala *et al*., 2012). Moreover, overconsumption of chicken eggs has been associated with fat accumulation in the Liver, which in a severe case, can progress to Non-Alcoholic Fat liver disease (NAFLD) or steatohepatitis (This is a type of fatty liver disease, characterized by inflammation of the liver with concurrent fat accumulation in liver.) (Mokhtari *et al*., 2017). Untreated steatohepatitis can lead to liver failure. The increasing threat of diet-related chronic health problems increases confusion in the selection of what food to eat and what not to. For instance, the preference for local chicken-sourced eggs over those from commercial layers is from the thinking that local chicken eggs are relatively healthier. The arguments are based on the differing husbandry practices between the local and commercial layer chickens, which is likely affecting the nutrient levels and composition of eggs from the two groups of chickens (Rochelle *et al*., 2019). While local chickens scavenge freely in the natural environment with minimal feed and drug supplementation, commercial-layer chickens are normally house-enclosed while intensively supplied with commercial feeds and drugs. Therefore eggs from the two sources are very likely to differ in the levels of proteins, fats, carbohydrates, vitamins and mineral elements supplied from the feed the chickens are eating (Rochelle *et al*., 2019). Moreover, some fractions of chicken eggs are preferred over others because of the supposed differing levels and composition of some nutrients. The egg yolk and egg white have levels of fat and proteins different enough (Réhault-Godbert *et al*., 2019) to probably affect the level of some parameters, including blood lipids and visceral fat differently when consumed by humans.

So, the current study aimed to determine the effects of different egg fractions from local or commercial layer chicken on the amount of blood lipids, abdomen fat tissues as well as hepatic fat distribution in the Wister rats.

2. Methodology

Study area

An experimental study design was conducted in the College of Veterinary Medicine and Biomedical Science (CVMBS), at Sokoine University of Agriculture (SUA), Morogoro, Tanzania. Research clearance before the study commencement was granted by the Research Ethical Committee of the SUA (reference no SUA/DPRTC/R/126/VET/3/2023/4). The Wistar rats used during the experiments were collected from the small animal research unit of the CVMBS. Before treatment, the animals were left to adapt for 2 weeks in cages under the standard environmental temperature, humidity and day-night cycles of 12/12 hours while fed with broiler starter and ad-lib water. Eggs produced by the free-ranging indigenous breed of chicken, namely the Kuchi, Ching'wekwe and Morogoro medium ecotypes, were collected from Morogoro peri-urban in Tanzania. Eggs from commercial layer chickens were purchased from a poultry farm keeping improved breeds of chickens under the battery cage system in Morogoro peri-urban. After collection, the eggs were processed in the Laboratory of Physiology, Pharmacology and Toxicology at CVMBS to prepare the treatment materials.

Egg processing

Processing of the eggs was done to prepare the different egg partitions. The process involved breaking the egg shell and then separating the Egg white from the egg yolk using a wooden spatula and Petri dishes. Thus, three fractions of the eggs' preparations were made and put in three different bottles. The first bottle contained the whole Egg (Egg white + Egg yolk), the second bottle had only the egg white and the last one contained only the Egg yolk. The bottles with egg portions were then stored at 4℃ in the refrigerator until the time of use.

Experimental setup and treatments

A total of 35 Wistar rats were randomized into seven groups based on different treatment materials. One group served as the control rats and was treated with tap water. The six other groups were treated with different egg preparations from the local or commercial layer chickens at a dosage of 10mg/g Body weight of rats adopting a protocol of Chairuk et *al*. (2021) with some modifications. Details are shown in **Table 1**. Guidelines for the proper use of laboratory animals were adequately followed during the rats' handling and restraints.

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Table 1. Experimental setup for the study to investigate effects of different chicken eggs' fractions on levels of blood lipids, abdomen fat tissues, and hepatic fat distribution in the Wister rats

Groups	**Treatment**	**Treatment duration (Days)**	**Parameters measured from all the groups**
G1 (n = 5)	Control group (Given tap water)	28	-Body weight -Weight of abdominal fat -Weight of the Liver -Total cholesterol -Triglycerides -High-density lipoprotein -Low-density lipoprotein -Histology of the Liver
G2 (n = 5)	Consumed whole Egg (Egg York +Egg White) from Layer's chicken, (10mg/g Body weight of rat)	28	
G3 (n = 5)	consumed Egg Yolk of Layer's chicken, (10mg/g Body weight of rat)	28	
G4 (n = 5)	Consumed egg white from Layer's chicken, (10mg/g Body weight of rat)	28	
G5 (n = 5)	Consumed whole Egg (Egg York +Egg White) from local chicken, (10mg/g Body weight of rat)	28	
G6 (n = 5)	Consumed Egg Yolk from local chicken, (10mg/g Body weight of rat)	28	
G7 (n = 5)	Consumed egg white from local chicken, (10mg/g Body weight of rat)	28	

*) The materials for treatment were fed to the rats by gastric gavage using specific feeding needles.

3. Data Collection

Measurement of body weight

At the end of the treatment period, the body weights of rats were recorded using a digital weighing balance. The data for body weights were used to calculate the weight indices of the Liver and abdominal fat.

Collection of the blood sample, Liver and abdominal fat

After the measurements of body weight, rats from all the groups were sedated in ether and then they were sacrificed. Blood samples were collected from the heart using a needle and plain vacutainer tube to prepare serum for lipids (Total cholesterols, Triglycerides, High-density lipoprotein and low-density lipoprotein) measurements. All the visceral fat under the abdomen was trimmed out using a dissecting blade and forceps and their weights were recorded using a digital weighing balance. Weights of abdominal fat were then divided by the body weight of the respective rats to calculate the abdominal fat weight index. The weights of the Livers of rats were also recorded using a digital weighing balance and then divided by the body weights of corresponding rats to calculate the liver weight index.

Lipids analysis was performed calorimetrically employing the Cholesterol assay kit (Erba Manheim, India, BLT 00034) for Total cholesterol (TC) and triglyceride assay kit (Erba Manheim, India, BLT 00057) for Triglycerides (TG) as per kit instructions. Also, the High-Density Lipoprotein assay kit (Erba Manheim, India, BLT 00032) was used for High-density lipoprotein Cholesterol (HDL-C) analysis following the kit instructions.

Then, the Friedewald Equation: **LDL-C (mg/dL) = TC (mg/dL) − HDL-C (mg/dL) − TG (mg/dL)/5** was used to calculate the serum levels of Low-Density Lipoprotein Cholesterol

(LDL-C).

Histology of the abdominal adiposity and the liver involved fixing the tissues 10% neutral buffered formalin, dehydration of the tissues at increasing concentrations of ethanol (75%, 95%, 95 %), clearing in xylene, embedding in paraffin wax, and tissue sectioning by a microtome before being assessed by a camera mounted microscopy. Microscopic examination was done at x 100 and x 200 magnifications.

Data Analysis

The IBM SPSS Statistics 20 software was used to compute the Mean and standard error of the mean for Weight indices of the abdominal fat and liver tissues, as well as the levels of TC, TG, HDL-C, and LDL-C. Comparison of the computed means between the groups employed the ANOVA. Pair-wise comparisons between the groups were done by Turkey's HD test. All values were regarded as statistically significant at $p < 0.05$ and highly significant at $p < 0.01$.

4. Results

The current study showed that whole egg or egg fractions from the commercial layer or local chicken caused a varied degree of abdominal fat weight gain when fed to rats compared to rats not eating any egg component (the Control) (**Figure 1**). Also, the weight of abdominal fat gained in rats eating the whole Egg (Egg white plus yolk) from commercial layer chicken exceeded significantly (P<0.05) that of rats eating separate egg fractions (only the yolk or only the egg white) from a similar source (**Figure 1**). Also, rats eating the egg yolk from commercial layer chicken showed a significantly (P<0.05) higher weight of abdominal fat relative to rats eating only the egg white from a similar source. Moreover, the whole Egg (Egg white plus yolk) and the egg yolk from local chicken caused a similar increase in abdominal fat weight in treated rats compared to when only the egg white from similar eggs was fed to the experimental animals (**Figure 1**). Also, the whole Egg (Egg white plus yolk), or egg fractions (only the yolk or only the egg white) from commercial layers chicken eggs caused more (P<0.05) gain of abdominal fat in treated rats relative to similar egg components from local chicken eggs (**Figure 1**).

Furthermore, the weights of the Liver were significantly higher (P<0.05) in rats treated with the whole Egg (Egg white plus yolk) or individual egg fractions (only the egg white, or only the yolk) from the commercial layer or local chicken relative to the negative control. However, feeding the whole egg (yolk + white) from commercial layer chickens caused more weight gain (P<0.05) in the Liver of rats relative to when only the egg white or the yolk from a similar source of eggs were separately fed to rats (**Figure 2**). Further comparison indicated the weight of the Liver of rats eating the egg yolk from commercial layer's chicken to exceed significantly (P<0.05) that of the rats which consumed only the egg white from the same egg sources. The local chicken-sourced whole Egg, egg white and Egg yolk resulted in an insignificantly (P>0.05) differing weights of liver tissues when fed separately to rats. However, further comparison indicated the whole Egg and the egg yolk from commercial layer chicken to exceed significantly (P<0.05) the related egg components from local chickens in increasing the weight of the Liver when fed to rats.

Furthermore, the level of Total Cholesterol (TC) was significantly (P<0.05) higher in rats eating either the whole Egg (mixture of Egg white and yolk) or only the yolk from commercial layer chicken as compared to the negative control (**Figure 3**). Also, the whole egg or egg fractions from local chicken and the egg white from the commercial layer had no significant effects on the total cholesterol level in treated rats in comparison to the control (**Figure 3**).

Also, levels of serum triglyceride (TG) were significantly higher (P<0.05) in rats eating the whole Egg (Egg white plus yolk) or egg fractions from commercial layers or local chicken eggs relative to the negative control rats (**Figure 4**). Furthermore, levels of serum TG in rats consuming only the egg yolk from commercial layer chicken exceeded significantly (P<0.05) that of rats eating the whole Egg or only the egg white from a similar egg source (**Figure 4**). Moreover, the egg yolk from local chicken eggs caused more rise of TG in the blood of rats relative to the egg white or a mixture of Egg white and yolk (**Figure 4**). Also, the whole egg or egg yolk from commercial layer chicken increased the TG level in the blood of treated rats than the similar egg components from local chicken eggs (**Figure 4**). Furthermore, serum levels of triglycerides were lowest in rats eating the egg white compared to rats eating other egg compartments from either commercial layer or local chicken (**Figure 4**).

Furthermore, the HDL-C was significantly more elevated in rats that ate the whole or the egg yolk from either commercial-layer or local chickens in comparison to the control rats (**Figure 5**). However, pair-wise comparison indicated that the commercial layer chicken sourced egg yolk caused more elevation of serum HDL-C level followed by the whole Egg and then the egg white, in that order compared to counterpart egg portions from local chickens. Nevertheless, the egg white from local chicken eggs caused no significant elevation of serum HDL-C in treated rats relative to the control rats (**Figure 5**).

Moreover, the whole Egg or individual egg fractions from the commercial layer or local chickens caused a significant rise of LDL-C in the treated rats relative to the control (**Figure 6**). Treatment with the whole Egg or only the yolk from commercial layer chicken eggs caused a similar increase in serum LDL-C to a level significantly higher compared to treatment involving only the egg white from a similar egg source (**Figure 6**). Likewise, treatment involving the whole Egg or only the egg yolk from local chicken eggs caused a similar increase in serum LDL-C which was however significantly higher than the level observed when only the egg white from a similar source of eggs was used (**Figure 6**). Moreover, the commercial layer sourced whole egg or egg fractions caused more elevation of serum LDL-C level compared to similar egg fractions from local chickens (**Figure 6**).

Figure 7 shows the histopathology of the Wistar rat's Liver. **A** group represents the negative control; **C** stands for rats eating the egg white from Layer's chicken, **E** for rats eating Egg white plus yolk from local chicken, **F** for rats eating Egg white from local chicken and **G** for rats eating the yolk from local chicken eggs. All those groups showed normal hepatocytes indicated by thin black arrows (**Figure 7**). However, picture **B**, for rats eating a mixture of yolk and Egg white from commercial layers eggs showed enlarged hepatocytes with high-fat deposition in the cell's cytoplasm (**Figure 7**). Picture labeled **D** representing the group of rats treated with yolk from commercial layers chicken eggs revealed a mixture of partially fat-infiltrated hepatocytes shown by thick short black arrows and normal hepatocytes shown by thin black arrows (**Figure 7**).

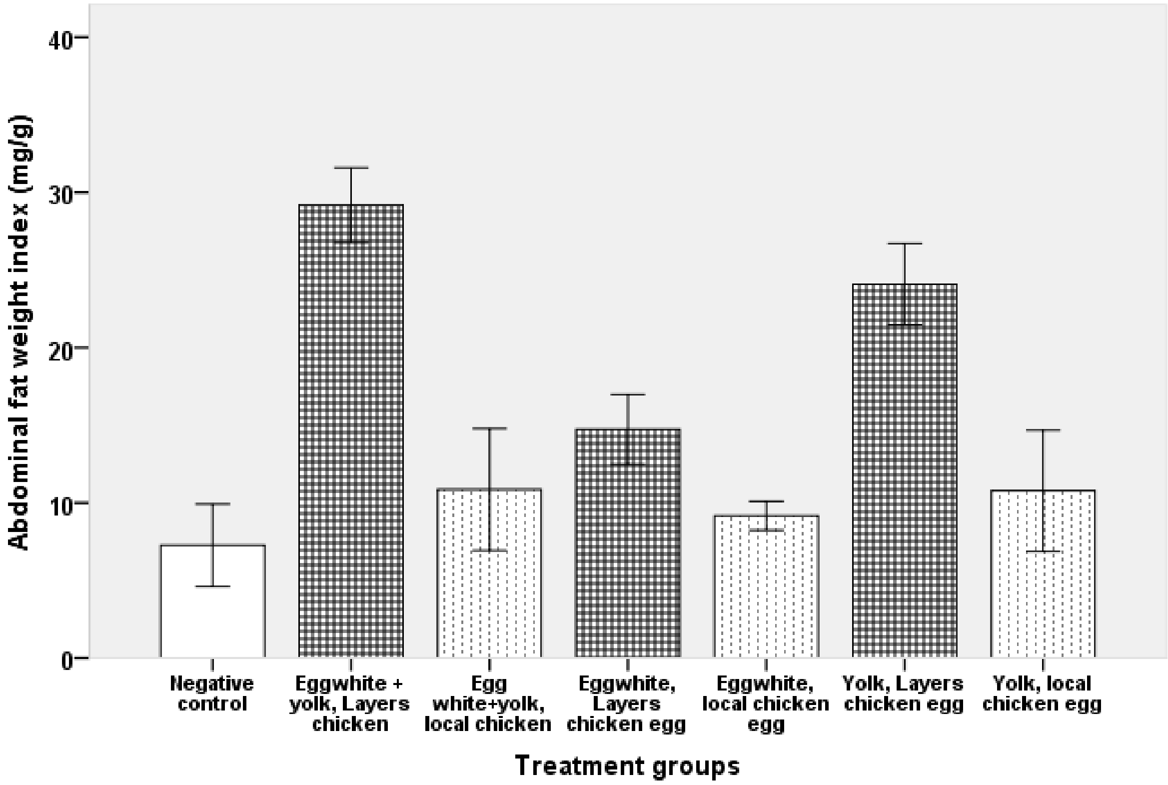

Figure 1. Effects on abdominal fat weight index (mg/g BW) of different egg components from the local or commercial layer breeds of chicken treated for 28 days in Wistar rats (n = 35).

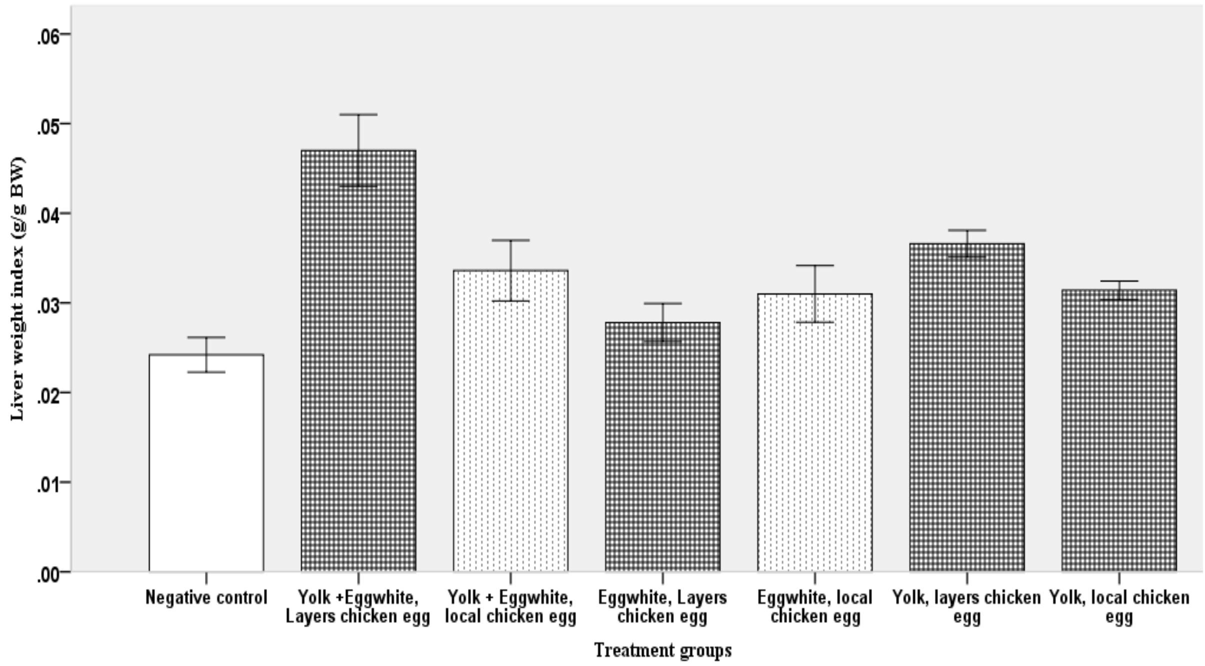

Figure 2. Effects on the weight index of the Liver (g/g BW) of different egg components from the local or commercial layer breeds of chicken treated for 28 days in Wistar rats (n = 35).

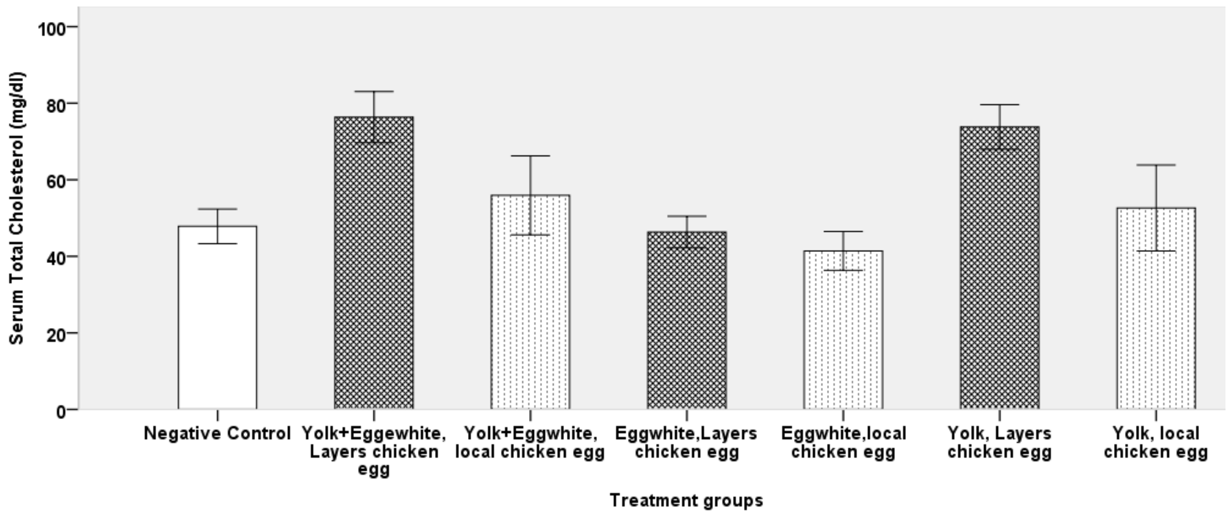

Figure 3. Effects on serum Total Cholesterol (TC) levels (mg/dl) of different egg components from the local or commercial laer breeds of chicken treated for 28 days in Wistar rats (n=35).

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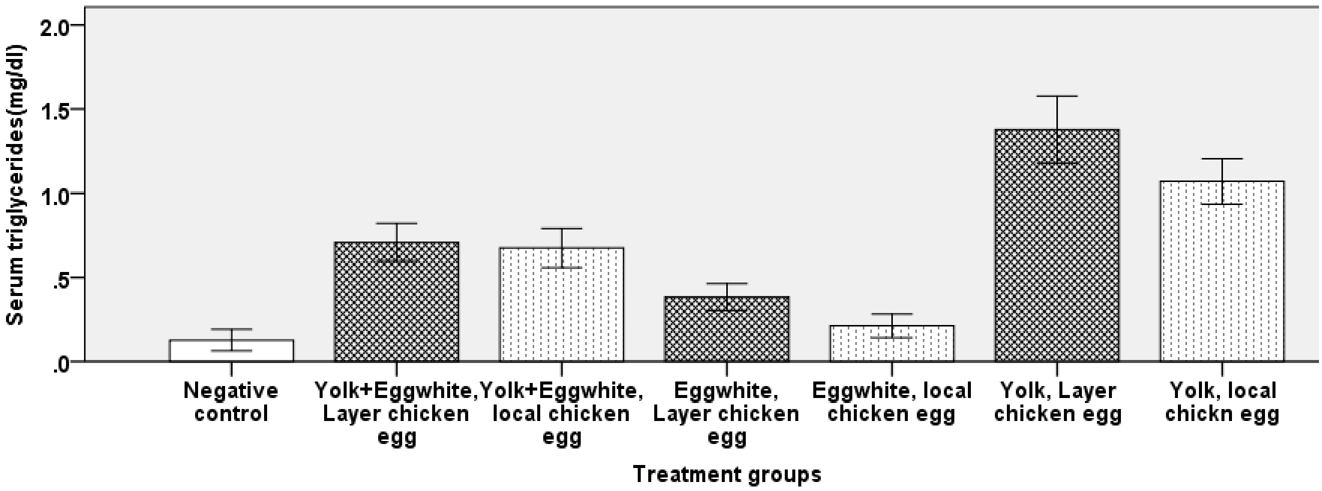


Figure 4. Effects on Serum Triglycerides (TG) levels (mg/dl) of different egg components from the local or commercial layer breeds of chicken treated for 28 days in Wistar rats (n = 35).

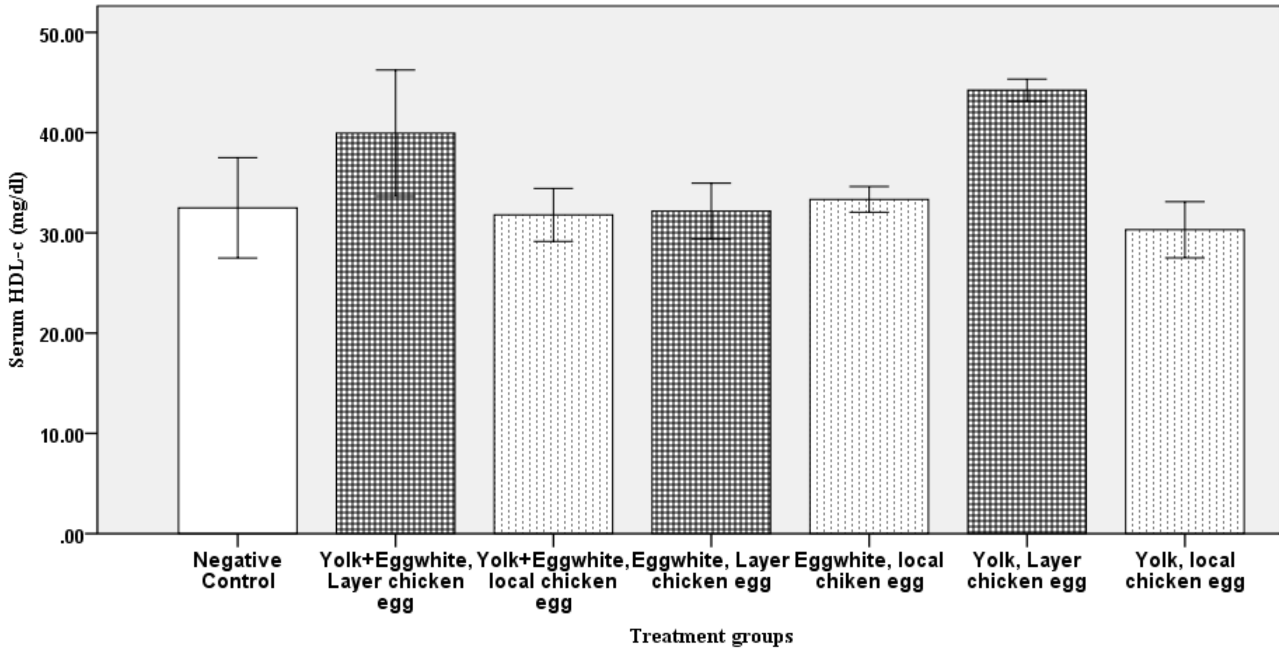


Figure 5. Effects on serum High-Density Lipoprotein cholesterol (HDL-c) levels (mg/dl) of different egg components from the local or commercial layer breeds of chicken treated for 28 days in Wistar rats (n=35).

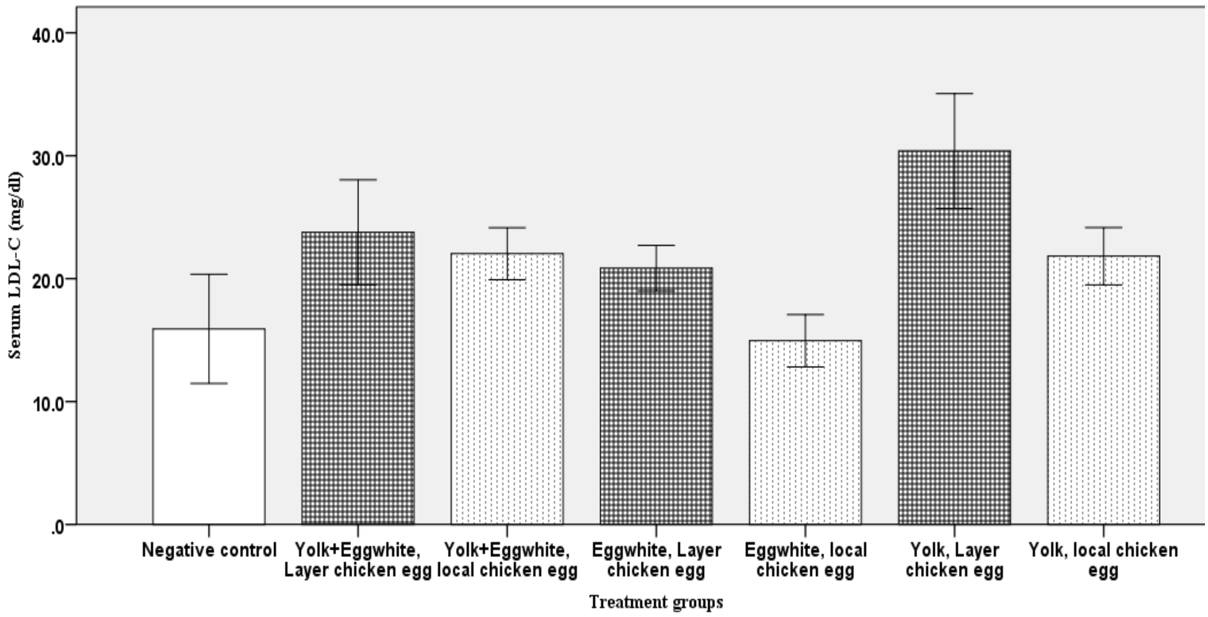
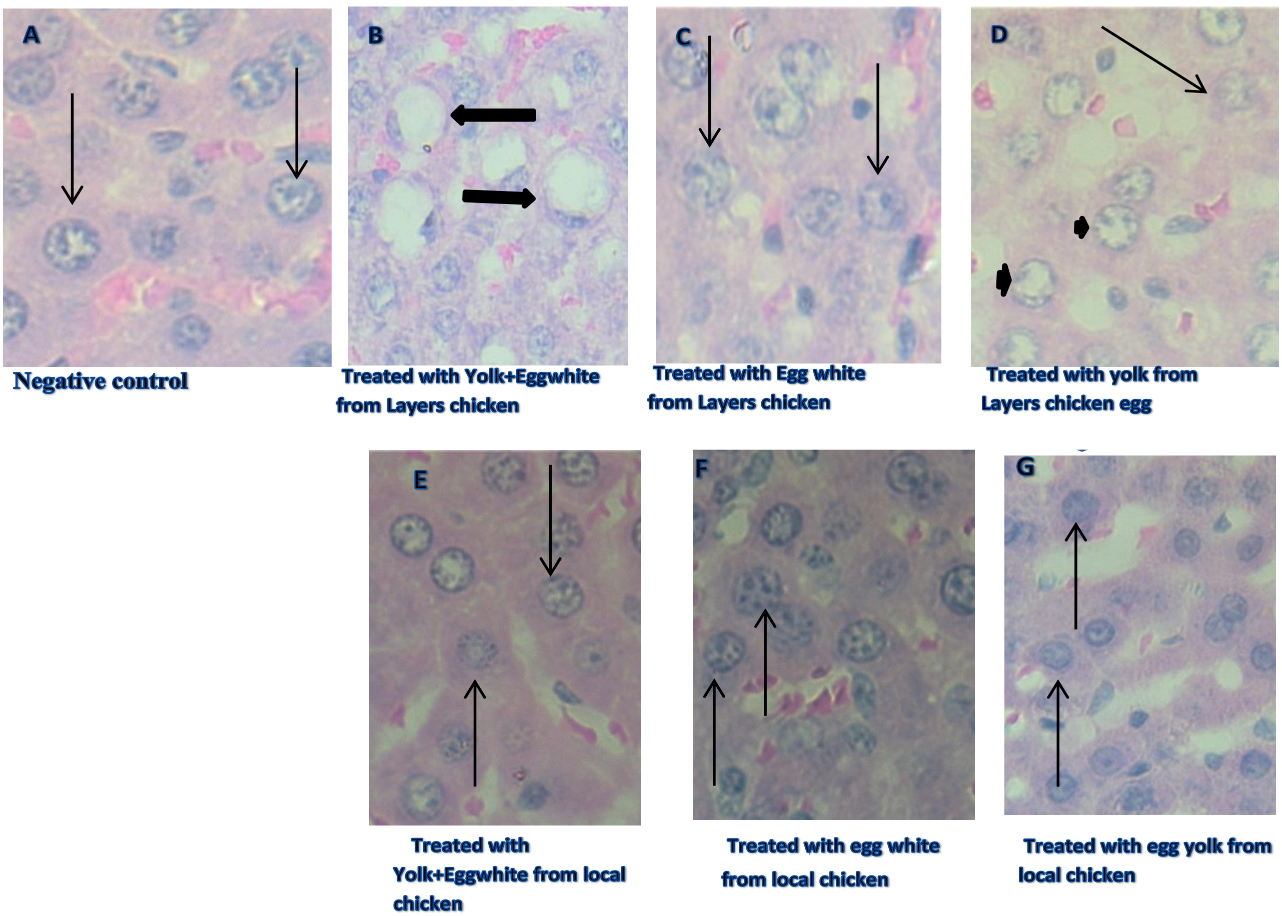


Figure 6. Effects on Serum Low-Density Lipoprotein Cholesterol (LDL-C) levels (mg/dl) of different egg components from the local or commercial layer breeds of chicken treated for 28 days in Wistar rats (n=35).



x 400 magnification.

Figure 7. Histological picture of the Liver of Wistar rats (n=35) treated (for 28 days) with different egg components from the local or commercial layer breeds of chicken.

Group **A** represents the negative control, **C is** for rats eating egg white from layer's chicken, **E** for rats eating Egg white plus yolk from local chicken, **F** for rats eating egg white from local chicken and **G** for rats eating the yolk from local chicken eggs showed normal hepatocytes indicated by thin black arrows. However, picture **B**, for rats eating a mixture of yolk and Egg white from commercial layers eggs showed enlarged hepatocytes with high-fat deposition in the cell's cytoplasm. Picture labeled **D** representing the group of rats treated with yolk from commercial layers chicken eggs revealed a mixture of partially fat-infiltrated hepatocytes shown by thick short black arrows and normal hepatocytes shown by thin black arrows.

5. Discussion

Different edible parts of chicken eggs have different levels of nutritional composition (Griffin 2016). The Egg white has three major parts namely, the outer thin albumen, the middle thick albumen and the inner thin albumen (Griffin 2016). About 10% of egg white is a protein called albumin, 87.72% of it is water, 0.85% of it is carbohydrates and 0.19% of it is fat (Griffin 2016; Abeyrathne *et al* 2013). Also, there are abundances of minerals and vitamins (0.42%) in the egg white including niacin, riboflavin, choline, magnesium, potassium, sodium and a trace of fat and carbohydrate with water taking a large portion (Jennifer *et al.*, 2005; Griffin 2016). The egg yolk is the inner portion of the chicken eggs held centrally (Réhault-Godbert *et al*., 2019). While 50% of the Egg York is water; 15.50% are proteins, 1.09% carbohydrate and 26.71% are Lipids (Réhault-Godbert *et al*., 2019). The egg yolk comprises the majority of the calories that are contained in the Egg. Also, the egg yolk contains a large portion of minerals (1.68%) (iron, phosphorus, calcium, potassium, thiamine, and riboflavin) and almost all of the fat-soluble vitamins (A, D, E and K) (Réhault-Godbert *et al*., 2019). Estimated by weight composition, the most prevalent fatty acids in egg yolk include unsaturated fatty acids (Oleic acid (47%), Linoleic acid (16%), Palmitoleic acid (5%), Linolenic acid (2%); and saturated fatty acids (Palmitic acid (23%), Stearic acid (4%), Myristic acid (1%) (Réhault-Godbert *et al*., 2019). The current study revealed that the whole Egg (egg white + yolk) or individual egg fractions (yolk or egg white) from the commercial layer or local chicken**s** had different effects in altering the levels of abdominal fat in treated rats. There was a high accumulation of abdominal fat in rats eating the whole Egg followed by those eating only the egg yolk from the commercial chicken layer probably due to the high content of fat in the egg yolk. Moreover, there was a low amount of abdominal fat in rats eating whole eggs or only the egg yolk from local chicken compared to rats eating similar egg compartments from commercial layer chicken. Why eggs from the commercial layer did cause more accumulation of abdominal fat than eggs from local chickens? It is probably because of the different nutrient levels in the eggs from the two sources (Rochelle *et al*., 2019). Eggs from commercial layer chicken are very likely to have higher amounts of fat and proteins in the egg yolk and egg white compared to eggs from local chickens (Rochelle *et al*.,

2019) hence affecting the treated animals differently. Moreover, the lowest values of abdominal fat weights in rats eating only the egg whites from both the local and commercial layer chicken were most likely due to the lowest content of fat in the Egg white relative to whole Egg or egg yolk. Nevertheless, results on abdominal fat weight gain caused by whole Egg or egg yolk from chickens in the current study in Wistar rats disagreed with the results reported in studies involving human subjects. Cassondra *et al*. (2019) revealed a significant decrease in body weight in Zuker diabetic obese rats after feeding them a whole egg from layer chicken for 56 days. The current results also were not in line with the results of Chairuk *et al*. (2021) who revealed in their studies a lack of association of the whole eggs or individual egg fractions consumption with the body weight and body lipids in treated rats relative to the control. Also, our results were in contrast to the results of Liu *et al*. (2020) who revealed a lower risk of central obesity and lower risk of excessive body fat in people who consumed >50 grams of whole Egg daily. However, the authors' results agreed well with the results of Shim and Seo (2021) who in their studies revealed a higher fat mass (FM), percentage body fat (PBF), and fat-to-muscle ratio (FtoM), among the people consuming 2 to 3 whole eggs per week relative to those consuming less than one Egg per week. Moreover, the increase in abdominal fat weight in rats consuming only the egg yolk from commercial layer chicken compared to the control in the current study contradicted the results of Chen *et al*. (2019). The author revealed a decrease in body weight in the male rats after treating them with egg yolk for 28 days (Chen *et al*., 2019).

Also, eggs obtained from the commercial layer and those obtained from local chicken affected differently the weight of the Liver when fed to the rats. The higher weight of the Liver in rats that ate the commercial layer sourced whole Egg or egg yolk than those that ate related egg parts from the local chicken was probably due to the different nutrient levels in eggs from the two sources (Rochelle *et al*., 2019). The probably higher level of protein and fat in the commercial layer chicken sourced eggs compared to eggs from local chickens (Rochelle *et al*., 2019) is likely to affect differently the weight of the treated rat's Liver. Moreover, both the proteins in Egg white and fat in egg yolk appeared to have contributed significantly to the ultimate weight of the rat's Liver in whole egg-treated rats. That is because there were higher values of liver weight in rats exposed to whole Egg (egg white + yolk) from commercial layer chicken compared to those feeding separately the egg yolk or egg white from similar eggs. Histopathology of the Liver supported further our findings. There were numerous enlarged fat–laden hepatocytes in the Liver of the rats that consumed the whole Egg from the commercial layer compared to the control. Also, rats feeding only the egg yolk from commercial layer chicken eggs revealed the presence of several fat-infiltrated hepatocytes. However, feeding the rats with the whole Egg or egg fractions from local chicken or the egg white from commercial layer chicken caused no significant histo-pathological alteration in the liver tissues as compared to the control. Results on hepatic fat infiltration following whole egg or egg yolk feeding in rats as revealed in the current study agreed well with the results of Mokhtari *et al*. (2017) and Lian *et al*. (2020) assessed in human subjects. In the study of Mokhtari *et al*. (2017), participants who consumed 2 to 3 eggs per week, were 3.56 times more likely to have NAFLD in comparison to those who consumed less than 2 eggs per week (OR: 3.56; 95% CI: 2.35-5.31).

Moreover, elevated levels of TC in rats that ate the whole Egg or only the egg yolk as compared to those eating the egg white from commercial layer chicken were most likely attributable to the differing fat content between the egg parts. Similarly, the elevation of TC in rats caused by egg fractions from the commercial layer compared to similar egg portions from the local chicken was probably due to the differing nutrient levels in the eggs from the two sources. Elevation of TC resulting from consumption of the whole Egg of chicken as observed currently disagreed with the results reported by Kim and Campbell. (2018) investigated in human participants. In their two Randomized Controlled Crossover Studies, provided by Kim and Campbell. (2018) concluded that dietary cholesterol in whole eggs is not well absorbed, and thus it does not acutely influence plasma total-cholesterol concentration and therefore not associated with longer-term plasma cholesterol control. However, some caution was also pointed out by Rianne *et al*. (2001) in their studies that dietary cholesterol from eggs can significantly raise the ratio of TC to HDL-C which ends up affecting the cholesterol profile. Thus the authors insisted on not ignoring the likely risks associated with chicken egg overconsumption.

Also, in comparison to the control, levels of TG were significantly higher in rats eating the egg yolk followed by those eating the whole Egg from either the commercial layer or local chickens. Moreover, compared to the control, rats that consumed the commercial layer sourced Egg had elevated levels of TG while no significant changes in the lipid level were revealed in rats eating the local chicken-sourced egg white. The higher TG level in rats eating the egg white from commercial layer chicken compared to the control was probably caused by some lipids in the egg white which despite being in low amounts were probably high enough to show the difference from the control.

A high level of HDL-C enhances the excretion of harmful cholesterol such as LDL-C hence protecting the body from cholesterol-caused cardiovascular diseases. The current study indicated that the egg yolk followed by the whole Egg from both the commercial layer and local chicken caused a significant elevation of HDL-C level in treated rats compared to the control. Also, to a lesser extent, the egg white from commercial layer chicken caused an elevation of HDL-C level in treated rats compared to the control. However, the Egg white from local chicken caused no significant elevation of HDL-C compared to the control. Thus, the current study indicates the egg yolk to be the portion of chicken egg that contributes significantly to elevating the HDL-C when consumed in animals. A relatively lower HDL-C level in rats treated with a whole egg compared to those treated with egg yolk was ascertained in this study was probably due to the dilution effects of the egg white in the egg yolk for rats eating a mixture of egg yolk and white. The higher levels of HDL-C in rats eating the whole Egg or egg yolk from the commercial layer compared to the rats eating similar egg portions from the local chicken was probably due to differing nutrient levels especially fat in eggs from the two sources.

The whole egg and egg yolk from the commercial layer and local chickens chicken resulted in an elevation of serum LDL-C levels in treated rats compared to the control. However, the effects leading to LDL-C elevation caused by the commercial layer chicken-sourced egg portions exceeded those caused by the corresponding egg parts from the local chickens. The possible differing nutrient levels including lipids in eggs from the commercial layer and local chicken could be the explanation for the observed different effects caused by eggs from the two sources. It is also well known that different edible portions of chicken eggs have different compositions and levels of nutrients. Thus, that could be the explanation for the higher levels of LDL-C in rats eating the whole Egg or the egg yolk compared to rats eating only the egg whites. The egg white is known to have low fat content while being rich in protein albumen while the egg yolk is rich in both fat and proteins. Higher levels of LDL-C in rats eating the egg white from the commercial layer compared to the control were probably caused by the smallest amount of fat contained in the egg white (Réhault-Godbert *et al.*, 2019) which is probably enough to make the difference from the control. Similar to our results, McNamara (2000) reported an increase in serum LDL-C responding to dietary cholesterol supplementation in the investigated human personnel. However, Knopp *et al.* (1997) reported a decrease in VLDL from 103 to 95 mg/dL ($p = 0.007$) in people consuming two chicken eggs per week which was probably not expected. Also, DiMarco *et al*. (2017) suggested from their studies that the daily intake of fewer than three eggs/day should probably be the recommended amount to attain favorable levels of LDL particle profile while improving the function of HDL and increasing the plasma antioxidants in healthy animals.

6. Conclusion

The current study revealed no significant effects on blood lipids and viscera fat caused by the egg white regardless of the egg source in treated rats compared to the control. However, the whole egg or egg yolk from the commercial layer had effects exceeding significantly similar egg portions from local chicken eggs in increasing the levels of viscera fat and blood cholesterols in treated rats.

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Authors contributions

Not applicable.

Competing interests

The authors have not declared any conflict of interest that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Macrothink Institute.

The journal’s policies adhere to the Core Practices established by the Committee on

Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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