Hong Kong Student Science Project Competition 2022

Extended Abstract (Investigation)

Team Number: SBBC226

Project Title:「掃」膠黃粉蟲, 有「益」塑膠速速無蹤 **The Effect of Probiotics on Plastic Digestion in Mealworms**

Project Type: Investigation

To our best knowledge and after thorough literature research, as at 30/6/2022, there are no similar works.

I. Background

Plastic pollution is alarming, it may lead to full occupation of landfills, and hinder the environment. In 2015, scientists from Stanford University discovered that styrofoam, polystyrene and polyethylene were efficiently degraded in the larval gut. Therefore, we investigate how probiotics impact plastic digestion in mealworms, aiming to speed up the rate of plastic degradation in mealworms.

Plastic wastes that can be degraded by mealworms are styrofoam, polystyrene, polyethylene. In mealworms' digestive tract, there are microorganisms, Exiguobacterium sp. strain YT2, that can break down polystyrene, polystyrene is mineralised to carbon dioxide and incorporated into lipids.

II. Objectives

To speed up the rate of plastic degradation in mealworms.

III. Hypothesis

Probiotics would increase the digestion effectiveness of polystyrene in mealworms.

The hypothesis can be tested by conducting experiments and comparing the digestion rate on polystyrene, plastic bags and surgical masks between batches of mealworms supplemented with probiotics and that without probiotics. This aid conclusion drawing of whether probiotics increase the digestion effectiveness of plastics in mealworms. Besides, we also compared the effect on digestion rate of polystyrene, plastic bags and surgical masks when probiotics are added at different timing prior to plastic feeding to investigate the optimum meal plan for plastic-eating mealworms.

IV. Methodology

Material used: mealworms, probiotics 60 Billion CFU, polystyrene, transparent plastic bags, carrots, surgical masks

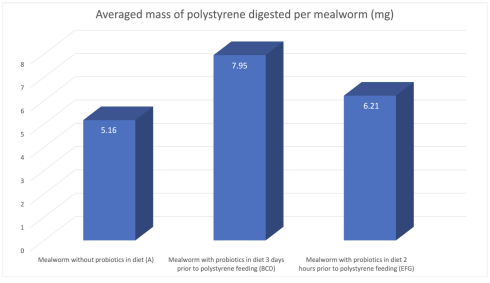
There are 7 setups for each phase, where one setup each includes mealworms without probiotics in the diet prior to polystyrene and plastic bags feeding respectively. Three setups have mealworms with probiotics in the diet 3 days and 2 hours prior to polystyrene feeding respectively. Three setups with mealworms with probiotics in diet 3 days and 2 hours prior to plastic bags feeding respectively. The research gap is whether probiotics would increase the digestion effectiveness of polystyrene in mealworms.

A control experiment is done by introducing carrot for day 1-3 then polystyrene for day 4-13 for mealworms, which illustrates the digestion rate of polystyrene in mealworms without probiotics into their diet.

A repeated experiment is performed by giving mealworms a second dose of probiotics.

In Phase 3 probiotics were consumed as mentioned above, while keeping diet plans of carrots the same. By comparing the mass of surgical masks added and left behind, as well as mealworms' excretion, we can obtain the required data.

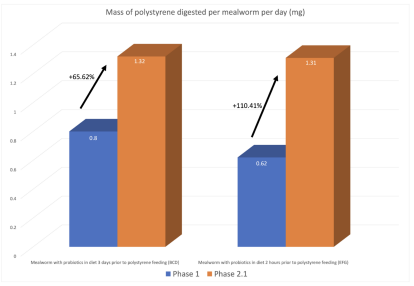
V. Results



▲ Averaged Mass of Polystyrene Digested Per Mealworm

Phase 1 Polystyrene

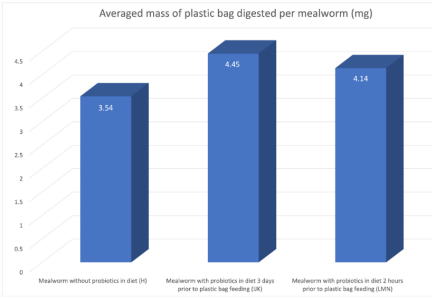
Compared with setup A, the digestion rate of polystyrene is enhanced after probiotics are added as supplements in mealworms' diet by 54.07% (setup B, C, D) and 20.35% (setup E, F, G). On top of that, feeding mealworms with probiotics 3 days prior polystyrene feeding, rather than 2 hours prior polystyrene feeding, is more effective in increasing the digestion rate of polystyrene.



▲ Mass of Polystyrene Digested Per Mealworm Per Day

Phase 2.1 Polystyrene

Results from phase 1 and phase 2.1 are compared. It is observed that there is a significant improvement in its digestion rate per day by 65.62% (setup B, C, D) and 110.41% (setup E, F, G), compared with only one dose of probiotics feeding. It is projected that if probiotics are consumed repeatedly and at regular intervals, digestion rate of polystyrene can be enhanced.



▲ Averaged Mass of Plastic Bag Digested Per Mealworm

Phase 2.2 Plastic Bags

Compared with setup H, the digestion rate of plastic bags is enhanced after probiotics are added as supplements in mealworms' diet by 25.71% (setup I, J, K) and 16.95% (setup L, M, N). Furthermore, feeding mealworms with probiotics 3 days prior plastic bags feeding, rather than 2 hours prior plastic bags feeding, is more effective in increasing the digestion rate of plastic bags.

Phase 3 Surgical Masks

In phase 3, with the positive results that probiotic feeding enhances plastic digestion in mealworms, we aim to extend our experiment investigation to a real life solution, surgical masks. We have replicated the same set as in phase 1. Unfortunately, there is an experimental defect during the design of the experiment: we overlook the fact that one of the layers of surgical masks absorb moisture in air, resulting in distorted data. We cannot draw any conclusion from this phase. Nonetheless, it is a good learning opportunity.

Limitations

Duration of experiment: The duration of polystyrene feeding is only 10 and 3 days in phase 1 and 2 respectively. The data collected may be less reliable. However, a rough outline of the outcome can be observed by the trend documented. Improvements can be made by extending the duration of the experiment and probiotics can be supplemented several times throughout the experiment to study the long-term effect of probiotics.

Mealworm cannibalism: In setup I-K of phase 2, few mealworms died and their corpses were eaten by other mealworms from the same setup. Mealworms may have other food sources other than polystyrene/ plastic bags, so the data relating to the digestion rate of polystyrene/ plastic bags/ mass of mealworm per setup may be distorted.

Importance of research

The conclusions can be implied to municipal waste treatment. By implementing the method of plastic degradation by mealworms in plastic-specific-landfills in a large-scale context, a considerable amount of waste can be reduced. Going further, from the results we have collected, we can feed probiotics repeatedly and at regular intervals to boost the digestion rate of plastics in mealworms significantly. During the implementation of large-scale plastic degradation by mealworms, we can use a few batches of mealworms alternatively to allow some time for supplementing previously-used mealworms with probiotics. Hence, enhancing the effectiveness of the system, mitigating plastic pollution.

VI. Conclusion

1: Probiotics would increase the digestion effectiveness of polystyrene in mealworms.

2: Probiotics feeding at a particular time prior to polystyrene feeding matters. Feeding mealworms with probiotics 3 days prior feeding polystyrene, rather than 2 hours prior feeding polystyrene, is more effective in increasing the digestion rate of polystyrene.

3: Continuous probiotics feeding prior to polystyrene feeding would enhance the digestion effectiveness of polystyrene in mealworms.

4: Probiotics would increase the digestion effectiveness of plastic bags in mealworms.

5: Probiotics feeding at a particular time prior to plastic bags feeding matters. Feeding mealworms with probiotics 3 days prior feeding plastic bags, rather than 2 hours prior feeding plastic bags, is more effective in increasing the digestion rate of plastic bags.

In short, our project meets the objective, to speed up the rate of plastic degradation in mealworms, since the finding of phase 1 and 2 proved that with probiotics in mealworms' diet, the digestion effectiveness of polystyrene and plastic bags is greater than without probiotics. We sincerely hope our research can contribute to building a cleaner and more sustainable world!

□ **Our project is developed based on our school's previous project and the enhancement is as below:**

HKUGA College's previous project, 2020 S.T. Yau High School Science Award (Asia).
The research is about the effect of a yeast diet combined with polystyrene on mealworm's mortality rate. Enhancement is made by exploring a different diet (probiotics) and more target substances (polystyrene, plastic bags, surgical masks).

A similar project and proposal is submitted to HKYSTIC 第24屆香港青少年科技創新大賽 and Greater Bay Area STEM Excellence Award 2022. Enhancement is made by adding in the investigation of phase 3 - surgical masks.