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Comparison of the Impact of Three Food Industry By-Products (Hops Residue, Coffee Grounds, and Onion Skins) on the Dispersal of Horseflies

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Abstract. Horseflies seriously affect the activity of horses, and this can also affect humans. For example, horses at work may become more agitated, and some horseflies may bite humans to transmit diseases. At present, there are still many prospects for the reuse of food by-products in expelling horseflies. This study utilizes three food by-products—coffee grounds, onion skins, and hops residue—to study their repellent effects. A purple modified box trap with 1-octen-3-ol as bait, arranged in a 2×2 Latin square, was placed at an outdoor racetrack. After pre-treatment (drying, crushing, and ethanol extraction) of each byproduct, the repellent effect was tested by comparing the capture rate of horseflies with that of the blank control group. The expected results will confirm that all three by-products have repellent effects on horseflies, but there are differences in efficiency. This study aims to screen economically efficient and environmentally friendly repellent materials from food waste, providing reference for the sustainable pest management of horseflies.

Keywords: Insect repellents, horseflies, food by-products

1. Introduction

Horses have occupied a large part of human history, and even now, they still hold a place. They have become important transportation "tools" or agricultural work partners in rural areas [1]. Later, like other livestock, they are increasingly used as companion animals [2]. They are also used for leisure and sports, such as equestrianism. In recent years, another use of horses has attracted widespread attention: in therapeutic horseback riding programs, horses and horseback riding are becoming increasingly popular [3].

Working horses are especially vulnerable due to their prolonged outdoor activity and intense exercise. The presence of horseflies around these animals causes irritation and also leads to behavioral disturbances such as restlessness, head-shaking, tail-swishing, and even kicking.

The term "horsefly" is usually used to refer to relatively large flies in the family Tabanidae (usually 10–30 millimeters in length). They have the habit of biting during the day and are external parasites. Their bites can cause significant blood loss in large mammals, disrupting their feeding, breastfeeding, and other important activities. In addition, horseflies can also mechanically transmit various important animal pathogens. For example, they can transmit viruses such as equine

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infectious anemia, vesicular stomatitis, hog cholera, rinderpest, and equine encephalitis, or bacteria such as Anaplasma marginale and Rickettsia burnetii. Thus, even if only a small number of flies bite livestock, it may lead to significant production losses [4,5].

The impact of horseflies does not only affect horses. For humans, particularly those who work closely with horses, the consequences can also be significant. At times, horseflies may bite people, causing conditions such as allergic reactions, inflammation, and infections [6]. More critically, they can be mechanical vectors of various pathogens, some of which are zoonotic—meaning they can spread from animals to humans. Moreover, the risk of harm from agitated or distressed horses increases, including kicks, falls, or trampling; all of these represent occupational hazards for workers.

At present, tetrachlorofen (TCVP), an existing insecticide used as a fly control feed additive for horses, mainly causes a significant decrease in whole blood cholinesterase activity, indicating that TCVP inhibits the activity of this enzyme. Additionally, horses exhibit significant behavioral changes, mainly manifested as increased reactivity and greater sensitivity to external stimuli, as well as reduced controllability, which makes them more difficult to manage. This will have adverse effects on both working horses and those used in equestrian sports, and the associated risk factors will increase [7]. The most common repellent, DEET, may damage plastic and some synthetic fiber clothing and is only safe for cotton, wool, and nylon [8]; if applied under sunscreen, it may increase the risk of neurotoxicity [9]; when its concentration reaches 50%–75%, it may cause skin erythema, vesicular necrosis, and scarring [10]; excessive use or ingestion by children may lead to poisoning, resulting in central nervous system symptoms such as drowsiness and seizures. From 1956 to 2008, 43 confirmed cases of DEET toxicity were reported, involving central nervous system involvement, cardiovascular effects, allergies, or skin manifestations [11,12]. Picaridin may cause skin irritation and is not recommended for children under 2 years old, as relevant toxicity studies are not yet sufficient [8,13]. IR3535 may cause eye irritation; ingestion or inhalation can lead to potential toxicity, and it may also damage plastics and clothing [13]; there is a lack of clear safety recommendations for its use in children and during pregnancy [14].

In addition, for some plant-based insect repellents: Citronella has a short duration of effectiveness, can only prevent mosquito bites for a short period, and is ineffective against ticks, flies, midges, etc. [15]; it may damage clothing and also cause eye irritation and skin allergies [13]. Lemon eucalyptus oil (PMD) may cause skin irritation in individuals with atopic constitutions [13] and is not recommended for children under 3 years old [14,16]. Permethrin, the most common type used on horse farms, cannot be directly applied to the skin and is only suitable for clothing, mosquito nets, etc. [17]; it may cause skin irritation; people allergic to chrysanthemums should avoid using it, and mosquitoes have begun to develop resistance to it [13]. From the perspective of physical repellent methods, horseflies can be kept away using horsecloths. However, the material and breathability of the horsecloth may affect the horse's comfort—especially in hot weather, which may cause physical discomfort to the horse. In addition, the conditions for using horsecloths are limited; in fact, mosquito-proof horsecloths are rarely used in competitions and training.

According to estimates, the annual production of organic waste in global cities is expected to exceed 1 billion tons by 2025 [18]. Furthermore, as the global population is expected to continue growing by 2050, it is necessary to establish an adequate food supply system to ensure future food security. In this context, population growth will lead to a corresponding increase in food waste, thereby exacerbating environmental issues related to proper waste management and disposal [19]. In this research, studying the repellent effect of food by-products can promote their recycling and to

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some extent address the waste problem. In addition, recycling these food by-products is less costly and more environmentally friendly.

2. Hypothesis

Regarding the experimental results, since these food by-products have already been proven to repel insects of the same order (Diptera), we hypothesize that all three by-products—hops residue, coffee grounds, and onion skins—will be effective in repelling horseflies. However, their repellent efficacy (or "degree of repellency") cannot be estimated at present; the specific differences in their repellent effects will be determined through experiments.

3. Theoretical basis

In previous studies, Icardin—used to repel blood-sucking arthropods (such as mosquitoes and ticks) from host animals [17]—was investigated and found to also have repellent effects on horseflies [20]. This indicates that certain substances effective at repelling mosquitoes may also work on horseflies.

As a dipteran insect, horseflies primarily rely on a highly sensitive olfactory system to locate hosts; they can achieve precise localization by detecting volatile chemicals released by the host [21]. In this study, we have selected three agricultural/food processing wastes—onion skins, coffee grounds, and hops residue—for investigation. Their volatile components, such as sulfur-containing compounds in onions [22], terpenes in coffee [23], and alpha acids in hops, may exert repellent effects on horseflies. Currently, it has been confirmed that coffee grounds can repel female Aedes albopictus [24]. Onions have also been proven effective in controlling dipteran pests [25]. Additionally, other studies have shown that hops residue can enhance the toxicity of insecticides against fall armyworms and has repellent effects on Drosophila melanogaster [26]. By using box traps to efficiently capture horseflies, we can systematically compare the repellent efficiency of these three food by-products.

4. Methodology and data

This research is going to use purple color Modified Box Trap , this color is the most effective color to attract horsefly [27], and by using 1-octen-3-ol as bait.

4.1. Guidelines for making improved box traps, (this trap is reference to Hansens & Race, 2011: Mikuška, Mlinarić, Begović, & Curran, 2016 and been improved)

4.1.1. Size and structure

Main frame: Constructed from a four-sided plywood box measuring 80 × 80 × 60 cm, with an open bottom (no base plate) and the top covered by a metal insect screen (serving as the "roof").

Opening positions: The bottom opening is positioned 50 cm above the ground to facilitate horsefly entry from all directions; a 20 cm wide opening is cut in the center of the top screen for installing the collection device.

4.1.2. Material list

The box is made of plywood (1–1.5 cm thick), which is cut into 4 side panels (80 × 60 cm each) and paired with a top screen (80 × 80 cm metal mesh). This design effectively prevents horseflies from

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escaping.

In this study, the collection device was modified to retain captured horseflies. In figure 1, it clearly presents the structure of the collection device. It consists of a movable collection cap (20 cm in diameter, 35 cm in height) that covers the top opening of the box and traps incoming horseflies. Its structure is similar to that of a primitive funnel fish trap. The materials used include plastic strips, plastic sheets, needle and thread/hot melt adhesive, and polyester mosquito net scraps (the same material as existing mesh bags).

First, cut the mosquito net into a fan shape, then fix it with plastic strips and roll it into a funnel (wide at the top, narrow at the bottom). The diameter of the funnel's large opening should match the entrance of the mesh bag, while the diameter of the small opening should be 5–8 cm (smaller than the size of a horsefly, making it difficult for horseflies to turn around and escape). Finally, fix the funnel at the opening inside the mesh bag using a needle and thread or hot melt adhesive—ensure the large opening faces the outside of the bag (the direction from which horseflies enter) and the small opening faces the inside of the bag.



Figure 1. Collection device

The supporting structure consists of 4 wooden pillars, which are used to fix the box at a height of 50 cm above the ground and ensure the bottom opening is suspended.

Next, paint the exterior of the box with purple paint, while leaving the interior unpainted.

4.1.3. Installation of bait device

Bait selection: 1-octen-3-ol (98% purity) is used as a chemical bait to simulate the odor of host animals.

Release device: Fill 4 mL of the bait into a plastic bottle, then insert a 5 cm-long cotton wick (serving as a volatile carrier) into the bottle mouth. Secure the bottle to a wooden stick inside the box, placing it 30 cm below the top screen to ensure the even diffusion of bait vapor.

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Figure 2. Purple color modified box trap

In figure 2, the hole box trap is been present.

4.2. Deployment point &location selection

The experiment was conducted at the Qiji Equestrian Center of Beijing Haidian Foreign Language Experimental School (Jingbei Campus). The modified box traps were placed on an outdoor racecourse, which aligns with the active habits of horseflies in ecological ecotones.

The traps were arranged in a 2 × 2 Latin square array with 50 meters between each trap. Their positions were swapped weekly to eliminate environmental deviations, and this position exchange was carried out four times in total. This setup allowed data collection from all groups at the same location, minimizing geographical errors as much as possible. For trap maintenance: given the fast evaporation rate of the bait, 4 mL of bait was replenished daily to ensure an adequate supply; meanwhile, captured specimens were stored in 70% ethanol.

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Figure 3. Placement of traps

In figure 3, it clearly shows the distribution of the four box traps

4.3. Different group design

The control group is designed as box traps containing only the 1-octen-3-ol bait, with no repellent materials added. For the other groups, each will be treated differently using processed food by-products: porous gauze bags (10 × 10 cm in size) are fixed around the bottom opening of the box traps (within a 1 m² frame), and these bags are used to hold the solid food by-products or their extracts.

4.3.1. Material pretreatment

In Figure 4, onion skins were cut into pieces directly after drying and set aside for later use.



Figure 4. Processed onion skin

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In Figure 5, coffee grounds were purchased from Weinuan Flagship Store on the JD app. They were simply dried and crushed, then set aside.



Figure 5. Processed coffee grounds

In Figure 6, beer hops were purchased from Anguo Yaoyuan Trading Co., Ltd. and had already been ground into small particles.



Figure 6. Processed hop residue purchased

4.3.2. Extraction

In Figure 7, take 10 g of chopped onion skins, add 1 L of anhydrous ethanol, and soak the mixture at room temperature for 1 hour (shake three times during soaking). Then filter the mixture to collect the supernatant.

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Figure 7. Processed onion skin solution

In Figure 8, crush 5 g of coffee grounds, add 25 mL of anhydrous ethanol, and soak the mixture for 2 hours (shake twice during soaking). Then collect the soaking solution.



Figure 8. Processed coffee grounds extract

In Figure 9, take 5 g of crushed hops, add 50 mL of ethanol, and soak the mixture at room temperature for 2 hours (shake once halfway through). Then filter the treated liquid using filter paper.

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Figure 9. The clear liquid of hop extract being filtered

4.3.3. Release

Pour the onion and hop extraction solutions separately into gauze bags, then hang the bags at the edge of the container for natural release. The extraction solutions were replenished once every two days to maintain continuous odor emission.

Place the coffee grounds and their soaking solution together into a gauze bag, then spray a small amount of water regularly to keep the contents moist and facilitate odor release.

4.4. Conclusion drawn

The number of horseflies captured will be counted weekly. By comparing this capture data, we can determine whether these food by-products have repellent effects and which one is the most effective.

5. Results and conclusions

In figure 10, these three are different horse flies that were caught respectively in the first, second and third weeks.



Figure 10. Horseflies been collected in three weeks

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Table 1. Number of horseflies collected

	Control group	Onion skin group	Coffee Grounds group	Hops Residue group	Total
Week1	14	33	3	15	65
Week2	12	15	35	57	119
Week3	92	7	69	29	197
Week4	100	18	13	8	139
Total	218	73	120	109	520

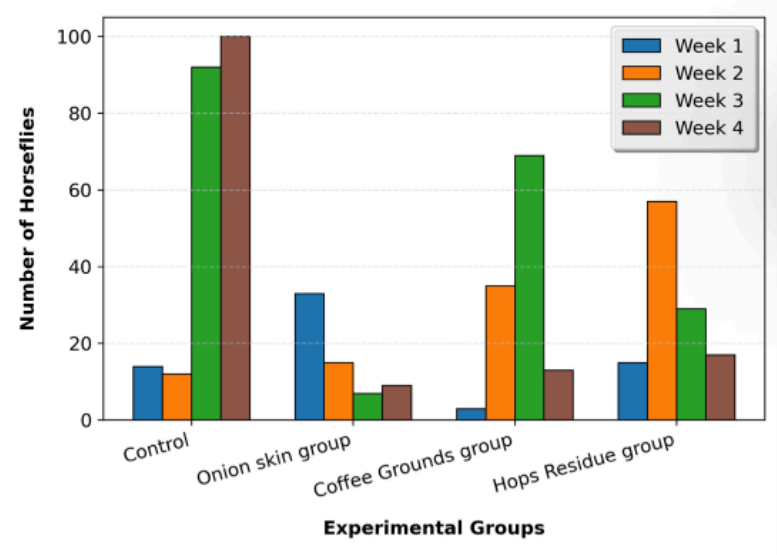


Figure 11. Bar chart of the number of horseflies in different groups

In table 1 and figure 11, we can directly see from the total data comparison of the four groups that all three food by-products exhibit a certain degree of repellent effect. Among them, onion skins have the most obvious effect, followed by hop residue and coffee grounds. When comparing the weekly data, we found significant geographical errors: the number of horseflies captured in the two groups closer to the stable (the top two groups) was significantly higher than that in the other groups. Therefore, comparing data within a single week may not be very reliable. In figure 12,it clearly shows the position swaps of the four groups of box traps.

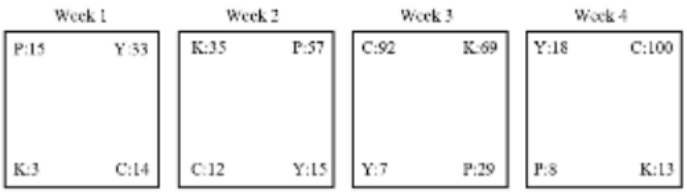


Figure 12. Display diagram of position order exchange, C is the control group, Y is the onion skin group, P is the hops group, K is the coffee grounds group

By comparing data from different time periods at the same location, differences in the repellent effects of the three food by-products can also be observed. However, since these data were collected

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across different time periods, they may be influenced by weather conditions. Specific weather conditions for each week are as follows,from(https://www.ip.cn/tianqi/hebei/zhangjiakou/huailai/):

•The first week had an average temperature of 21.21°C, with 2 sunny days, 4 cloudy days, and 1 rainy day;

•The second week had an average temperature of 24.64°C, with 6 cloudy days and 1 sunny day;

•The third week saw the average temperature rise to 26.5°C, with 5 cloudy days and 2 rainy days;

•The fourth week had an average temperature of 26.21°C, with all 7 days being cloudy.

The similar number of horseflies captured in Groups C and Y (bottom right corner) can be attributed to differences in light and humidity between the first and second weeks—these factors are known to affect the activity levels of horseflies [29]. Overall, however, all three food by-products demonstrated repellent effects. Comparison of the other three groups of data further confirmed that onion skins had the most significant repellent effect, followed by hop residue and coffee grounds.

6. Discussion and evaluation

6.1. The significance and value of research

This study aims to reduce horsefly density by processing food by-products, providing a feasible prevention and control plan for environments where humans and horses coexist. It also seeks to reduce reliance on chemical pesticides, making horsefly management greener and more sustainable.

Reducing horsefly populations in high-frequency horse activity scenarios (such as equestrian centers) can not only improve animal welfare but also mitigate threats to humans. Specifically, it reduces interference with horse training and the spread of horsefly-borne diseases, lowers the cost of disease prevention and control, and indirectly supports the equestrian economy and related outdoor industries.

6.2. Limitations and future directions

A major limitation of this study is the insufficient experimental duration. The experiment should be repeated more times to minimize geographical and environmental errors. Additionally, weather conditions significantly affect the results: more horseflies can be captured on sunny days, while fewer are caught on rainy days. On hot, sunny days, horsefly populations are even higher, leading to comparison errors at the same geographical location due to temperature increases [29]. As evidenced by the data over these weeks, the number of horseflies gradually increased, which can be attributed to rising temperatures and varying rainfall timing. However, controlling weather-related errors is challenging given the limited experiment duration, and manipulating weather conditions for each experiment is not feasible.

Regarding the processing of food by-products, ethanol extraction may fail to fully isolate all active ingredients. Exploring alternative technologies (e.g., cold pressing, steam distillation) or directly testing unextracted raw materials could reveal different repellent efficiencies.

Another limitation is the single research location—experiments were only conducted at one racetrack, which may compromise the generalizability of the conclusions. Repeating the experiment across different regions (with distinct horsefly species and environmental conditions) would improve result robustness. Meanwhile, setting up multiple trap groups at different locations on larger horse farms could further reduce errors.

Finally, expanding the range of tested materials (e.g., other known insect-repellent wastes like citrus peels and tea leaves) would broaden the selection of potential repellents.

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6.3. Durability and application limitations

While food by-product repellents are relatively safe, environmentally friendly, and help reduce waste by promoting recycling, they suffer from poor durability. In applications using these three types of food by-products, changes in environmental conditions—such as light, temperature, and humidity—may cause their active ingredients to decompose or lose efficacy, thereby weakening the repellent effect. Specifically, in high-temperature and high-humidity environments, the effectiveness of these plant-based repellents decreases significantly.

Additionally, their active ingredients are highly volatile: after application or deployment, they lose their repellent effect over a short period due to volatilization. This requires frequent reapplication, creating inconvenience for users. For instance, in this experiment, the repellents in the gauze bags needed to be replenished every two days, and on particularly dry days, the repellents even dried out prematurely.

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