Impact of Background Fruit Odors on Attraction of
*Drosophila suzukii* (Diptera: Drosophilidae) to Its
Symbiotic Yeast

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Abstract

Background odors produced by plants in the environment can interfere with the response of insects to a point-releasing attractant, especially when their compositions overlap. In this study, a series of binary choice tests was conducted in a wind tunnel to investigate whether background odors emitted from cherry, blueberry, blackberry, or raspberry fruits would affect the level of *Drosophila suzukii* (Matsumura) attraction to its symbiotic yeast, *Hanseniaspora uvarum* (Niehaus) (Saccharomycetales: Saccharomycetaceae). Whether an increase in the intensity of background odors would affect the attractiveness of *H. uvarum* to *D. suzukii* was also investigated, either by increasing the number of cherry or raspberry fruit per cup or by increasing the number of fruit cups surrounding the cup baited with the yeast. In wind tunnel assays, background fruit odors interfering with *D. suzukii* attraction to the yeast varied among fruit types. Raspberry odor inhibited the attractiveness of *H. uvarum* to the fly the most, followed by blackberry odor, whereas cherry and blueberry odors had no significant impact on the attraction. An increase in the intensity of odors by adding more cherry or raspberry fruit per cup did not increase the impact of fruit odor on the attraction; however, adding more raspberry cups around *H. uvarum* linearly decreased its attractiveness, suggesting that background host fruit abundance and likely increase in host odor may influence *D. suzukii* attraction to yeast odor depending on host species.

Key words: fruit odor, attractiveness, yeast, wind tunnel

Herbivorous insects live in a complex olfactory environment with high semichemical diversity (Schröder and Hilker 2008). Resource-indicating odors from host plants are not only expected to mix with those background odors emitted from competitors or nonhost plants (Byers et al. 1987, Zhang and Schlyter 2003) but also comprise a substantial variation in response to phenological development, environmental, and biotic challenges (Knudsen et al. 2008). Many studies have shown that plants release hundreds of volatile compounds, while some herbivorous insects only use a subset of 10 odors or fewer for host location (Bruce et al. 2005, Bruce and Pickett 2011, Cai et al. 2017). Therefore, it is a quite challenging task for herbivores to successfully locate their food sources and ovipositional sites under such high noisy background odors.

There are three different types of background odors: irrelevant background odors and background odors that either mask or enhance the behavioral responses of a foraging insect to the resource-indicating odors (Schröder and Hilker 2008). Irrelevant background odors have no impact on olfactory orientation because a resource-searching insect may have no receptor available in its olfactory system to detect the components. Masking background odors are perceived by a resource-searching insect, but 1) elicit no response per se, rendering resource-indicating odors less detectable (Schröder and Hilker 2008), 2) overlap with and outcompete the resource-indicating odors in large quantities, making them ‘invisible’ to the insect, or 3) act as repellents, countering the attractiveness of resource-indicating odors which are attractive when present alone (Schröder and Hilker 2008). For example, host plant volatiles of *Brassica napus* L. (Brassicaceae: Capparales) were less detectable by the pollen beetle, *Meligethes aeneus* (Fabricius) (Coleopter: Nitidulidae), in the presence of odors of a nonhost plant, *Lavandula angustifolia* Miller (Lamiales: Lamiacae) (Mauchline et al. 2005). Few Oriental fruit flies, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) were captured by traps baited with an orange, *Citrus sinensis* (L.) (Sapindales: Rutaceae) (Wyatt et al. 1998). Onion aphids, *Neotoxoptera formosana* (Takahashi) (Hemiptera: Aphididae), were no longer attracted to their host-plant odor in the presence of α-pinene, a single repellent background volatile (Hori and Komatsu 1997). On the other hand, response-enhancing
background odor renders a resource-inducing odor more detectable (Schröder and Hilker 2008). For example, the attraction of *Heliothis virescens* (Fabricius) (Lepidoptera: Noctuidae) to tobacco host odors was significantly enhanced in the presence of (∆-7)-germacrene D isolated from an essential oil, ylang-ylang (*Cananga odorata* Hook (Magnoliaceae: Annonaceae)) (Mozuraitis et al. 2002).

*Drosophila suzukii* (Matsumura) has become a global devastating pest, causing millions of dollars of crop losses on a range of soft and stone fruits (Bolda et al. 2010, Lee et al. 2011, Cini et al. 2012). *Drosophila* spp. rely on yeasts for food, development, and reproduction (Hamby and Becher 2016). Yeast–sugar mixtures containing baker’s yeast, *Saccharomyces cerevisiae* (Saccharomycetales: Saccharomycetaceae), are currently attractive and reliable fermentation baits for *D. suzukii* compared with others (Burack et al. 2015, Jaffe et al. 2018). However, *S. cerevisiae* is rarely found in natural populations of *Drosophila* species in the field (see references therein Hoang et al. 2015). Instead, field-collected larvae and adults of *D. suzukii* host a specific yeast community, representing 28 species of yeasts (Hamby et al. 2012). Among them, *Hanseniaspora uvarum* (Niehaus) (Saccharomycetales: Saccharomycetaceae) is the predominant (Hamby et al. 2012) and preferred yeast by *D. suzukii* (Scheidler et al. 2015).

Detecting the presence of an insect pest, monitoring its activity, and assessing population density are crucial steps for managing any insect pest. Since its invasion into the United States, much effort has been directed to developing attractants and traps to improve *D. suzukii* detection and monitoring. Initial *D. suzukii* monitoring systems utilized apple cider vinegar, a baker’s yeast and sugar water mixture, or a wine/vinegar mixture (Cha et al. 2012, 2014; Landolt et al. 2012; Burack et al. 2015; Huang et al. 2017). Fruit and leaf volatiles have also been identified as feeding and oviposition attractants for this species (Revadi et al. 2015). Mated *D. suzukii* females were attracted to volatiles emitted from intact raspberry, blackberry, blueberry, cherry, and strawberry fruits (Revadi et al. 2015). The attractiveness of baits is shown to be influenced by the physiological state of the fruit fly (Swoboda-Bhattarai et al. 2017, Wong et al. 2018), crop type (Burack et al. 2015, Jaffe et al. 2018), and time of the growing season (Wong et al. 2018, Jaffe et al. 2018).

The present study aimed to evaluate the attractiveness of symbiotic yeast, *H. uvarum*, to *D. suzukii* in the presence of background fruit odors. First, we investigated whether the attractiveness of *H. uvarum* was affected by the presence of fruit odors emitted from raspberry, blackberry, cherry, and blueberry in a wind tunnel; then we further investigated whether a greater intensity of raspberry and cherry odors would affect the fly attraction to the yeast.

### Materials and Methods

#### Fly Colony

All flies used in the study originated from a field-derived laboratory colony of *D. suzukii* reared and maintained on a solid standard cornmeal (Dalton et al. 2011) in 50-ml polystyrene vials (Genesee Scientific, El Cajon, CA) in a growth chamber at 24°C, a photoperiod of 16:8 (L:D) h, and 45% relative humidity (Kirkpatrick et al. 2016). This colony was established from a sample of individuals isolated from cherry fruit collected from orchards at Trevor Nichols Research Station of Michigan State University during the summer of 2015. Flies used were 2–3 d old, anesthetized by CO₂, and then transferred to and kept in a Petri dish (100 × 15 mm) lined with a moist Whatman filter paper (90 mm) for 2–3 h before the experiments.

#### Yeast Culture

The symbiotic yeast species, *H. uvarum*, was gifted from the Phaff Yeast Collection at the University of California–Davis and cultured on PDA plates (100 × 15 mm), with 2.5% Potato Dextrose and 2% agar (Becton, Dickinson and Company Sparks, MD) in an incubator at 28°C. Yeast stock was recultured every 2 wk to maintain active culture. Before the experiment, a loop full of yeast taken from the stock strain was re-inoculated on a small PDA plate (60 × 15 mm) and allowed to grow for 2 d for the following behavioral experiments.

#### Wind Tunnel Description

A wind tunnel measuring 48 × 45 cm in cross-section and 81 cm in length was constructed from PVC pipes (22 mm internal diameter) as a supporting frame. Each of the 4 longer sides was covered and sealed with a sheet of 8-gauge clear vinyl plastic (JOANN Fabrics and Crafts, Lansing, MI) by a hot glue gun. Both ends were covered with cloth screens (20 mesh/cm; JOANN Fabrics and Crafts, Lansing, MI) stretched tightly and uniformly across each opening. A modified box fan covered with an activated carbon filter (Pollentec, Phoenix, AZ) entirely at the front was used to generate wind speed at 30 cm/s at one end of the tunnel (upwind end). The floor of the tunnel was lined with a cotton cloth with green polka dots (9 mm diameter) on a white background to provide visual orientation cues for the flies.

#### Wind Tunnel Bioassay

To investigate whether the attractiveness of *H. uvarum* was affected by the presence of fruit odors, a series of binary choice tests between the yeast and fruit was conducted in the wind tunnel. Two white paper coffee cups (355 ml, 89 mm diameter at the bottom, 112 mm diameter on the top, 58 mm in height), one containing *H. uvarum* grown on PDA media for 2 d after initial inoculation and the other containing PDA media only (control) or one of the following unwashed fruits purchased from a local grocery store in MI: 6 sweet Bing cherries, 9 raspberries, 9 blackberries, or 12 blueberries, were placed side by side with no space in between at the upwind end of the tunnel. Cups were covered with modified white cappuccino lids with additional three holes (0.1 mm diameter) punched 40 mm away from each other around the edge to allow flies to enter but prevent them from responding to the color of the fruit. At the downwind end, 110 starved mixed-sex flies (sex ratio not recorded) were released. Numbers of flies landing on the outside of the cup and entering the cup were recorded every 5 min for the first hour after release. The number of flies trapped inside cups was counted the next day. This experiment was replicated six times on different days using different cohorts of flies.

#### Intensity of Fruit Odor

Two experiments were conducted to assess whether a greater intensity of host odor (more fruit in each cup in experiment 1 or more fruit cups in experiment 2) affected *D. suzukii* attraction to the yeast. In experiment 1, a coffee cup baited with *H. uvarum* grown on a PDA plate for 2 d after initial inoculation was paired side by side with another coffee cup (no space in between) baited with either 0, 9, 18, 27, or 36 raspberries placed in the center of a white mesh cage (34 × 34 × 61 cm with a vinyl window, BioQuip Products, Compton, CA). In each cage, 110 mixed-sex flies (sex ratio not recorded) were released and allowed to respond for 24 h. Numbers of male and female flies captured inside the cup were counted afterward. This experiment was repeated using sweet Bing cherry fruit at densities of 0, 6, 12, 18, and 24 cherries per cup (cherry fruit were often large and...
took more space in the cup compared with raspberry). This study
was replicated 10 times for each fruit on different days using dif-
ferent cohorts of flies.

To mimic a monitoring trap often surrounded by hundreds of
fruit in the field, a coffee cup baited with 
*m. uvarum* grown on a PDA
plate 2 d after initial inoculation was tightly surrounded by 6 coffee
cups containing the following combinations of fruit or nothing in
experiment 2: 6 empty cups, 1 cup baited with 8 sweet cherries +
5 empty cups, 2 cups baited with 8 sweet cherries each + 4 empty
cups, 4 cherry cups with 8 sweet cherries each + 2 empty cups, 6
cherry cups with 8 sweet cherries each. Six cups were the maximum
number of cups that could be arranged against each other with no
space in between or around the yeast cup. There was no space between
the center yeast cup and any of the 6 cups. Each cage received over
200–300 mixed-sex flies (sex ratio not recorded) depending on fly
availability. These flies were allowed to respond for 24 h. This experi-
ment was replicated five times on different days using different
cohorts of flies. The whole experiment was also conducted in the
same manner but using 10 raspberries per cup instead. Due to the
variation in total numbers of flies released in each cage, fly captures
by cups baited with *m. uvarum* were presented as the proportion
of flies calculated by dividing the number of flies captured by the total
number of flies released in each cage (Fig. 4). The fly recapture rate/
cage was calculated by dividing the total number of flies captured by
all cups (a cup baited with the yeast + 6 cups around it) by the total
number of flies released in each cage (Fig. 5).

### Statistical Analysis

The number of flies contacting and entering the cup traps observed
in the wind tunnel bioassays was analyzed by repeated measures
ANOVA with treatments as the subject factor and observation time
as the within subject factor after normality and homoscedasticity
assumption were met (SAS Institute 2020). Numbers of male and
female flies trapped in each cup on the next day were analyzed by
paired *t*-tests. Fly capture data by *m. uvarum* as influenced by num-
bers of fruit per cup were analyzed as a 2 × 5 factorial design with
fruit type (cherry or raspberry) as one factor and the number of
fruits as the other after normality and homoscedasticity assumptions
were met (SAS Institute 2020). Mean separations were performed
via a post hoc Tukey’s HSD test. Orthogonal polynomial contrast
was used to detect a linear, quadratic, cubic, or quartic pattern in
the proportion of fly captured by cups baited with *m. uvarum*
around by a various number of fruit cups and in the proportion of
fly recaptured in each cage (SAS Institute 2020).

### Results

#### Wind Tunnel Bioassay

Significantly more flies were attracted to and eventually entered
the cup baited with *m. uvarum* compared with the cup baited with
PDA (control, *F*~1,5~ = 9.75, *P* = 0.03, Fig. 1A), blueberry (*F*~1,5~ = 5.60,
*P* = 0.05, Fig. 1B), or cherry (*F*~1,5~ = 12.34, *P* = 0.01, Fig. 1C).
However, the number of flies entered the cup baited with *m. uvarum*
was significantly less than that baited with raspberry (*F*~1,5~ = 20.15,
*P* < 0.01, Fig. 1E). There was no significant difference in the number
of flies entering cups baited with *m. uvarum* and blackberry fruit
(*F*~1,5~ = 0.01, *P* = 1, Fig. 1D). There was a significant time effect within
the treatment in all the binary tests, meaning that the number of flies
inside cups increased significantly over time during the 60-min ob-
ervation period (*F*~1,5~ = 12.62, *P* < 0.01 for control vs *m. uvarum*;  
*m. uvarum*; *F*~1,5~ = 16.51, *P* < 0.01 for blueberry vs *m. uvarum*; *F*~1,5~ = 37.30,
P < 0.01 for cherry vs *m. uvarum*; *F*~1,5~ = 80.55, *P* < 0.01 for
raspberry vs *m. uvarum*; *F*~1,5~ = 9.05, *P* < 0.01 for blackberry vs
*m. uvarum*). Most flies on cups baited with either fruit or *m. uvarum*
entered the cups within 2–3 min after landing and remained inside,
but flies landing on empty control cups remained outside and even-
tually flew off.

The number of male and/or female flies captured by the cups
baited with *m. uvarum* was significantly higher than that trapped by
cups baited with nothing (male: *t*~5~ = 6.25, *P* < 0.01; female: *t*~5~ = 5.46,
P < 0.01), cherry (male: *t*~5~ = 4.60, *P* < 0.01; female: *t*~5~ = 3.56,
P = 0.02), or blueberry (male: *t*~5~ = 3.30, *P* = 0.02; female: *t*~5~ = 1.07,
P = 0.33; Fig. 2). In contrast, cups baited with *m. uvarum* captured
significantly lower numbers of male and female flies than cups baited
with raspberry (male: *t*~5~ = 2.14, *P* = 0.05; female: *t*~5~ = 4.20, *P* < 0.01).
Cups baited with *m. uvarum* were equally attractive to cups baited
with blackberry (male: *t*~5~ = 0.97, *P* = 0.38; female: *t*~5~ = 1.75, *P* = 0.14).

#### Intensity of Fruit Odor

*m. uvarum* was significantly attracted to *m. uvarum*
compared with controls in the absence of cherry (*F*~1,10~ = 105.05,
P < 0.01) or raspberry fruit (*F*~1,10~ = 16.72, *P* < 0.01) in mesh cages
(Fig. 3). However, cups baited with *m. uvarum* were equally
between cups baited with the yeast and fruit by Tukey’s HSD tests at 0, 9, 18, 27, or 36 raspberries (B) in a mesh cage. The asterisk indicates significance emitted from another cup baited with 0, 6, 12, 18, or 24 sweet Bing cherries (A) or Hanseniaspora uvarum baited on a PDA plate in the presence of fruit odor.

Fig. 2. Mean total number of male and female Drosophila suzukii (+SEM) captured in a coffee cup trap baited with Hanseniaspora uvarum on a PDA plate and the one baited with one of the following substances: a PDA plate (control), 6 sweet Bing cherries, 9 raspberries, 9 blackberries, or 12 blueberries. Means within groups topped with different lowercase letters for males and uppercase letters for females differed significantly by paired t-tests at P ≤ 0.05.

Fig. 3. Mean number of Drosophila suzukii (+SEM) captured by a coffee cup baited with Hanseniaspora uvarum on a PDA plate in the presence of fruit odor emitted from another cup baited with 12 cherry fruit (Fig. 3A) or raspberry fruit (Fig. 3B), except for the cups baited with 12 cherry fruit (F1,25 = 105.05, P < 0.01). Numbers of D. suzukii attracted to H. uvarum across cages were not significantly different regardless of the absence or presence of various numbers of cherry (F4,25 = 1.89, P = 0.14) or raspberry fruit (F4,25 = 0.77, P = 0.56).

Drosophila suzukii attraction to H. uvarum was significantly affected by the number of cups baited with raspberry (F4,16 = 2.39, P = 0.05), but not with cherry (F4,16 = 2.07, P = 0.13; Fig. 4). There was also a significant block (replicate over time) effect for raspberry (F4,16 = 4.42, P = 0.01), but not for cherry background odor (F4,16 = 0.27, P = 0.89). Among four polynomial functions tested, only a linear relationship between the mean proportion of flies captured by H. uvarum and the number of raspberry cups was significant (linear function: F4,16 = 8.87, P < 0.01; quadratic function: F4,16 < 0.01, P = 0.99; cubic: F4,16 = 0.66, P = 0.43; quartic: F4,16 = 0.01, P = 0.92). Attractiveness of H. uvarum decreased linearly as the surrounding number of raspberry cups increased. However, an increase in the number of cherry cups around H. uvarum did not significantly affect its attraction (linear function: F4,16 = 2.44, P = 0.14; quadratic function: F4,16 = 5.64, P = 0.06; cubic: F4,16 = 0.07, P = 0.80; quartic: F4,16 = 0.15, P = 0.70).

The mean proportion of D. suzukii recaptured in each cage containing cherry fruits was similar regardless of the number of cups baited with cherries (F4,16 = 2.13, P = 0.12; Fig. 5). In contrast, the recapture rate/cage significantly increased as the number of cups baited with raspberries increased (F4,16 = 6.48, P < 0.01). Both linear (F4,16 = 9.11, P < 0.01) and quadratic functions (F4,16 = 15.99, P < 0.01) were significant for the relationship between the mean proportion of fly captures and the number of cups baited with raspberry fruit, whereas other functions were not (cubic function: F4,16 = 0.29, P = 0.59; quartic function: F4,16 = 0.53, P = 0.48).

The mean proportion of D. suzukii recaptured in cages increased linearly in the presence of one and two cups of raspberries but plateaued afterward.

Attractive to those baited with differing abundances of cherries (6 cherries: F4,16 = 3.44, P = 0.09; 18 cherries: F4,16 = 0.01, P = 0.93; 24 cherries: F4,16 = 0.29, P = 0.60; Fig. 3A) or raspberries (9 raspberries: F4,10 = 0.68, P = 0.43; 18 raspberries: F4,10 = 0.03, P = 0.86; 27 raspberries: F4,10 = 0.16, P = 0.70; 36 raspberries: F4,10 = 0.24, P = 0.63; Fig. 3B), except for the cups baited with 12 cherry fruit (F4,16 = 105.05, P < 0.01). Numbers of D. suzukii attracted to H. uvarum across cages were not significantly different regardless of the absence or presence of various numbers of cherry (F4,25 = 1.89, P = 0.14) or raspberry fruit (F4,25 = 0.77, P = 0.56).

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the attraction seen in the wind tunnel assay. This was likely due to a plume emitted by diffusion from the yeast overlapping with the one from cherry or raspberry, resulting in flies not being able to distinguish two attractive sources, since the bioassay was conducted in a cage under still air conditions and cups were placed against each other with no space in between.

Background odor has been shown to influence the attraction of some other insects to volatile chemicals. For example, the attraction of apple fruit moths, *Argyresthia conjugella* Zeller (Lepidoptera: Argyresthiidae), to a synthetic rowan volatile anethole was significantly reduced in the presence of background odors emitted from rowan leaves in a wind tunnel bioassay, whereas 2-phenyl ethanol was synergistically attractive in the presence of rowan leaf volatiles when 2-phenyl ethanol itself was not attractive (Knudsen et al. 2008). Canopy background volatile noise produced by the crop and many noncrop plants strongly compete with the attractiveness of synthetic host plant volatiles to grapevine moth females, *Lobesia botrana* (Denis & Schiffermüller) (Lepidoptera: Tortricidae), under field conditions (Cha et al. 2008).

The impact of fruit background odor on the attractiveness of *H. uvarum* in this study varied among fruit types: raspberry odor had the strongest effect, whereas blueberry and cherry odors had the least (Figs. 1 and 2). This was very likely due to different fruit emitting different odor blends. Small fruits produce a diverse range of volatiles, consisting of hundreds of different chemical compounds that make up their aromas and contribute to their flavor (Du and Qian 2010). There are approximately 250 volatile compounds identified in raspberries and blackberries (Du and Qian 2010), 100 volatile compounds identified in blueberries (Du and Qian 2010), and only 28 volatile compounds identified in sweet Bing cherries (Mattheis et al. 1992). Furthermore, an increase in the intensity of raspberries odor by adding more raspberry cups around *H. uvarum* linearly decreased the attractiveness of *H. uvarum* (Fig. 4), indicating that host abundance and the accompanying increase in odors can also have a strong impact on the attraction of *D. suzukii* to the yeast.

In addition, the physiological state of *D. suzukii* may also have some influence over their attraction to yeast and fruit odors. In the present study, 2- to 3-d-old flies were used, but their reproductive stage was not examined. Previous studies have shown that gravid *D. suzukii* females with high egg loads were more attracted to ripe fruits than to fermentation-based baits, suggesting that reproductively immature females seek fermentation-based baits for food, whereas mature females seek fruits as their ovipositional sites (Swoboda-Bhattarai et al. 2017, Wong et al. 2018). Therefore, it would be interesting to see whether the developmental stage of *D. suzukii* females would have impact on their attraction to the yeast in the presence of background fruit odors.

In the field especially when unlimited fruits are available for *D. suzukii* to utilize during the growing season, the background odors released from the fruits can easily mask or outcompete the point-releasing volatiles from the monitoring trap. If the odor components from the attractants and background volatiles overlap, the faint odor from the attractant will not provide a distinct signal to the target pest (Knudsen et al. 2008). Therefore, an attractant must stand out from the background of volatiles to increase its chance of attracting insect pests. This could be accomplished either by increasing the amount of the attractant or by increasing the specificity of the attractant (Schröder and Hilker 2008). If the odor of the attractant overlaps with its background odor, then increasing its amount will only slightly increase its detectability (Schröder and Hilker 2008). On the other hand, if the composition of the attractant differs from its background odor, then the attractant will

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**Discussion**

*Drosophila suzukii* was strongly attracted to live yeast *H. uvarum* over a blank control in the present study. This was consistent with the finding by Hamby et al. (2012) who reported that *H. uvarum* was preferred the most by this fly among yeast species tested. However, the level of attraction could be influenced by the presence of fruit odor depending on fruit type in our wind tunnel study. In the presence of blueberry and cherry odors (Fig. 1B and C), *D. suzukii* still preferred the yeast over fruit and the level of attractiveness of *H. uvarum* was similar to that in the absence of fruit odor (Fig. 1A), indicating that blueberry and cherry odors did not affect the attraction of *D. suzukii* to the yeast in this specific study under these specific conditions. However, odors emitted from blackberry were equally attractive to those emitted from the yeast (Fig. 1D). In the presence of raspberry odor, fewer flies were attracted to the yeast, whereas more flies approached and entered the cups containing the raspberries (Fig. 1E), indicating that the presence of raspberry odor significantly reduced the attractiveness of *H. uvarum*. An increase in the intensity of odors by adding more cherry or raspberry fruit in a single cup did not dramatically increase the effect of fruit odor on the attraction to the yeast (Fig. 3), but instead closed the gap in

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**Fig. 4.** Mean proportion of *Drosophila suzukii* (±SEM) captured by a coffee cup baited with *Hanseniaspora uvarum* on a PDA plate surrounded by 0, 1, 2, 4, or 6 cups baited with six sweet Bing cherries or nine raspberries per cup in a mesh cage.

**Fig. 5.** Mean recapture rate of *Drosophila suzukii* (±SEM) per cage containing a coffee cup baited with *Hanseniaspora uvarum* on a PDA plate surrounded by 0, 1, 2, 4, or 6 cups baited with six sweet Bing cherries or nine raspberries per cup in a mesh cage.
be highly detectable even at a small amount (Anfora et al. 2009). This would necessitate the use of yeast or fermentation volatiles including H. uvarum in different ways in different fruit crops for effective detection. The presence of raspberry and blackberry odors appeared to have a stronger impact on the attraction of D. suzukii to the yeast than cherry and blueberry odors; thus, the use of H. uvarum as the attractant in cherry and blueberry crops would have a much better chance of attracting D. suzukii than in raspberry and blackberry crops. As research on D. suzukii attractants continues, the influences of background odors produced from main crops need to be considered to fully optimize fly attractants because the specificity of the attractant’s composition relative to that of the background odor is crucial for its attractiveness to the target pest under field conditions.

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Author Contributions

JH and LG: conception of experiments. JH: conception of experiments; data analysis. JH: writing the manuscript. LG: editing the manuscript.

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