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BIO 204-100
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Hornworm Bioenergetics Lab

1a) Hypotheses

In this study we examined the effects of two different diets on the consumption efficiency ("CE"), assimilation efficiency ("AE"), and production efficiency ("PE") of tobacco hornworms.

H_0: There will be no difference between control and fiber treatments across CE, AE, and PE.
H_a: The fiber treatment will yield a higher CE than the control treatment.
H_a: The control treatment will yield a higher AE than the fiber treatment.
H_a: The control treatment will yield a higher PE than the fiber treatment.

1b) Methods

Using a random-number generator a sample of 48 *Manduca sexta* larva, commonly known as tobacco hornworn, were randomly assigned to two treatments: (i) a control diet of hornworm chow and, (ii) a diet enriched with 2% fiber by weight. As such, each treatment initially had a sample size of 24. Each individual hornworm was assigned to their own enclosure – a cup with a sufficient amount of air holes in the lid. All other factors besides the diets were the same – ie. room temperature, same feeding time, and size of enclosure. On Day 0 of the experiment, the initial weight of each hornworm was recorded in grams and 2.0 g of the designated diet for the respective treatments was also provided to each individual hornworm. During Days 1-5 hornworm excrement was first removed from each individual hornworm enclosure, weighed in grams and recorded, then collectively disposed of. Weighing equipment and forceps were sanitized before proceeding with the next step involving their food. If any food appeared to be dried up or moldy it was removed, weighed, recorded as unconsumed, and properly disposed of. All other food was left in the cup, and an additional appropriate serving of food was added if necessary – this was also weighed in grams and recorded as "food provided". On Day 6 no husbandry activity took place as the school was closed (however the day before extra food was provided). On Day 7 husbandry resumed as per normal (similar to Days 1-5). Finally, on Day 8, the last of the data collection regarding weighing excrement and unconsumed food took place in addition to recording the final weights of each hornworm. Data was then compiled and analyzed via JMP statistical software.

1c) Results

It is important to note that one of the hornworm individuals from the fiber treatment was omitted from the statistical analysis due to an issue with reporting. An additional hornworm from this same treatment died in care, resulting in a final sample size of N=22 for the fiber treatment.

A t-test comparing Consumption Efficiency yielded a p-value of 0.2619. Across 24 hornworm larva in the control treatment the CE ranged from 31.99% to 100% with a mean of 83.96%

(**Figure 1**) and a standard deviation of 17.36%. Across 22 hornworm larva in the fiber treatment the CE ranged from 62.84% to 98.78% with a mean of 86.61% (**Figure 1)** and a standard deviation of 9.86%.

A t-test comparing Assimilation Efficiency yielded a p-value of 0.6258. Across 24 hornworm larva in the control treatment the AE ranged from 12.37% to 55.85% with a mean of 42.59% (**Figure 2**) and a standard deviation of 10.92%. Across 22 hornworm larva in the fiber treatment the AE ranged from 28.83% to 60.85% with a mean of 43.56% (**Figure 2**) and a standard deviation of 9.46%.

A t-test comparing Production Efficiency yielded a p-value of 0.9204. Across 24 hornworm larva in the control treatment the PE ranged from 13.19% to 73.43% with a mean of 50.95% (**Figure 3**) and a standard deviation of 14.73%. Across 22 hornworm larva in the fiber treatment the PE ranged from 34.18% to 79.86% with a mean of 56.94% (**Figure 3**) and a standard deviation of 13.66%.

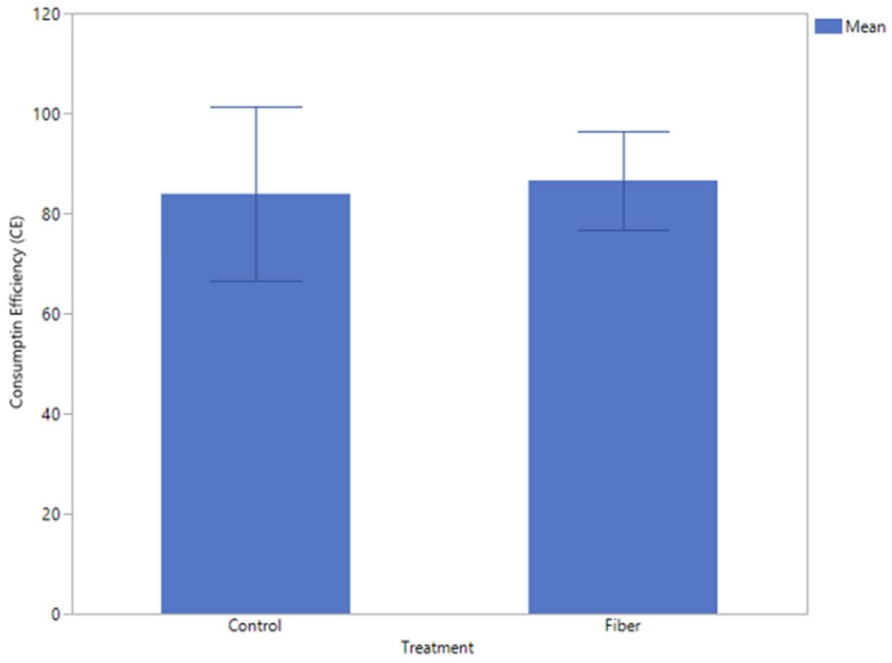

Figure 1: A comparison of control and fiber treatments on the Consumption Efficiency [(food provided/food consumed)*100] of tobacco hornworm. Error bars represent one standard deviation.

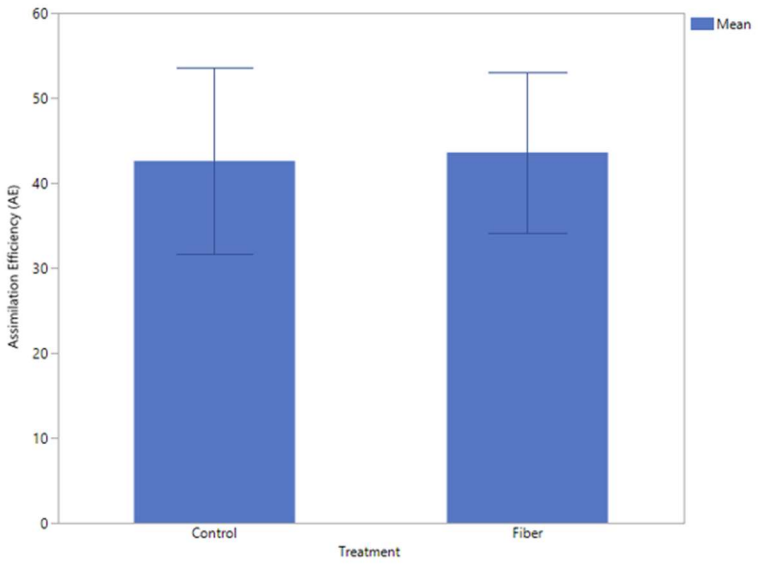

Figure 2: A comparison of control and fiber treatments on the Assimilation Efficiency Efficiency [(weight gained/food consumed)*100] of tobacco hornworm. Error bars represent one standard deviation.

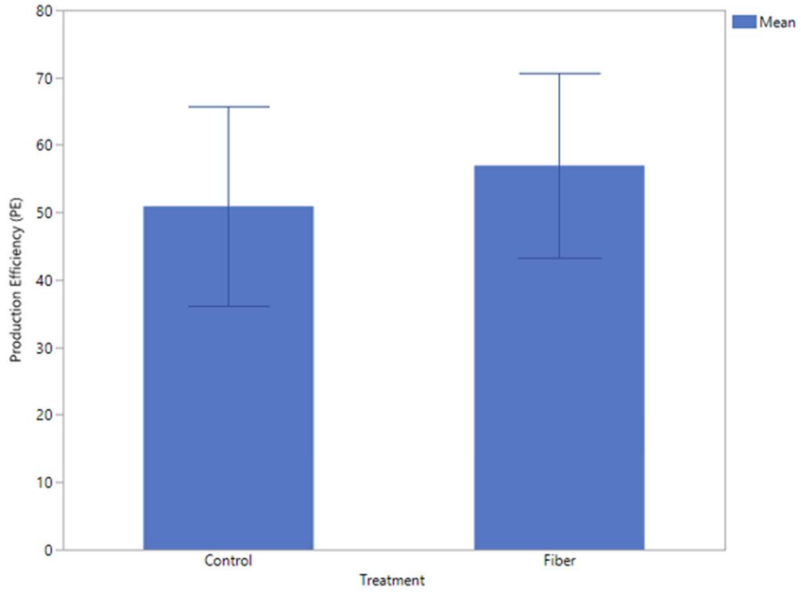

Figure 3: A comparison of control and fiber treatments on the Production Efficiency [(weight gained/assimilation)*100] of tobacco hornworm. Error bars represent one standard deviation.

1d) Conclusion

We cannot reject the null hypothesis as there is no statistically significant difference between the two treatments regarding the three bioenergetic efficiencies tested (CE, AE, and PE). At the larval stage hornworms are eating voraciously and accumulating biomass very quickly – many of the worms tripled their biomass by the end of the experiment. A possible explanation is that the 2.0% fiber enrichment is perhaps not sufficient enough to affect or detect differences in bioenergetics in the larval stage of the hornworms.

Question 2) What could change or impact the bioenergetics for an organism? (For example, what could cause a change in the amount of food consumed? Assimilated? Excreted?) Describe three things that may happen in the real world to change the bioenergetics of the organism.

In contrast to a controlled lab setting, there are many factors that could impact bioenergetics for an organism in the real world. Most notably is the presence of other organisms would introduce competition – when competition is involved consumption efficiency (CE) will most certainly be affected. Another factor that would affect CE, AE, an PE would be the health of the organism – if an organism is diseased or has a mutation these efficiencies could all be decreased or increased depending on the situation. Additionally, environmental conditions such as weather and temperature could have an effect on the behavior of an organism and their feeding patterns resulting in bioenergetics also being impacted.

Question 3) When we work with living organisms, things frequently go in unexpected or surprising directions. Describe a component of this activity that did not go as expected or was surprising.

I was personally surprised at how quickly the hornworms grew in mass over the duration of the experiment as this was my first experience working with these organisms and analyzing bioenergetics. A component of the experiment that did not go as planned would be that early on in the experiment the scale my lab partner and I used was not recognizing the weight of the excrement – a new scale had to be brought in. Lastly, we unfortunately lost one of the hornworms who passed away due to an unknown cause which was certainly unexpected as well.

Question 4) If you were going to perform a second bioenergetics experiment on tobacco hornworm larvae, what type of experiment would you perform? Please describe the experiment IN DETAIL. Include the null and alternative hypotheses, the treatments and number of organisms/treatment, and any other details that you think are important.

As a follow-up experiment, I would be interested in performing a similar bioenergetics experiment using tobacco hornworm larva and comparing the effect of two treatments specially in connection with consumption efficiency. The two treatments would consist of hornworm chow and tobacco plants.

H_0: There will be no difference in consumption efficiency between the two treatments.

H_A: The tobacco plant treatment will yield a higher consumption efficiency that the control treatment.

A sample of 100 tobacco hornworns, would be randomly assigned to two treatments: (i) a control diet of hornworm chow and, (ii) a diet of tobacco plants. Each treatment would have a sample size of 50. Each individual hornworm will be assigned to their own enclosure – a cup with a sufficient amount of air holes in the lid. All other factors besides the diets will be controlled for – ie. room temperature, same feeding time, and size of enclosure. On Day 0 of the experiment, the initial weight of each hornworm will be recorded in grams and 2.0 g of the designated diet for the respective treatments will be provided to each individual hornworm. During Days 1-5 hornworm excrement will be removed from each individual hornworm enclosure, weighed in grams and recorded, then collectively disposed of. Weighing equipment and forceps are to be sanitized before proceeding with the next step involving their food. If any food appears to be dried up or moldy it will be removed, weighed, recorded as unconsumed, and properly disposed of. All other food will be left in the cup, and an additional appropriate serving of food will be added if necessary, weighed in grams and recorded as “food provided”. Finally, on Day 8, the last of the data collection will take place in addition to recording the final weights of each hornworm. Data will then be compiled and analyzed via JMP statistical software.