

Phys 150 HW 1 Solutions ①

1.3 (a) The energy yield per liter oxygen for a given food type is just the

$$\frac{\text{energy released}}{\text{amount food}} \cdot \frac{\text{amount food}}{\text{vol oxygen consumed}}$$

$$\text{carbohydrates} \quad 4.1 \frac{\text{kcal}}{\text{g}} \cdot \frac{9}{0.81 \text{ L}_{\text{O}_2}} = \boxed{5.1 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}}$$

$$\text{fats} \quad 9.3 \frac{\text{kcal}}{\text{g}} \cdot \frac{9}{1.96 \text{ L}_{\text{O}_2}} = \boxed{4.7 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}}$$

$$\text{proteins} \quad 4.0 \frac{\text{kcal}}{\text{g}} \cdot \frac{9}{0.94 \text{ L}_{\text{O}_2}} = \boxed{4.3 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}}$$

$$\text{alcohols} \quad 7.1 \frac{\text{kcal}}{\text{g}} \cdot \frac{9}{1.46 \text{ L}_{\text{O}_2}} = \boxed{4.9 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}}$$

For the energy yield per  $\text{L}_{\text{O}_2}$  to be roughly constant, the standard deviation of the values for the different food types must be small compared to the average value.

$$\text{The average value, } \mu = \left( \frac{5.1 + 4.7 + 4.3 + 4.9}{4} \right) \frac{\text{kcal}}{\text{L}_{\text{O}_2}} = \boxed{4.8 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}}$$

$$\text{The standard deviation, } \sigma = \left( \langle (x - \mu)^2 \rangle \right)^{1/2}$$

$$= \left( \frac{(5.1 - 4.8)^2 + (4.7 - 4.8)^2 + (4.3 - 4.8)^2 + (4.9 - 4.8)^2}{4} \right)^{1/2} = \boxed{0.6}$$

Then, to compare the standard deviation to the mean, we take the ratio,  $\frac{\sigma}{\mu} = \frac{0.6}{4.8} \sim \boxed{0.12}$

Then the standard deviation is about 12% of the mean which is fairly small.

So we can say that the energy yield/ $\text{L}_{\text{O}_2}$  is roughly constant for different food types.

We can do the same calculation, this time using the  $\frac{\text{carbon dioxide released}}{\text{amount food}}$  to get the energy released per  $\text{L}_{\text{CO}_2}$  released:

$$\text{carbohydrates} \sim 5.1 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}, \quad \text{fats} \sim 6.7 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}, \quad \text{proteins} \sim 5.3 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}, \quad \text{alcohols} \sim 7.3 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}$$

$$\text{Similarly we find the mean, } \mu \approx 6.1 \frac{\text{kcal}}{\text{L}_{\text{O}_2}} \quad \text{and standard deviation, } \sigma \approx 1.9 \frac{\text{kcal}}{\text{L}_{\text{O}_2}}$$

Then  $\frac{\sigma}{\mu} = \frac{1.9}{6.1} \sim 0.31$ . So the energy yield/ $\text{L}_{\text{CO}_2}$  is not roughly constant for the different food types.

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