Fat Content in Ground Meat: A statistical analysis

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Abstract

This exercise is designed to illustrate some of the properties of lipids and is included in our freshman level Biochemistry Lab. Using common laboratory equipment, students separate fat from protein in regular and lean hamburger and ground turkey. Students use a chi-square analysis to compare their results to the statement of fat content on the meat package labels.

Notes for Instructor

The majority of the dry matter of cells consists of carbon, oxygen, nitrogen, and hydrogen organized into larger molecules of four main types: proteins, carbohydrates, lipids (fats), and nucleic acids. These molecules often combine to make even larger molecules that are important to cellular structure and function.

Lipids are a group of diverse fatty or oily substances that are insoluble in water. The simplest lipids are composed of carbon, hydrogen, and oxygen atoms and upon hydrolysis produce glycerol and fatty acids. Lipids function to store energy and they play a significant structural role as components of membranes, which control the movements of other lipids or lipid soluble materials in and out of the cells.

The students test a selection of ground meats to determine if the labels accurately reflect the fat content. Each group of students is assigned three samples of ground meats of varying grades. After determining the percentage of fat found in the samples, each student runs some statistical tests on their data.

We discuss the properties of fats as observed during the procedure and later relate the amount of fat found from the three types of meat to their origin on the cow and on the bird. The ground meats are purchased from a local grocery store. Students have to deal with applied arithmetic, percents, and statistics at a very basic level which is a challenging task for many. Regardless of their academic backgrounds, students enjoy being food lab technicians for the duration of this exercise.

Student Outline

Materials and Methods

- hot plates (do not need to be stirring)
- 100-ml graduated cylinders
- small funnels
- pieces of cheesecloth (to fit the funnels)
- 250 ml beakers
- glass stirring rods
- triple beam balances
- pieces of wax paper about 4” square
- Ground hamburger, leanest available
- Ground hamburger, fattiest available
- Ground turkey

Procedures

Each group will obtain 25 grams of lean ground hamburger, regular ground hamburger, and ground turkey and process them in the following manner.

1. Weigh out 25 grams of the first ground meat sample, the lean hamburger. Weigh a piece of wax paper on the triple beam balance, then add the meat, then subtract the wax paper from the total.
2. Place the sample in a beaker and add 100 ml water. Break up and stir the ground meat with a glass stirring rod, carefully heat the sample until it is boiling. Boil about 10 minutes, stirring occasionally.
3. When finished with boiling, carefully remove the beaker from the hot plate. Allow the solution to cool until it can be handled without causing a burn.
4. Pour the contents into the 100-ml graduated cylinder, using the funnel and cheese cloth to filter out the meat and so only the liquid is collected.
5. Measure the amount of fat that has risen to the top from your sample directly from the measurement increments on your graduated cylinder. A good approximation of volume to mass is: 1 ml fat = 1 gm fat. You should wait about 5 minutes for all the fat to rise to the top.
6. Record results under Observed Value (o) in Table 1.
7. Clean the beaker, graduated cylinder, funnel and stirring rod and repeat procedure with the next sample. Repeat for the last sample.

Results

Statistical Analysis of Your Ground Meat Samples

Prior to a statistical analysis of any set of data, certain underlying assumptions are usually tested and accepted. For this experiment and analysis, we are assuming the data are normally distributed, samples are chosen randomly, and that our observations are independent (one group's results are not affected by another's). If the deviations are not normally distributed (following a bell shaped curve) we could use different statistical tests called nonparametric statistics. However, we will expect that the deviations from the expected mean in the fat content in ground meats follow a bell-shaped curve. Two statistical tests lend themselves well to this set of data: the chi-square and the *t*-test. The chi-square allows us to test observed vs. expected values. The *t*-test allows us to test for differences between means (averages). Each group will gather their data and run a chi square test. Then we will pool our data and run a *t*-test using a statistical program.

Please note that this exercise can be expanded to include a Student's *t*-test only if you are willing to buy a lot of ground meat from different stores. This ensures that the samples are coming from different animals. Information regarding the *t*-test is included in this exercise.

Chi-square analysis of fat content

First, calculate the amount of fat you would expect in a 25-gram sample of meat. For example, if the package label states 85% lean, then you would expect that 15% of the contents to be fat. Thus, 15% of the 25 grams will be fat, 85% of the sample will be protein. To convert percent into weight, take 15% of 25 grams [0.15 x 25 = 3.75 grams fat)]. To calculate expected protein content, take 85% of 25 grams [0.85 x 25 = 21.25 grams protein]. You will need to calculate the expected results for all three samples and record them under Expected Value (e) in Tables 1-3.

Forming a hypothesis

By converting percent data derived from the package label into weight, a proportion or ratio is established which can be analyzed by a chi square statistical procedure. In statistics, we actually test a hypothesis of "no difference" called the null hypothesis (H_0). The alternative hypothesis (H_A) will be a statement of "difference." For our experiment with ground meat, our statistical hypotheses are:

H_0: There is no difference in the stated label of fat content and the actual fat content calculated.

H_A: The fat content stated on the package label differs from the calculated fat content of the sample.

Analysis of data

Once you have calculated your chi square value (X^2_{calc}), compare it to the value of 3.841, which, as can be seen in Table 4, is the critical chi-square value used with a *p* (probability) value of 0.05, with degrees of freedom (d.f.) = 1. If your number is less than this, you have no reason to question your null hypothesis. If your number is greater than 3.841, the null hypothesis is rejected as being non-representative of your observed data (i.e., the real ratio of fat to protein is not as stated on the package label).

t-test for fat content in ground meat (optional)

Each group has performed a chi square statistical test to determine whether or not the fat content in your samples differs significantly from the expected (package label) value. We can now combine data across all the groups to obtain a more accurate estimate of the fat content. This combined data will be tested with an independent *t*-test. Prior to testing this data, it is common practice to produce a scatter plot of the data points to determine if trends or biases are present. The class as a whole will analyze the pooled data as scatter plots on the chalkboard.

In order to plot the data, the y-axis will represent the fat content in grams and the x-axis will be the lab group numbers 1 – 7. We will draw a line parallel to the x-axis at the expected value then plot the points and observe their distribution about the line. If all the points fall to one side or the other of the line, the observed differences between the estimated and the expected value could be due to an incorrect hypothesis (i.e., an error in the package label) or an inadequate method of testing.

Lastly, your instructor will enter your pooled data for fat content into a computer and obtain results for the *t*-test. The degrees of freedom for the two-tailed *t*-test for fat content in ground meat will be n – 1, where n = the number of groups participating in the lab. So, degrees of freedom will be 7 – 1 = 6.

The two-tailed *t*-test is a mathematical method to determine if the mean (average) of the experimental data for fat content is significantly different from the expected value. We will take the average of the fat content from the 7 groups and compare it to the expected value. Each of the 7 values in the third column (observed – expected) of Table 5, for example, will be entered into the computer to compute the significance level for the *t*-test. Once the values are entered, the results of the *t*-test will include a *t*-statistic and a two-tailed level of significance (*p*-value). This process is repeated for the data from each of the other two Tables.

The hypotheses are identical to those formulated for the chi-square test. We reject the null hypothesis if the *p*-value obtained by the calculator is less than 0.05.

Questions for students.

1. Why does the fat rise to the top?
2. What happened to the meat protein when you boiled it?
3. Does it matter how much water is used to boil the meat?
4. Did all the fat rise to the top or was some left in the meat sample; if so, how might this affect your calculated estimate and chi square analysis?
5. Did your results support or not support the null hypothesis? Briefly explain.
6. When you graphed the pooled data, do the deviations around the expected mean look symmetrically distributed across the expected mean or do you see bias? How can you adjust the expected value to match the bias?

References

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Table 1. Chi square calculation for Lean Hamburger; d.f. =1, *p* at .05 level , $\chi^2_{crit} = 3.841$

	Fat	Protein
Observed values (o)		
Expected values (e)		
Difference [o - e] = (d)		
Difference squared (d^2)		
d^2 /e		
$\chi^2_{calc} = \sum d^2$ /e		= ________

Table 2. Chi square calculation for Regular Hamburger; d.f. =1, *p* at .05 level , $\chi^2_{crit} = 3.841$

	Fat	Protein
Observed values (o)		
Expected values (e)		
Difference [o - e] = (d)		
Difference squared (d^2)		
d^2 /e		
$\chi^2_{calc} = \sum d^2$ /e		= ________

Table 3. Chi square calculation for Ground Turkey; d.f. =1, *p* at .05 level , $\chi^2_{crit} = 3.841$

	Fat	Protein
Observed values (o)		
Expected values (e)		
Difference [o - e] = (d)		
Difference squared (d^2)		
d^2 /e		

$\chi^2_{calc} = \sum d^2$ /e = ________

Table 4. Distribution of chi-square values.

d.f. p=	0.99	0.95	0.80	0.50	0.30	0.20	0.10	0.05	0.02	0.01
1	0.0002	.0039	.064	.455	1.074	1.642	2.706	3.841	5.412	6.635
2	0.0201	.103	.446	1.386	2.408	3.219	4.605	5.991	7.824	9.210
3	0.115	.352	1.005	2.366	3.665	4.642	6.251	7.815	9.837	11.341
4	0.297	.711	1.649	3.357	4.878	5.989	7.779	9.488	11.668	13.277
5	0.554	1.145	2.343	4.351	6.064	7.289	9.236	11.070	13.388	15.086

Table 5. Data used for a one sample *t*-test that will be entered into a calculator. Repeat this table for regular ground hamburger and ground turkey.

Lean Ground Hamburger

Group #	(Observed Value)	(Observed Value – Expected Value)
1		
2		
3		
4		
5		
6		
7		