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Survey of total cholesterol levels in Nigerian chicken eggs and the correlation of total cholesterol levels in chicken eggs with whole egg mass

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Abstract
A survey of the total cholesterol levels in Nigerian chicken eggs was carried out and its correlation with whole egg mass was established. Total cholesterol levels were determined with analytical grade cholesterol determination kit using enzymatic colorimetric method for egg samples obtained from poultry farms in three regions across the country. These were designated as regions A, B, and C. The mean total cholesterol level per egg in these regions were found to be 242, 213, and 247 mg/egg respectively. This showed that total cholesterol level is highest in eggs from region C, followed by region A and the least in B. The same trend observed above was seen with whole egg mass in region C, as it had the highest whole egg mass (55 g) followed by region A (54 g) and the least in region B (52 g). The mean total cholesterol level in eggs from Nigerian poultry farms is 233 mg/egg, while the mean whole egg mass is 54 g. In general, total cholesterol levels in Nigerian chicken eggs are high when compared with the USADA reported mean value of 213 mg/egg. A correlation analysis showed that there is a strong positive correlation (r= 0.912) between egg total cholesterol and whole egg mass, so that generally, total cholesterol levels increase with increase in whole egg mass and the relationship is governed by y=10.86$\varkappa$-349.

Keywords: cholesterol, chicken eggs, whole-egg mass, Nigeria

1. Introduction
Cholesterol belong to the category of neutral lipids. It is probably the most important steroid as it is a precursor of a number of equally important steroids found in animals. Some of these include bile acids, vitamin D, adrenocorticoids and the sex hormones [1]. It is also widely distributed in all animal products such as meat, milk and especially in the yolk of eggs [2]. In avian eggs, cholesterol is found only in the yolk and as such, the yolk's total cholesterol is the egg's total cholesterol. Cholesterol is a structural component of cell membranes and a precursor of a number of biochemical molecules. In humans like in most vertebrates, cholesterol is also found in plasma where it exist as free cholesterol or cholesteryl esters being transported by low density lipoproteins (LDL) [1, 2]. For years now, prolonged high levels of plasma cholesterol carried by elevated levels of LDL have been implicated in the formation of waxy deposits/arterosclerotic plaques on the walls of arteries- a medical condition called aterosclerosis [1, 3], thus clogging them up. This prevent the transport of oxygen and other life-supporting materials carried in blood to vital body organs and tissues thus causing their sudden death and hence that of the individual in which this occur [4]. This is the situation in individuals with heart attacks and stroke. Plasma cholesterol levels are moderated by the balance between endogenous intake and dietary intake and the rate of metabolic degradation but mostly by dietary intake. As such knowledege of cholesterol contribution from staple dietary sources like egg becomes important. This study is a survey of the total cholesterol level in chicken eggs from poultry farms across Nigeria and the correlation of this with whole egg mass. From the relationship between whole egg mass and the cholesterol content in it, this study will afford households an on-the-spot method of accurately estimating the cholesterol content in chicken eggs.

2. Materials and Methods
Fifty chicken eggs (laid by Rhode ireland strain) obtained from commercial poultry farms in three regions across Nigeria were used for the study. In the cholesterol determination experiment, an egg was picked at a time and its whole mass determined using a chemical balance after which it was carefully punctured with a glass rod to drain the albumen and recover the yolk. The yolk was then rolled on a paper towel to remove adhering albumen. The mass of the whole yolk was then measured with a chemical balance and recorded. The total cholesterol content was then determined in mg/g by enzymatic colorimetric method using the total cholesterol determination kit supplied by RANDOX. In this method, 9 mL of distilled water was added to 1 mL of egg yolk in a test tube and aggitated vigorously to homogenise. Twenty microliters (20 uL) of the homogenised yolk was then added to 1 mL of the cholesterol determination reagent supplied with the cholesterol determination kit from RANDOX, shaken well and incubated for 10 minutes at 25 ^{o}C to allow for color development after which it was transfered into a cuvette and the absorbance measured at 500 nm against a reagent blank. The above procedure was then repeated for the remaining egg samples. The concentration of cholesterol in mg/g yolk was obtained by evaluating the following expression for each egg.

$$\text{Cholesterol Conc. (mg/g)} = \frac{A_{sample}}{A_{Standard}} \times Conc.of\ Standard \times \frac{10}{W}$$

Where: A is absorbance, W is mass of 1 mL yolk sample, 10 is the dilution factor

3. Results and Discussion

3.1 Survey of total cholesterol levels in Nigerian chicken eggs

The results obtained are as shown in Table 1. Table 1 show whole egg masses, yolk masses as well as the yolk total cholesterol levels of eggs obtained from selected poultry farms in three geographical regions across Nigeria. The mean total cholesterol content per egg for regions A, B and C are 242, 213 and 247 mg/egg respectively. The observed values are very similar to those obtained in related studies [5, 6] and because cholesterol levels of between 240 - 400 mg/egg have been adjudged to be on the high side [6], total cholesterol levels in Nigerian poultry eggs can be said to be high. Although the mean total cholesterol levels per egg in regions A and C are not far from each other (242 and 247 mg/egg respectively) and have a mean value of 245 mg/egg, a difference is observed between this value and that of region B (213 mg/egg). A t-test comparison at 0.05 level of probability and a degree of freedom of 49 showed that the observed difference is statistically significant as the calculated t-value (8.90) is greater than the critical t-value (1.70). The observed difference may likely be due to variation in poultry feed[7].

In Table1, the mean whole egg masses in regions A, B and C are 54, 52 and 55g respectively. In regions A and C, the mean whole egg masses are similar but a marginal difference is observed when their resultant mean value (54.5 g) is compared with that obtained in farm B (52 g). This is especially so because a t-test at 0.05 level of probability and degree of freedom of 49 showed that this difference is not significant since the calculated t-value (0.52) is less than the tabulated/critical t-value (1.76).

In region A, it is generally observed that as the whole egg mass increased, total cholesterol levels also increased. However there are a few exceptions, for instance, while samples A_1 and A_2 showed increase in whole egg mass hence an increase in whole yolk cholesterol content, samples A_4 and A_5 with even higher egg masses showed lower yolk cholesterol content which differs from the normal observed trend. This is most likely due to occasional increase in density of egg shell material with no consequence on the potential size of the would-be chick. The mean whole egg mass in region A is 54 g and the mean total cholesterol content of eggs from this region is 242 mg/egg

In region B, it is observed that as whole egg mass increased, total cholesterol content per egg also increased without variations in the trend. This implies that the greater the mass of the egg, the higher would be the total cholesterol per egg and vice versa. The mean whole egg mass from region B is 52 g and the mean total cholesterol content is 213 mg/egg.

The result obtained from region C show the same trend as region B with few exceptions seen between C_1 and C_2 and between C_4 and C_5, where minute increment in the whole egg mass does not translate into an increase in the egg total cholesterol content. However, it must be stated that the observed increment is very minute. The mean whole egg mass is 55 g and the mean total cholesterol content is 247 mg/egg of the three regions, chickens from region C produce eggs with the largest whole egg mass and the highest total cholesterol content, followed by region A and the least being region B. The mean whole egg mass and egg total cholesterol content of the three regions was found to be 54g and 233mg/egg respectively. Regardless of variations in breeding conditions across regions A, B and C, it was observed that for the most part, total cholesterol content per egg increased steadily with increase in whole egg mass. This may be related to the fact that the amount of cholesterol needed for embryonic development increases with increase in potential size of the prospective embryo [8].

A particularly curious observation is seen when although certain eggs have yolk masses commiserate with their observed whole egg mass, the amount of cholesterol per gram of the yolk turned out to be lower than expected as seen in A_{13}, A_{15} and B_{14}. This means that there are very few exceptional cases where certain egg yolks contained lower amounts of total cholesterol per gram than the general observed level. However in eggs where the whole yolk mass is small and cholesterol content per gram of yolk is observed to be slightly higher than expected the cholesterol concentration per gram of yolk was always slightly higher than normal thus ensuring that the egg cholesterol is fairly constant for a prescribed whole egg mass as observed with C_3 and C_7. It is important to note that the observed marginal differences between the total cholesterol content of eggs across all three regions may be attributed to diet variation [8].

3.2 Correlation of Whole Egg mass With Total Cholesterol Levels

The plot of total cholesterol per egg against whole egg mass in figure 2 above gives a straight line and the relationship between the two variables is governed by: $y = 10.86\varkappa - 349$, where y and $\varkappa$ are the total cholesterol per egg (in mg) and whole egg mass (in g) respectively. The slope and intercept on y are 10.86 and -349 respectively. The correlation analysis gave the correlation coefficient (r) of the line to be 0.912. This shows a near perfect and positive linear relationship between total cholesterol levels per egg and whole egg mass. This means there is a strong positive correlation between the two parameters and cholesterol level per egg increases as whole egg mass increases. From the above established relationship, the corresponding total cholesterol content in a given chicken egg can be estimated once we know the whole egg mass using the regression equation: $y=10.86\varkappa-349$.Also the plot tilts more towards the whole egg mass suggesting that yolk cholesterol content is determined by whole egg mass.

4. Conclusion

The study revealed that the mean total cholesterol level in chicken eggs from Nigerian poultry farms is 233 mg/egg and on average, each egg weighs 54 g. This is an indication that the total cholesterol levels in Nigerian eggs though high, is lower than the recommended daily allowance of 300 mg cholesterol per day set by the USADA and AHA [9].

Results from the Correlation analysis (r=0.912), showed there is a strong positive correlation between total cholesterol level in egg and whole egg mass as the level of the former increases with increase in magnitude of the later and this relationship is governed by the linear equation $y=10.86\varkappa-349$.

The above linear equation which positively correlates the yolk total cholesterol levels in eggs with whole egg mass thus affords households a rapid or instant means of deducing how much cholesterol may be present in a given egg by simply

weighing it and substituting the mass into the equation without the rigors of a laboratory determination with such information, households can then moderate their dietary cholesterol intake from eggs in relation to the approved American Heart Association and the USADA dietary guidelines [10, 11]. Also, it does not appear that whole egg mass affects total cholesterol level in eggs as would whole yolk mass. This is because the study showed that eggs with large whole egg masses and a disproportionately small whole yolk mass still contained in such yolks an amount of total cholesterol that is proportionate to the whole egg mass as such yolks have a slightly higher concentration of cholesterol per gram yolk (C_3 and C_7).This ensures that total cholesterol level is fairly constant for a prescribed egg mass

4.1 Table and Graph

Table 1: Whole Egg mass, yolk mass, and yolk total cholesterol content per Egg in Nigerian poultry farms.

S. no	Egg farm ID number	Whole egg mass (g)	Whole yolk mass (g)	Cholesterol content (mg/g of yolk)	Yolk total cholesterol content in egg (mg/egg)
1	A_1	51.658	13.832	16.831	232.805
2	A_2	52.509	14.683	17.007	249.715
3	A3	52.799	13.902	17.149	238.407
4	A_4	53.815	13.313	17.239	229.503
5	A_5	54.102	10.518	14.351	222.694
6	A_6	54.695	14.123	18.863	259.409
7	A_7	55.280	14.778	15.809	233.619
8	A_8	57.981	15.879	16.886	268.129
9	A_9	51.658	13.832	16.831	232.805
10	A_{10}	52.509	14.683	17.007	249.715
11	A_{11}	52.799	13.902	17.149	238.407
12	A_{12}	53.815	13.313	17.239	229.503
13	A_{13}	54.102	10.518	14.351	222.694
14	A_{14}	54.695	14.123	18.863	259.409
15	A_{15}	55.280	14.778	15.809	233.619
16	A_{16}	57.985	15.879	16.886	268.129
Farm	Mean	54.11,±1.84		16.76	241.79±14.77
17	B_{17}	46.628	10.095	13.755	150.621
18	B_{18}	47.946	11.713	13.258	155.287
19	B_{19}	49.323	11.497	14.432	165.930
20	B_{20}	51.893	11.562	17.399	201.163
21	B_{21}	52.571	13.314	16.759	223.126
22	B_{22}	54.630	14.130	17.487	247.088
23	B_{23}	55.162	15.232	16.701	254.386
24	B_{24}	56.111	15.609	16.883	263.521
25	B_{25}	56.335	15.872	15.995	253.879
26	B_{26}	46.628	10.095	13.755	150.621
27	B_{27}	47.946	11.713	13.258	155.287
28	B_{28}	49.323	11.497	14.432	165.930
29	B_{29}	51.893	11.562	17.399	201.163
30	B_{30}	52.571	13.314	16.759	223.126
31	B_{31}	54.630	14.130	17.487	247.088
32	B_{32}	55.162	15.232	16.701	254.386
33	B_{33}	56.111	15.609	16.883	263.521
34	B_{34}	56.335	15.872	15.995	253.879
Farm	mean	52.29±3.36		15.85	212.74±41.67
35	C_{35}	52.311	13.485	17.254	232.670
36	C_{36}	52.432	14.606	15.909	232.371
37	C_{37}	53.742	13.240	18.569	245.854
38	C_{38}	54.291	14.102	17.737	250.126
39	C_{39}	54.782	14.280	17.378	248.164
40	C_{40}	55.342	15.512	16.743	259.715
41	C_{41}	56.019	14.632	17.074	249.823
42	C_{42}	57.458	15.816	16.429	259.836
43	C_{43}	52.311	13.485	17.254	232.670
44	C_{44}	52.432	14.606	15.909	232.371
45	C_{45}	53.742	13.240	18.569	245.854
46	C_{46}	54.291	14.102	17.737	250.126
47	C_{47}	54.782	14.280	17.378	248.164
48	C_{48}	55.342	15.512	16.743	259.715
49	C_{49}	56.019	14.632	17.074	249.823
50	C_{50}	57.458	15.816	16.429	259.836
Farm mean		54.53±1.54		17.14	247.32±9.78
Overall	Mean	53.59±2.52	16.58±1.43	16.58 ±1.52	233.10±31.73

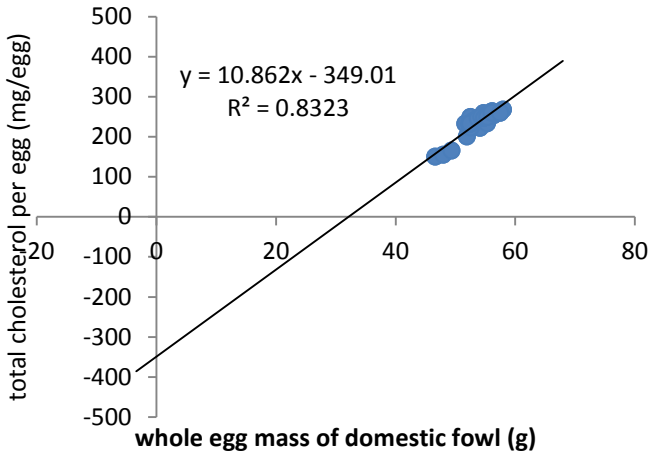

Fig 1: Plot of Yolk Cholesterol content versus Whole egg mass

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