CLAUDIA BENVENUTI[a] - SILVIA GUIDI[a] - DONATELLA GOGGIOLI[a] -
PIO FEDERICO ROVERSI[a] - GIUSEPPE MAZZA[a*]

HOST SUITABILITY OF COMMERCIAL GREEN, YELLOW, AND RED-FLESHED KIWIFRUIT CULTIVARS FOR THE MEDITERRANEAN FRUIT FLY *CERATITIS CAPITATA* (WIEDEMANN, 1824) (DIPTERA TEPHRITIDAE)

[a]*Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA), Centro di ricerca Difesa e Certificazione, Cascine del Riccio, Via Lanciola 12/a, 50125, Firenze, Italia. GM https://orcid.org/0000-0002-6644-1429*

[*]Corresponding Author: giuseppe.mazza@crea.gov.it

Benvenuti C., Guidi S., Goggioli D., Roversi P.F., Mazza G.- Host suitability of commercial green-, yellow-, and red-fleshed kiwifruit cultivars for the mediterranean fruit fly *Ceratitis capitata* (Wiedemann, 1824) (Diptera Tephritidae).

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae), is among the most economically important quarantine pests worldwide, affecting international fruit trade due to strict phytosanitary regulations. Despite the growing commercial importance of kiwifruit (*Actinidia* spp.), its host status for *C. capitata* remains debated, particularly for recently introduced cultivars. This study evaluated the suitability of three commercial kiwifruit cultivars, green kiwifruit (*Actinidia chinensis* var. *deliciosa* cv. 'Hayward'), yellow kiwifruit (*A. chinensis* var. *chinensis* cv. 'Jintao'), and red-fleshed kiwifruit (*A. chinensis* var. *chinensis* cv. 'Dong hong'), as hosts for *C. capitata* under laboratory no-choice conditions. Persimmon (*Diospyros kaki* cv. 'Jiro') and clementine (*Citrus* x *clementina*) were included as positive controls. Fruits were exposed to gravid females for 48 h under controlled laboratory conditions, and larval abundance, pupal recovery, adult emergence, sex ratio, and developmental time were assessed. Significant differences among fruit types were observed for larval and pupal abundance, adult emergence, and developmental time. Persimmon consistently supported the highest immature survival and fastest development, confirming its high suitability as a host. In contrast, all kiwifruit cultivars showed low infestation levels and reduced adult emergence. Green and yellow kiwifruit were the least suitable hosts, whereas red kiwifruit showed slightly higher larval and adult recovery, although still markedly lower than persimmon. Adult sex ratios did not significantly deviate from 1:1 in any host fruit. The results confirm the poor host but not non-host status of commercial kiwifruit cultivars for *C. capitata* and provide the first data on the susceptibility of red-fleshed kiwifruit under laboratory conditions. These findings support the use of integrated phytosanitary approaches, including cold-treatment protocols, to facilitate safe international trade of kiwifruit while minimizing unnecessary chemical treatments.

Key Words*: Actinidia chinensis*, agricultural pest, Mediterranean fruit fly, phytosanitary security, poor host

INTRODUCTION

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann, 1824) (Diptera: Tephritidae), is among the most economically important fruit fly pests worldwide, attacking more than 350 host plant species (Papadopoulos *et al*., 2001; Liquido *et al*., 2017). Native to eastern sub-Saharan Africa, this species has successfully invaded many regions globally, causing substantial economic losses in fruit production systems. Its broad host range and remarkable ecological adaptability contribute to its ability to colonize novel environments (Giunti *et al*., 2023).

Beyond direct fruit damage, the presence of *C. capitata* strongly affects international fruit trade because many countries impose strict phytosanitary restrictions on commodities originating from infested areas (White and Elson-Harris, 1992; EPPO, 2026). Consequently, understanding the host status of commercially traded fruits is essential for the development of evidence-based quarantine measures and postharvest disinfestation protocols.

Kiwifruit (*Actinidia* spp.) has become an increasingly important commodity in global fruit markets during the last decades, with major production occurring in countries such as Italy, China, New Zealand, Chile, Greece, France, Japan, and the USA (Nishiyama, 2007). Commercial kiwifruit production mainly involves cultivars belonging to *Actinidia chinensis* Planch. varieties: *Actinidia chinensis* var. *deliciosa* (A. Chev.) A. Chev. and *Actinidia chinensis* var. *chinensis* Planch. (https://www.worldfloraonline.org/). Despite the growing commercial importance of kiwifruit, its host status for *C. capitata* remains debated. Field evidence of natural infestation is limited and inconsistent. In Argentina, Segura *et al*. (2006) recovered *C. capitata* from a single collection of kiwifruits, reporting minimal levels of infestation compared with preferred hosts. Similarly, Papachristos *et al*. (2014) observed minimal infestation levels in Greece and reported no adult emergence from field-collected fruits.

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Laboratory studies demonstrated that medflies can oviposit and complete development in some kiwifruit cultivars, although immature survival and adult emergence were generally extremely low (Krainacker *et al*., 1987; Papachristos *et al*., 2014; Follett *et al*., 2019). Overall, available evidence suggests that kiwifruit represents a poor or marginal host for *C. capitata*.

Several factors may contribute to the reduced suitability of kiwifruit for medfly development. Papachristos *et al*. (2014) suggested that the dense fruit surface hairs may reduce oviposition by females, whereas additional biochemical and nutritional factors may negatively affect immature survival. Kiwifruits are characterized by relatively high acidity and contain several bioactive compounds, including phenolic compounds, flavonoids, amino acids, fatty acids, and cysteine proteases, which may interfere with larval development (Castaldo *et al*., 1992; Dembitsky *et al*., 2011; Park *et al*., 2011).

Despite the low susceptibility of kiwifruit to infestation, quarantine concerns remain important because complete development of *C. capitata* may still occur under favorable conditions. Therefore, effective phytosanitary measures are required to ensure quarantine security during international trade.

Cold treatment is considered one of the most promising postharvest disinfestation strategy for kiwifruit because the commodity tolerates prolonged low-temperature storage. Previous studies demonstrated that cold storage effectively controls *C. capitata* in kiwifruit (De Lima 1992; Brown *et al*., 2024), and recent evidence suggests that medfly populations from different geographic regions show similar susceptibility to cold treatment (Hallman *et al*., 2019). These findings support the development of standardized phytosanitary protocols while minimizing the need for chemical treatments.

Although several studies investigated the susceptibility of green and yellow kiwifruit cultivars to *C. capitata*, information regarding recently introduced red-fleshed cultivars is currently lacking. Red kiwifruit cultivars are experiencing rapid commercial expansion worldwide, increasing the importance of assessing their potential susceptibility to quarantine pests.

The aim of the present study was to evaluate the suitability of three commercial kiwifruit cultivars, including a red-fleshed cultivar, as hosts for *C. capitata* under laboratory no-choice conditions and to further assess the phytosanitary risk associated with kiwifruit trade.

MATERIALS AND METHODS

Insect Colony

A wild strain of the Mediterranean fruit fly, *Ceratitis capitata*, originally collected in 2024 from persimmon orchards in Southern Italy (Province of Caserta, Campania region), was used in the experiments. Colonies were maintained in a climate-controlled room at 25 ± 2 °C, 60 ± 5% relative humidity, and a 12:12 h (L:D) photoperiod.

For larval development, a solid larval diet was used according to Pašková (2007), whereas the adult diet followed the formulations described by Cavalloro and Girolami (1969) and Del Rio and Cavalloro (1979).

Adults were reared in plastic cages (BugDorm®, model DP1000, MegaView Science Co., Ltd) with mesh on three sides (30 × 30 × 30 cm). The cages were maintained in darkness except for one mesh-covered side, which was illuminated with LED floodlights (cool white light, 50 W, 95 lm/W) to stimulate oviposition. Eggs, predominantly laid on the mesh-covered side of the cage, were collected twice per week. The eggs deposited on the mesh subsequently fell into a water-filled tray positioned beneath the cage, which maintained egg hydration. Eggs were then collected and transferred onto the solid larval diet described above. At the end of larval development, pupae were recovered from the diet and transferred into adult rearing cages, where adult emergence occurred.

Sexually mature adults aged 7–10 days were selected for all bioassays following the protocol described by Diamantidis *et al*. (2009).

Fruit Material

The following fruit species and cultivars were included in the study: 1) green kiwifruit, *Actinidia chinensis* var. *deliciosa* cv. “Hayward”, 2) yellow kiwifruit, *Actinidia chinensis* var. *chinensis* cv. “Jintao”, 3) red-fleshed kiwifruit, *Actinidia chinensis* var. *chinensis* cv. “Dong hong”.

Persimmon, *Diospyros kaki* cv. “Jiro” and clementine, *Citrus* x *clementina* late-maturing commercial cultivar, commonly cultivated in Mediterranean areas, were used as positive control.

All fruits used in the present study were tested at commercial ripeness and market-ready conditions, corresponding to the developmental stage at which fruits are commonly traded and potentially exposed to infestation during postharvest handling and export. Although susceptibility may vary across fruit maturation stages, the present experimental conditions specifically reflect the phytosanitary risk associated with fruits intended for commercial distribution and international trade.

All fruits were free from visible damage, and untreated with postharvest chemicals. Prior to exposure, fruits were washed under running tap water and air-dried at room temperature.

Experimental Design

A no-choice oviposition test was conducted between January to March 2026 following the general methodology described by Papachristos *et al*. (2014). In particular, in our study, two replicates were performed for each fruit treatment. Each replicate consisted of 10 fruits placed inside an entomological cage, resulting in a total of 20 fruits per fruit species/cultivar. For each cage, 100 adult flies (50 males and 50 females) were released. This infestation likely overestimates natural infestation risk under commercial field conditions. In addition, two sugar-water feeders and an adult diet source were provi-

ded inside each cage throughout the exposure period. All experiments were conducted under controlled laboratory conditions at 25 ± 2 °C, 65 ± 5% relative humidity, and a 12:12 h (L:D) photoperiod. Fruits were exposed to insects for 48 h, according to exposure periods adopted in previous studies (e.g., Ozaki, 1980).

After the exposure period, fruits were removed from the cages and individually transferred to 480 mL ventilated plastic containers for insect rearing (https://www.omnesartes.com/it/61-barattoli-per-insetti-in-plastica) containing sterile sand as a pupation substrate until adults emergence. Containers were maintained under the same environmental conditions described above until completion of insect development. Nevertheless, the experiment was terminated after two months.

For each fruit and replicate, the following parameters were recorded: number of ready to pupate third instar larvae; number of pupae; number of emerged adults and sex ratio; developmental time data for each developmental stage; fruit weight (g), and soluble solids content (°Brix). Fruit weight was recorded for all samples (n = 20) using a calibrated analytical laboratory balance (precision ±0.01 g). Soluble solid content (°Brix) was measured with a refractometer on an additional 10 fruits per species/cultivar to assess fruit nutritional quality.

Statistical Analysis

Given the exploratory nature of the study and the relatively small sample size, non-parametric analyses were preferred over generalized count models. Fruit quality parameters, including fruit weight and soluble solids content (°Brix), as well as the number of third-instar larvae, pupae, and emerged adults, were first assessed for normality and homogeneity of variances using the Shapiro–Wilk and Levene's tests, respectively. Fruit quality parameter data did not meet the assumptions of normality and homoscedasticity, whereas data on the number of larvae, pupae, and emerged adults were highly skewed and characterized by a high frequency of zero values. Therefore, non-parametric analyses were applied. Differences among fruit treatments were evaluated using the Kruskal–Wallis rank-sum test (H), followed by Benjamini–Hochberg-adjusted post-hoc pairwise comparisons to control the false discovery rate.

Sex ratio of emerged adults was analyzed using Chi-square goodness-of-fit tests (χ^2) to assess deviations from the expected 1:1 male-to-female ratio for each host fruit.

Developmental time data of *Ceratitis capitata* were analyzed separately for each developmental stage (larva, pupa, and adult emergence) across the five host fruits described above: clementine, green kiwi, yellow kiwi, red kiwi, and persimmon. Descriptive statistics were calculated for each host fruit and developmental stage, including sample size (n), mean, standard deviation (SD), median, and range (minimum–maximum). Since assumptions of normality and homoscedasticity, assessed as above, were not consistently met and sample sizes were highly unbalanced among treatments, non-parametric analyses were applied. Differences in developmental time among host fruits were tested separately for each developmental stage using Kruskal–Wallis rank-sum tests followed by Dunn's multiple comparison post-hoc tests with Holm correction for pairwise comparisons.

Statistical significance was set at $\alpha = 0.05$. All statistical analyses were performed using R Statistical Software (R Core Team, 2025).

RESULTS

Concerning fruit quality, the Kruskal-Wallis test revealed a statistically significant difference between the groups for fruit weight ($H = 90.6275$, $df = 4$, $p < 0.0001$) and soluble solids content (°Brix) ($H = 40.9501$, $df = 4$, $p < 0.0001$)(see Fig. I).

Post-hoc pairwise comparisons for fruit weight indicated that all five fruit types formed distinct statistical groups, demonstrating distinct weight profiles for each category (Fig. I, 1), with persimmon exhibiting the highest overall mass. For the analysis of sugar content, pairwise comparisons revealed distinct clustering among fruits (Fig. I, 2). The highest soluble solids concentrations were observed in persimmon and red kiwi, which did not differ significantly from each other (median = 17.75 and 18, respectively). Yellow kiwi constituted a separate statistical tier with an intermediate median value (median = 16.25). Conversely, clementine (median = 14) and green kiwi (median = 12) exhibited significantly lower soluble solids content compared to all other groups, with green kiwi identified as the least sweet cultivar.

Concerning insect fitness and development, the Kruskal-Wallis test revealed highly significant differences among the fruit types regarding the abundance of larvae ($H = 27.479$, $df = 4$, $p < 0.0001$), pupae ($H = 44.4635$, $df = 4$, $p < 0.0001$), and emerged adults ($H = 49.1724$, $df = 4$, $p < 0.0001$), respectively (see Figs. II).

Regarding larval abundance, post-hoc pairwise comparisons indicated that persimmon supported a significantly higher number of larvae compared to all other treatments ($p < 0.001$), standing alone (Fig. II, 1). Red kiwi formed a distinct group, showing significantly higher larval counts than green kiwi ($p = 0.0453$), but remaining statistically comparable to clementine and yellow kiwi. Green kiwi supported the lowest overall larval development, though its counts did not statistically differ from clementine or yellow kiwi, which exhibited intermediate, overlapping distributions.

For pupal abundance, pairwise comparisons revealed a shifting clustering pattern among the fruits (Fig. II, 2). Persimmon again exhibited the highest overall insect density, forming an exclusive statistical tier that significantly outpaced all other groups ($p < 0.0001$). Clementine formed a separate distinct group, showing significantly higher pupal levels than green kiwi ($p = 0.0032$) and yellow kiwi ($p = 0.0118$). Conversely, red kiwi occupied an overlapping transitional status, as its pupal abundance was not statistically distinguishable from either green kiwi or

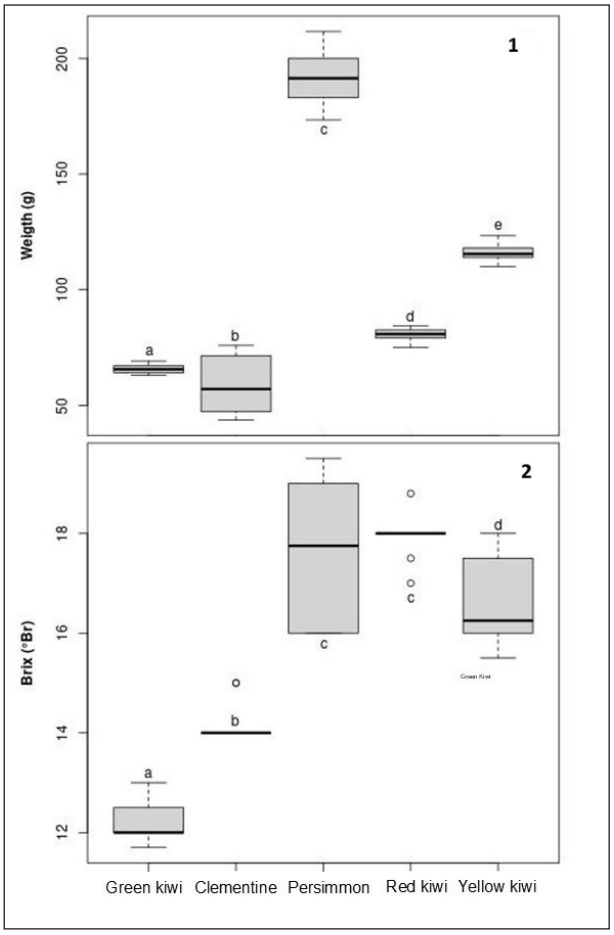


Fig. I – 1) Fruit weight distribution (g) and 2) soluble solids content (°Brix) across different fruit types. Different letters indicate statistically significant differences by pairwise comparisons ($p < 0.05$).

clementine. Green kiwi and yellow kiwi presented the lowest pupal counts.

A highly consistent trend was observed for adult emergence (Fig. II, 3). Pairwise comparisons confirmed that persimmon yielded the highest number of adults, differing significantly from all alternative hosts ($p < 0.0001$). Clementine maintained its position as the second most favorable host for final development, forming its own distinct significance rank, which was significantly higher than green kiwi ($p = 0.0084$) and yellow kiwi ($p = 0.0095$). Similar to the pupal stage, red kiwi remained within an intermediate significance group, showing no statistical variance from kiwi fruits or clementine. Ultimately, green kiwi and yellow kiwi were grouped together as the least productive hosts for adult emergence.

Adult sex ratio did not significantly differ from 1:1 in any host fruit tested (χ^2, $p > 0.05$). However, a slight female-biased trend was observed in kiwi fruits and clementines, whereas persimmon showed an approximately balanced sex ratio (Table 1).

Developmental time significantly differed among host fruits for all developmental stages (larval stage: $H = 128.10$, $p < 0.001$; pupal stage: $H = 148.22$, $p < 0.001$; adult emergence: $H = 61.73$, $p < 0.001$; Table 2). During the larval stage, persimmon fruits showed significantly shorter developmental times compared with all kiwi cultivars and clementines. No significant differences were detected among clementine, green kiwi, yellow kiwi, and red kiwi. Similar differences were observed during the pupal stage. Clementines exhibited the longest pupal developmental time, whereas persimmon showed the shortest duration. Total developmental time until adult emergence also varied among host fruits. Adults emerging from persimmon and yellow kiwi completed development significantly faster than those reared on clementines, green kiwi, and red kiwi, which did not significantly differ from each other.

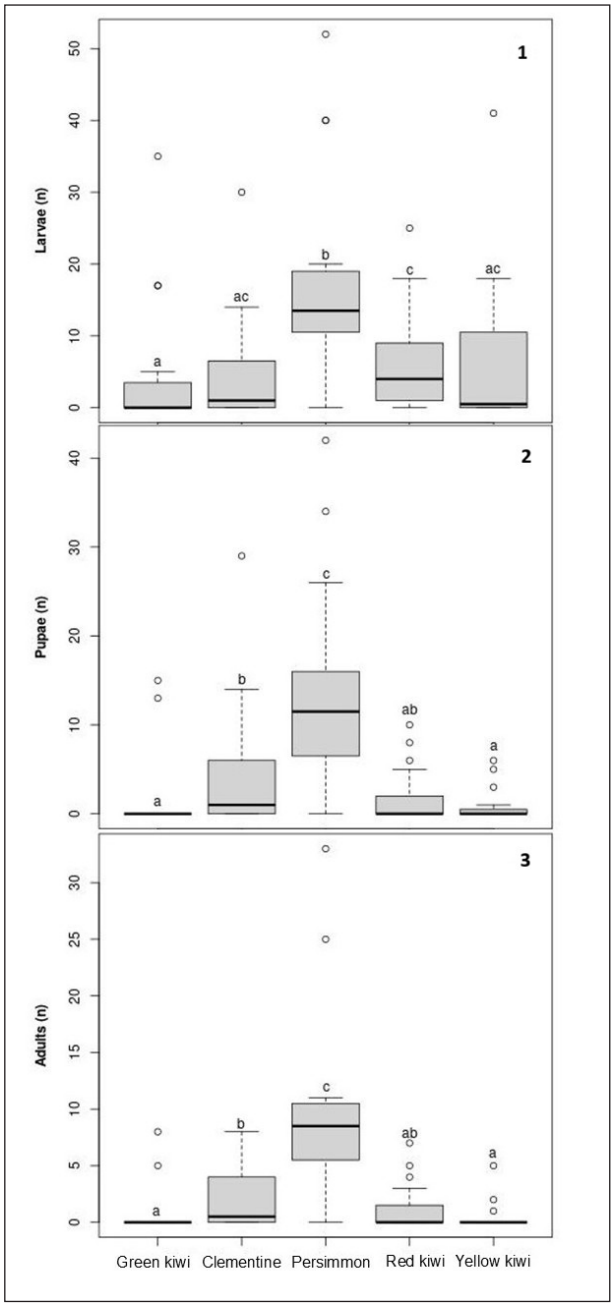


Fig. II – 1) Larval abundance, 2) pupal abundance, and 3) total number of emerged adults of *Ceratitis capitata* from the different host fruit types. Boxplots display the median (solid horizontal line), the 25th and 75th percentiles (box boundaries), and outliers (open circles). Different letters above the boxes indicate statistically significant differences determined by post-hoc pairwise comparisons ($p < 0.05$).

Table 1 - Number of male and female *Ceratitis capitata* adults obtained from different host fruits and total adult emergence.

Fruit	Male	Female	Total adults	% Female	Sex ratio (M:F)	χ^2	p-value
Clementine	17	28	45	62.2%	1 : 1.65	2.69	0.10
Green kiwi	5	8	13	61.5%	1 : 1.60	0.69	0.41
Yellow kiwi	3	5	8	62.5%	1 : 1.67	0.50	0.48
Persimmon	95	89	184	48.4%	1.07 : 1	0.20	0.66
Red kiwi	8	14	22	63.6%	1 : 1.75	1.64	0.20

Table 2 - Developmental time (days) of *Ceratitis capitata* reared on different host fruits under laboratory conditions. Values are expressed as mean ± standard deviation (SD), together with median and minimum–maximum range for each developmental stage. Different letters within each developmental stage indicate significant differences among host fruits according to Dunn's post-hoc tests ($p < 0.05$).

Stage	Host fruit	n	Mean ± SD (days)	Median	Min–Max	Group
Larvae	Clementine	83	13.94 ± 1.94	14	11–18	a
	Green kiwi	26	13.54 ± 1.58	14	11–18	a
	Yellow kiwi	16	13.81 ± 3.21	12.5	10–20	a
	Red kiwi	35	13.89 ± 2.51	13	11–21	a
	Persimmon	267	11.09 ± 1.93	11	8–15	b
Pupae	Clementine	82	17.04 ± 1.70	18	12–20	a
	Green kiwi	28	16.11 ± 2.48	16	12–20	ab
	Yellow kiwi	16	14.81 ± 3.04	13.5	12–21	bc
	Red kiwi	35	15.23 ± 2.62	14	12–21	b
	Persimmon	267	13.12 ± 2.25	13	9–19	c
Adults	Clementine	45	26.51 ± 1.49	26	25–29	a
	Green kiwi	13	25.92 ± 0.64	26	25–27	a
	Yellow kiwi	8	23.75 ± 2.12	23	20–26	b
	Red kiwi	22	25.91 ± 2.33	26.5	22–28	a
	Persimmon	184	22.98 ± 3.21	23	19–29	b

DISCUSSION AND CONCLUSIONS

The present study confirms the low susceptibility of commercial kiwifruit cultivars to *Ceratitis capitata* under laboratory no-choice conditions and provides new evidence regarding the host suitability of the red-fleshed cultivar 'Dong hong'. Although complete development from egg to adult was recorded in all kiwifruit cultivars tested, infestation levels and adult emergence remained consistently low compared with the positive control fruits, particularly persimmon. These findings further support the classification of kiwifruit as a poor host for *C. capitata*, in agreement with previous laboratory and field studies (e.g., Papachristos *et al*., 2014; Follett *et al*., 2019). Moreover, infestation observed under forced laboratory no-choice conditions likely overestimates natural infestation risk under commercial field conditions. Such experimental conditions are commonly adopted in host status studies because they maximize the likelihood of oviposition and therefore provide a conservative assessment of potential host suitability.

Among the fruit species tested, persimmon proved to be by far the most suitable host for medfly development, supporting significantly higher numbers of larvae, pupae, and emerged adults, as well as shorter developmental times. Clementine also supported successful development, although at lower levels than persimmon. In contrast, all kiwifruit cultivars were characterized by reduced immature survival and lower adult emergence, suggesting that kiwi fruits represent suboptimal developmental substrates for medfly larvae. These results are consistent with earlier observations reporting very low infestation rates in kiwifruit under both laboratory and field conditions (Segura *et al*., 2006; Papachristos *et al*., 2014; Follett *et al*., 2019).

Green and yellow kiwifruit exhibited the lowest overall suitability for medfly development, whereas red kiwifruit showed slightly higher larval and adult recovery. Nevertheless, the infestation levels observed in red kiwifruit remained markedly lower than those recorded in persimmon and generally overlapped with the values observed in the other kiwi cultivars. Similarly, differences in fruit size alone do not appear to explain the infestation patterns observed in the present study. Although persimmon fruits were substantially larger than kiwifruit, yellow kiwifruit showed greater average fruit mass than green and red kiwifruit while still supporting extremely low immature survival and adult emergence. Moreover, clementines, despite having fruit weights comparable to green- and yellow- kiwifruit cultivars, consistently supported higher medfly development. These findings strongly suggest that susceptibility is driven more by qualitative fruit traits than by fruit size alone, including physical barriers, nutritional composition, acidity, and defensive

biochemical compounds. Moreover, these findings suggest that the recently introduced red-fleshed kiwifruit cultivar may be somewhat more permissive to medfly development compared with green and yellow cultivars, while still maintaining an overall poor host status. Indeed, as reported also in Zanoni (2018) for apples, even within the same fruit species, different fruit varieties may considerably affect various aspects of the biology of both immature and adult medflies.

Other studies have shown that low soluble solid content and high acidity levels can negatively affect development time and pupal weight, leading to reduced larval and pupal survival rates (Vargas *et al*., 1984; Papadopoulos *et al*., 2002; Papachristos *et al*., 2008). However, in our study, the highest soluble solids concentrations recorded in persimmon and red kiwi did not differ significantly from each other, whereas yellow kiwi formed a distinct statistical group with intermediate median values. Nevertheless, these differences were not reflected in comparable numbers of larvae, pupae, or adults, suggesting that soluble solids content alone cannot explain host suitability. Moreover, Papachristos *et al*. (2014) also reported no significant correlation between female oviposition and either fruit firmness or soluble solids content, and Papachristos *et al*. (2008) found that pulp chemical properties, including soluble solids content, had only minor effects on larval and pupal survival and developmental time.

Since information regarding the susceptibility of red kiwifruit cultivars to tephritid infestation is currently lacking, the present study provides useful baseline data for future risk assessment and quarantine evaluations. All fruits used in the present study were tested at commercial ripeness and market-ready conditions, corresponding to the developmental stage at which fruits are commonly traded and potentially exposed to infestation during postharvest handling and export. Therefore, the observed low susceptibility of kiwifruit cultivars is likely representative of realistic postharvest and trade conditions. The reduced suitability of kiwifruit for *C. capitata* development may result from a combination of physical and biochemical resistance factors. Previous studies suggested that the dense surface hairs of some kiwifruit cultivars may act as oviposition deterrents by limiting female acceptance and egg deposition (Papachristos *et al*., 2014). However, the infestation levels observed in both yellow- and red-fleshed kiwifruit, which are characterized by smoother and less pubescent fruit surfaces compared with green kiwifruit, suggest that surface morphology alone cannot explain host suitability. Kiwifruit also contains several bioactive compounds, as reported above, which may interfere with larval physiology and development (Castaldo *et al*., 1992; Dembitsky *et al*., 2011; Park *et al*., 2011). Although these mechanisms were not directly investigated in the present study, they likely contribute to the low developmental success observed in kiwi fruits.

Interestingly, developmental times differed significantly among host fruits. Medflies reared on persimmon completed larval and pupal development more rapidly than those reared on kiwifruit cultivars and clementines, suggesting a more favorable nutritional environment, as underlined also in Papachristos *et al*. (2014), comparing nectarines and kiwi fruits. Delayed development observed in kiwi fruits may reflect nutritional limitations or physiological stress affecting immature stages. Similar patterns have previously been reported for poor or marginal hosts of tephritid fruit flies (e.g., Follett *et al*., 2019).

Despite the low infestation levels observed, complete development of *C. capitata* was still possible in all kiwifruit cultivars tested under laboratory exposure conditions. It should also be emphasized that the present experiments were conducted under forced laboratory no-choice conditions with high insect pressure, which likely overestimate infestation levels compared with natural field and commercial situations. Therefore, kiwifruit cannot be considered a non-host commodity. However, the consistently low recovery of pupae and adults, together with previous field observations reporting extremely low or absent natural infestations (Papachristos *et al*., 2014; Follett *et al*., 2019), indicate that commercial kiwifruit cultivars should be regarded as poor hosts with relatively low phytosanitary risk.

From an applied perspective, these findings have important implications for quarantine management and international trade. The poor host status of kiwifruit suggests that phytosanitary measures may potentially be optimized using systems approaches that combine field management with postharvest disinfestation protocols. During development of quarantine treatments for fruit flies, potential protocols are normally validated by testing large numbers of insects in the host commodity. These efficacy standards may be too stringent for commodities that are rarely infested or poor hosts and a less severe postharvest treatment might still provide quarantine security. Thus, as suggested by Follett and McQuate (2001) fewer insects may be needed during research to develop quarantine treatments on poor hosts because of the inherently lower risk.

Previous studies demonstrated that cold treatment is highly effective against *C. capitata* in kiwifruit (De Lima, 1992) and recently Brown *et al*. (2024) demonstrated that a cold treatment of 2.9 °C or below for 18 days induces *C. capitata* mortality in kiwifruit at a rate that exceeds 99.9968% with a degree of confidence greater than 99%. Moreover, medfly populations from different geographic regions show no significant differences in cold susceptibility (Hallman *et al*., 2019). Consequently, the integration of orchard management strategies, bait applications, and cold-treatment protocols as suggested by Brown *et al*. (2024) could provide a high level of quarantine security while minimizing unnecessary chemical treatments and facilitating international trade (e.g., Follett and McQuate, 2001). Overall, the present results reinforce the view that kiwifruit represents a marginal host for *C. capitata*.

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