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Optimizing the Luring Period of Protein and Food Baits for Melon Fly (*Zeugodacus cucurbitae* Coquilette) Management

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Backgrounds: This study was carried out to determine the effective duration of protein and food baits in field traps for maximizing melon fruit fly captures. As protein and food baits trap both male and female fruit flies, employing these traps in field conditions is considered as a reliable alternate management strategy.
Aim of the Work: Determination of trap placement periods in field conditions for maximum trap catches of melon fruit flies.

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Methodology: Olfactometer bioassays were conducted to assess the persistence of bait attractiveness. Changes in pH and protein content of baits were monitored over time.
Results: Proteinex bait showed peak attraction between I–X days after preparation (DAP), while soybean bait was most effective from I–IX DAP. Tomato bait attracted the highest number of fruit flies at XII–XII DAP, and banana bait showed maximum attraction at I–VIII DAP. Protein baits had higher pH and protein content, correlating with their superior trap efficacy.
Conclusion: For effective melon fly management, proteinex and soybean baits should be replaced every 10–12 days, tomato baits every 13 days, and banana baits every 8 days. The higher pH and protein content of protein baits contributed to their greater effectiveness, making them a valuable tool in sustainable pest control strategies.

Keywords: Melon fruit fly; protein bait; food bait; bait pH; protein content.

1. INTRODUCTION

The melon fruit fly, *Zeugodacus cucurbitae* Coquillett (Diptera: Tephritidae) is the most devastating pest of cucurbitaceous vegetables and fruits in various regions of the world (Kapoor, 1993). The melon fruit fly, *Z. cucurbitae* is considered as an important agricultural pest affecting a variety of cultivated fruits and vegetables. It is mainly polyphagous but oligophagous populations have also been found in Thailand, Malaysia and France (Reunion Island, Indian Ocean) (Clarke et al*.,* 2001; Vayssières et al*.,* 2008; Hafsi et al*.,* 2016).

The melon fruit fly attacks 61 species of plants from 19 distinct families with 28 of them are cucurbits and the rest are non-cucurbit hosts. (De Meyer et al*.,* 2015). The fruit fly damages the economic part crop by oviposition, larval feeding on ovaries, fruit pulp and rottening of damaged fruits (Viraktamath et al*.,* 2003). Inspite of direct losses caused by these fruit flies, indirect losses were also caused in the form of rejection of export produce due to the presence of fruit fly maggots as quarantine restrictions and eradication procedures are very strict (Badii et al*.,* 2015). This makes the melon fly as the insect of global importance which adversely affects the food security and Indian economy through export.

With regard to the management of fruit flies, effectiveness of insecticidal control is very minimum as the damaging stage of the insect *i.e.,* maggots remain inside the fruit, pupation occurs in soil and the adults roam in the adjacent areas of the host crop. Various mixtures of methyl eugenol and cuelure have been tested and found that traps baited with a 10:90 ratio of cue-lure to methyl eugenol were more effective in monitoring and managing *Z. cucurbitae* in guava and vegetable crops (Ahmad et al*.,* 2023). But these parapheromones attract only males resulting in partial control only. Hence, alternative ways of fruit fly management have to be chosen for the control of their control. One of the most suitable and practical method of management of fruit fly is “Attract and kill strategy” through employing protein and food baits which attracts both male and female fruit flies. These baits can be prepared easily in low cost. However, their effectiveness is limited to a period of time and thereafter, replacing with fresh bait is essential for maximum trapping efficiency. So, it is essential to know the maximum keeping period of the protein and food baits in field conditions to replace them with fresh baits to achieve maximum fruit fly catches. However, research studies in this direction are very limited. In view of this, the present study was undertaken in this direction as trapping through protein and food baits is an ecofriendly approach which will address the quarantine issues of fruit fly globally.

2. MATERIALS AND METHODS

2.1 Determining Attractiveness and Peak Attraction Period of Protein and Food Baits

From our previous research studies on the efficacy of some food and protein baits for trapping fruit flies, soybean & proteinex protein baits and tomato & banana food baits were selected as the most attractive fruit fly baits (Manikantha et al*.,* 2022; Nithya et al*.,* 2024). With the intention of knowing the optimum trapping period of these baits, their attraction was tested in the laboratory conditions using olfactometer from first to 15 days after preparation of baits.

Table 1. Protein and food baits evaluated

S. No.	Treatments	Ingredients
1	Proteinex bait	Proteinex powder (10%) + jaggery (10%) + ammonium acetate (5%) + borax (2%) + malathion (0.001%)
2	Soybean bait	Soybean powder (10%) + jaggery (10%) + ammonium acetate (5%) + borax (2%) + malathion (0.001%)
3	Tomato bait	Tomato pulp (10%) + jaggery (10%) + citric acid (5 g) + yeast 10 g + borax 2% + malathion (0.1%)
4	Banana bait	Banana pulp (10%) + jaggery (10%) + citric acid (5 g) + yeast 10 g + borax 2% + malathion (0.1%)
5	Negative control of protein bait	Jaggery (10%) + ammonium acetate (5%) + Malathion (0.001%) + borax (2%).
6	Negative control of food bait	Jaggery (10%) + citric acid (5 g) + malathion (0.1%) + yeast 10 g + borax (2%)

During the preparation of baits, ammonium acetate was used as a female fruit fly attractant. Jaggery was used to increase the attractiveness of bait. Borax was added to all the treatments to prevent the decomposition of trapped flies and to boost the alkalinity of the bait. As fruit flies are needed continuously for conducting bioassay studies, they were mass cultured in the laboratory. Infested cucurbit fruits were maintained in the insect cages with sand layer on its floor to facilitate pupation of fruit fly maggots. Sand was sprayed with water on need basis to maintain the humidity within and in turn the turgidity of fruits. The emerged fruit flies are provided with adult fruit fly diet (honey, proteinex powder and water mixed in 1:1:3 ratio) and were utilized for the laboratory experiments.

Olfactometer bioassays were conducted with protein (soybean, proteinex) and food (tomato, banana) baits to evaluate their attractiveness to melon fruit flies over 15 days after preparation. A four-armed olfactometer was chosen to allow simultaneous testing of bait, negative control and untreated control samples under controlled conditions. Sponges saturated with the baits served as odour sources and were kept in the odour arms. Dry sponge served as untreated control. Prestraved fruit flies (30 nos.) were released inside the olfactometer. During the experiment, olfactometer was covered with a dark red cloth to minimize light-induced biases in fruit fly attraction as this experiment is intended only for the assessment of preference of fruit flies to odour sources only. Each treatment was replicated thrice to ensure reliability of results and minimize experimental variability and during each replication, direction of olfactometer was changed.

After preparing the baits, each bait was divided in to fifteen parts and kept in different containers. Bioassays on the attraction of baits to fruit flies were conducted consecutively for fifteen days with 1 day old, 2 day old, likewise upto 15 days old bait *i.e.,* with baits of different fermentation periods. Attraction of adult fruit flies towards the bait samples was recorded based on the number of adult flies present in the area of odour of samples after one hour.

2.2 Monitoring pH and Protein Content Changes in Baits Over Time

As attraction of food and protein baits to fruit flies increase with the increase of pH and protein contents, pH of the protein and food baits was recorded from 1st day after preparation (DAP) to 15th DAP continuously with the digital portable pH meter.

Protein content was measured from 1 to 15 DAP to track potential degradation over time. Protein content was estimated using the micro Kjeldahl method as this is a scientific procedure used to determine the protein content of a sample by quantifying its nitrogen content.

3. RESULTS

3.1 Attraction of Melon Flies to Protein Baits of Various Fermentation Periods

Proteinex Bait: Attraction of proteinex bait to fruit flies increased from I day after the preparation of bait (DAP) to X DAP *i.e.,* 9.33 and 24.67 respectively (Table 2). From XI DAP (20.00 fruit flies), a slight reduction in attraction was observed and on XV DAP, 16.67 flies were attracted to proteinex bait. Among the 15 days of fermentation periods, on IX and X DAP, more number of fruit flies was attracted to proteinex bait (24.67 fruit flies). Next to this, on VIII DAP 21.33 fruit flies were attracted followed by VII

DAP (20.67 fruit flies) and XI DAP (20.00 fruit flies). In negative control, attraction of fruit flies ranged from 2.67 (I and XV DAP) to 6.33 (XI DAP). Attraction index (AI) was maximum on IX DAP (0.67) followed by X DAP (0.66) and VIII DAP (0.52) (Table 4). Lowest AI of 0.22 was recorded on I DAP.

Soybean Bait: Attraction of soybean bait to fruit flies increased from I DAP (10.00 fruit flies) to IX DAP on which maximum attraction (21.33 fruit flies) was found (Table 2). This was followed by X DAP on which 20 fruit flies were found to be attracted to the soybean bait. Attraction on VIII and XI DAP were ranked next with 19.33 attracted fruit flies. Least attraction was found on I DAP (10.00 fruit flies). On XV DAP, 14.67 fruit flies were recorded near the odour source of soybean bait. In negative control, attraction of fruit flies ranged from 2.67 (I DAP) to 6.00 (VI and VII DAP). Among the different fermentation periods, 0.51 is the highest AI observed on IX DAP followed by X DAP (0.49) and VIII DAP (0.47) (Table 4). AI was low (0.24) on I DAP. Attraction index is an index of luring capacity of the baits.

Table 2. Assessment of changes in bait attractiveness to melon fruit flies - Protein baits – Olfactometer bioassays

Days after preparation of bait	Number of fruit flies attracted					
	Proteinex bait			Soybean bait		
	Bait odour arm	Negative control	Untreated control	Bait odour arm	Negative control	Untreated control
I	9.33 (3.05)^{g}	2.67	0.33	10.00 (3.15)^{g}	2.67	1.00
II	14.67 (3.83)^{f}	3.33	0.33	12.67 (3.56)^{fg}	3.33	1.33
III	15.33 (3.91)^{ef}	4.00	0.00	13.33 (3.65)^{ef}	3.33	0.67
IV	18.00 (4.24)^{cde}	4.67	0.67	14.67 (3.83)^{def}	4.00	0.33
V	18.67 (4.32)^{bcd}	5.33	0.33	16.67 (4.08)^{bcde}	5.33	0.67
VI	19.33 (4.40)^{bcd}	5.33	0.00	17.33 (4.16)^{bcd}	6.00	1.00
VII	20.67 (4.54)^{bc}	6.00	0.67	18.00 (4.24)^{abcd}	6.00	0.67
VIII	21.33 (4.62)^{ab}	5.67	0.00	19.33 (4.40)^{abc}	5.33	1.00
IX	24.67 (4.97)^{a}	4.67	0.00	21.33 (4.62)^{a}	5.00	0.67
X	24.67 (4.97)^{a}	5.00	0.67	20.00 (4.47)^{ab}	5.33	0.33
XI	20.00 (4.47)^{bc}	6.33	0.00	19.33 (4.40)^{abc}	5.33	1.00
XII	18.67 (4.32)^{bcd}	5.67	0.67	18.67 (4.32)^{abc}	4.67	1.67
XIII	18.67 (4.32)^{bcd}	4.00	0.00	16.67 (4.08)^{bcde}	4.67	0.67
XIV	18.00 (4.24)^{cde}	4.00	0.67	15.33 (3.91)^{cdef}	4.00	1.00
XV	16.67 (4.08)^{def}	2.67	0.33	14.67 (3.83)^{def}	3.33	1.33
CD (0.05)	0.42			0.45		
S.E(d)	0.10			0.13		

**Mean of three replications*

Figures in parentheses are square root transformed values

Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=0.05)

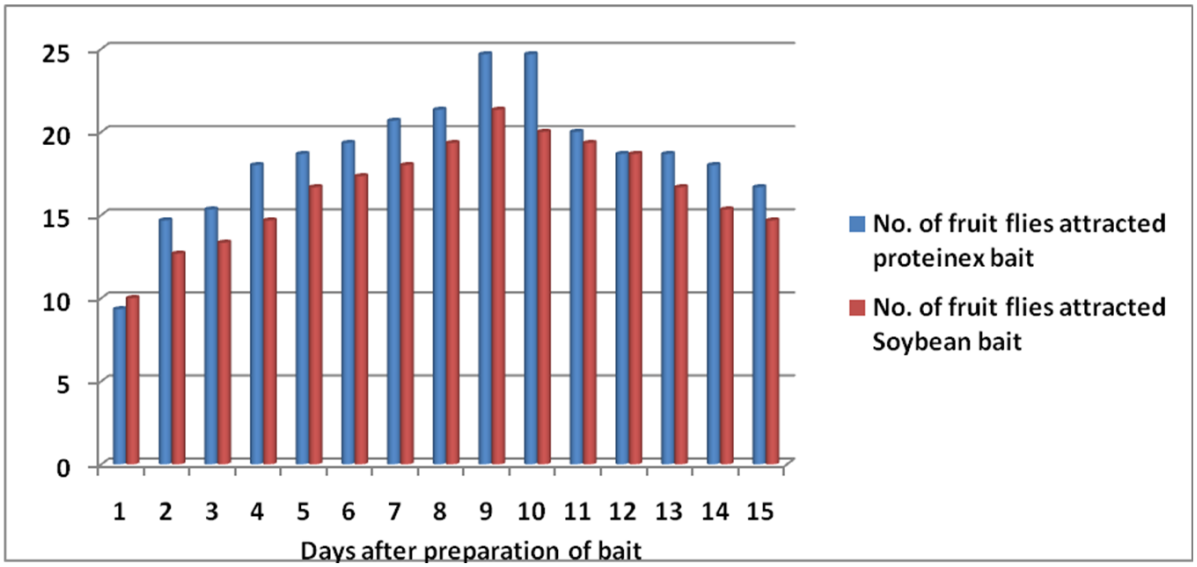

Fig. 1. Assessment of attractiveness of protein baits with time

3.2 Evaluation of Attraction of Melon Flies to Food Baits of Various Fermentation Periods

Tomato Bait: On I DAP, 8 fruit flies were observed near the odour source of tomato bait and this was gradually increased with the fermentation of the bait. Maximum attraction of fruit flies was recorded on XII and XIII DAP *i.e.,* 16.67 fruit flies (Table 3). Next to this, attraction was more on XI day (16 fruit flies). In the odour area of negative control, 1.33 fruit flies (I DAP) to 6.67 fruit flies (VIII DAP) were noted. AI was high (0.40) on IX DAP followed by X and VI DAP (0.36) (Table 4) while it was low (0.22) I DAP.

Banana Bait: Number of fruit flies attracted towards the banana bait odour source increased from I DAP (9.33 fruit flies) to VIII DAP (15.33 fruit flies). Thereafter, a gradual decline was observed in bait attraction on XV DAP (10.00 fruit flies) (Table 3). In negative control, attraction of fruit flies ranged from 2.00 fruit flies (I and XV DAP) to 6.00 fruit flies (VII DAP). Banana bait recorded minimum and maximum attraction indices of 0.22 and 0.33 on II and VIII DAP respectively. Next to these, AI was more (0.31) on IX and XI DAP (Table 4).

3.3 Changes in pH of the Protein and Food Baits with Time

Protein Baits: In proteinex bait, pH ranged from 7.03 (I DAP) to 7.69 (XV DAP) (Table 5). pH of soybean bait ranged between 6.18 (I DAP) to 6.89 (XV DAP). From I to XV DAP, pH of both protein baits varied in an uncertain pattern. However, this change in pH with time was not significant and in general pH was stable during the 15 days period in protein baits.

Food Baits: pH of food baits (banana and tomato) gradually increased from I to XV DAP. In banana bait, pH ranged from 3.04 (I DAP) to 4.57 (XV DAP). From II DAP to XV DAP, pH values were on par with each other and revealed that pH values of banana bait have not varied significantly with time. pH of the tomato bait was in the range from 3.48 (I DAP) to 4.22 (IX DAP). The highest pH (4.22) was recorded on IX DAP followed by 4.21on XV DAP. In tomato bait, pH values were found to be stable with minor variations from III to XV DAP.

3.4 Changes in the Protein Content of Protein Baits and Food Baits with Time

Protein Baits: Protein content of proteinex and soybean baits ranged from 21.69% (XI DAP) to 26.25% (I DAP) and 20.10% (XV DAP) to 22.31% (I DAP) respectively (Table 5). In both the baits, highest protein content was found on I day after preparation (DAP). In proteinex bait, more protein content was recorded on I and II DAP (26.25 and 24.50% respectively). From III to VIII DAP, slightly low protein content was recorded however, they were on par with the protein contents of I and II DAP. From IX DAP, comparatively less protein content was recorded

and on the last day (XV DAP) protein content noted was 21.94%. In soybean bait, protein content was found to be stable during the first 3 DAP. Thereafter, protein content was slightly reduced up to XII DAP. However, protein content of the soybean bait on XII DAP (20.56%) was statistically on par with the I DAP (22.31%). Protein content of soybean bait was reduced from XIII (20.31%) to XV DAP (20.10%).

Food Baits: In food baits, protein content varied from 4.20% (XV DAP) to 5.38 % (I and II DAP) in tomato bait and 4.69% (XV DAP) to 6.29% (I DAP) in banana bait (Table 5). In both the food baits, protein content was high on I DAP. In tomato bait, protein content was high during I to V DAP (5.38 to 5.07%). Later, it was slightly decreased with time and reached to 4.20% on XV DAP. With regard to the banana bait, protein content was not significantly different from I DAP (6.29%) to XIII DAP (5.12%). on XIV and XV DAP, slight reduction in protein content was observed (5.06 and 4.69% respectively).

Table 3. Assessment of changes in bait attractiveness to melon fruit flies - Food baits – Olfactometer bioassays

Days after preparation of bait	Number of fruit flies attracted					
	Tomato bait			Banana bait		
	Bait odour arm	Negative control	Untreated control	Bait odour arm	Negative control	Untreated control
I	8.00 (2.83)^{d}	1.33	1.00	9.33 (3.05)^{d}	2.00	1.00
II	11.33 (3.36)^{cd}	2.67	1.67	9.33 (3.05)^{d}	2.67	1.67
III	12.00 (3.46)^{bc}	2.67	1.00	10.00 (3.16)^{cd}	2.67	1.00
IV	13.33 (3.65)^{abc}	3.33	0.67	12.00 (3.46)^{abcd}	4.00	1.33
V	8.00 (2.83)^{d}	4.67	1.00	11.33 (3.36)^{cde}	3.33	2.00
VI	11.33 (3.36)^{cd}	4.00	0.33	13.33 (3.65)^{abc}	4.67	0.67
VII	12.00 (3.46)^{bc}	6.00	0.67	14.67 (3.83)^{ab}	6.00	1.67
VIII	13.33 (3.65)^{abc}	6.67	1.67	15.33 (3.91)^{a}	5.33	0.33
IX	14.67 (3.83)^{abc}	4.67	2.00	14.67 (3.83)^{ab}	5.33	1.00
X	14.67 (3.83)^{abc}	4.00	1.33	14.00 (3.74)^{ab}	5.33	1.00
XI	16.00 (4.00)^{ab}	4.00	1.67	14.00 (3.74)^{ab}	4.67	1.33
XII	16.67 (4.08)^{a}	3.33	1.00	13.33 (3.64)^{abc}	5.33	1.67
XIII	16.67 (4.08)^{a}	3.33	0.67	11.33 (3.36)^{cde}	2.67	1.67
XIV	14.67 (3.83)^{abc}	2.67	0.33	12.00 (3.46)^{abcd}	3.33	0.67
XV	13.33 (3.63)^{abc}	3.33	1.00	10.00 (3.16)^{cd}	2.00	1.33
CD (0.05)	0.60			0.27		
S.E(d)	0.16			0.15		

**Mean of three replications*

Figures in parentheses are square root transformed values

Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=0.05)

Table 4. Attraction indices of protein and food baits to melon fruit flies

S. No.	Days after preparation of bait	Attraction Index			
		Proteinex bait	Soybean bait	Tomato bait	Banana bait
1	I	0.22	0.24	0.22	0.24
2	II	0.38	0.31	0.29	0.22
3	III	0.38	0.33	0.31	0.24
4	IV	0.44	0.36	0.33	0.27
5	V	0.44	0.38	0.33	0.27
6	VI	0.47	0.38	0.36	0.29
7	VII	0.49	0.40	0.33	0.29
8	VIII	0.52	0.47	0.33	0.33
9	IX	0.67	0.51	0.40	0.31
10	X	0.66	0.49	0.36	0.29
11	XI	0.46	0.47	0.31	0.31
12	XII	0.43	0.47	0.33	0.27
13	XIII	0.49	0.40	0.29	0.29
14	XIV	0.47	0.38	0.31	0.29
15	XV	0.47	0.38	0.27	0.27

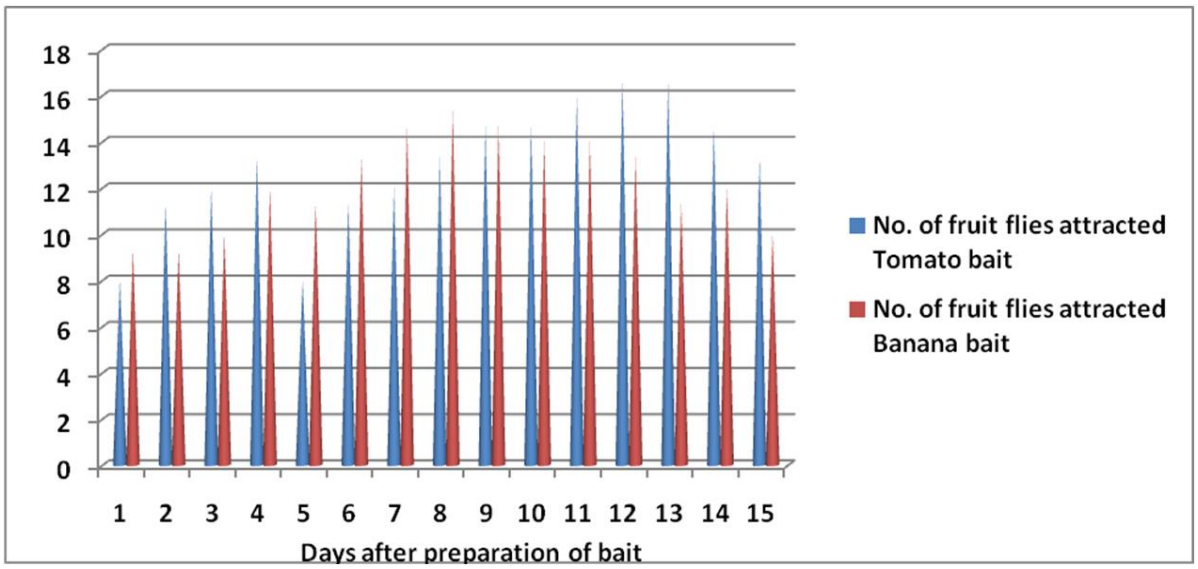

Fig. 2. Assessment of attractiveness of food baits with time

3.5 Correlation of pH and Protein Content of Baits and their Attraction of Fruit Flies

Correlation of pH values of the baits and their attraction to fruit flies revealed that attraction of all the baits showed positive correlation with their pH *i.e.,* when pH of the bait was increased, attraction to fruit flies was also increased. In proteinex bait (+0.692) and tomato bait (+0.763) (Table 5), positive correlation between pH and bait attraction were highly significant while it is significant in soybean bait. This positive correlation was insignificant in banana bait (+0.114). Protein content of the baits and their attraction to fruit flies were negatively correlated however, this correlation was found to be insignificant.

4. DISCUSSION

Maximum attraction of fruit flies to protein baits was observed on IX and X days after preparation of bait. Attraction index was high in protein baits on IX DAP. In tomato and banana baits, maximum attraction to fruit flies was recorded on XIII and VIII DAP respectively. This may be due to the increase in the emission of fruit fly attractant odours from the protein and food source baits with time. Iqbal et al. (2020) also demonstrated that in olfactometer studies, protein hydrolysate, yeast and ammonium

acetate-based lures captured more number of *Bactrocera cucurbitae* adults with some attraction in negative control. In the present study also, in the odour zones of negative controls of protein and food baits, 6.00 to 6.67 fruit flies were observed. This attraction in negative control is due to the presence of base bait materials (jaggery, ammonium acetate & borax in protein baits and jaggery, yeast, citric acid & borax in food baits).

pH of both the protein baits increased from I to XV days after preparation. This is a desirable quality as increase in pH of the bait is directly proportional to the fruit fly trap catches. This finding was also justified by Heath et al. (1994) who claimed increase in attraction of food and protein baits with the increase in pH.

Among the baits, proteinex bait recorded more pH followed by soybean, banana and tomato baits. High attraction capacity of protein baits to food baits is due to their high pH content. This is in agreement with the findings of Bateman and Morton (1981) who reported that increase in pH increased the attractiveness of protein hydrolysate to *B.tryoni*. Mazor et al. (1987) also opined that increase in the pH of protein baits boosted the attractiveness to *Ceratitis capitata*. This was proved in our present studies also in

Table 5. Changes in pH and protein content of protein and food baits

Days after preparation of bait	Soybean bait		Proteinex bait		Tomato bait		Banana bait	
	pH	Protein content (%)	pH	Protein content (%)	pH	Protein content (%)	pH	Protein content (%)
I	6.18 (2.49)^{a}	22.31 (28.18)^{a}	7.03 (2.65)^{a}	26.25 (30.82)^{a}	3.48 (1.87)^{b}	5.38 (13.41)^{a}	3.04 (1.74)^{b}	6.29 (14.51)^{a}
II	6.26 (2.50)^{a}	22.19 (28.10)^{a}	7.18 (2.68)^{a}	24.50 (29.66)^{ab}	3.38 (1.84)^{b}	5.38 (13.41)^{a}	3.22 (1.79)^{ab}	5.91 (14.40)^{ab}
III	6.22 (2.49)^{a}	22.19 (28.10)^{a}	7.13 (2.67)^{a}	23.62 (29.08)^{bc}	3.81 (1.95)^{ab}	5.25 (13.25)^{ab}	3.58 (1.89)^{ab}	5.70 (13.81)^{abc}
IV	6.15 (2.48)^{a}	21.43 (27.57)^{ab}	7.05 (2.66)^{a}	23.62 (29.08)^{bc}	3.95 (1.99)^{ab}	5.07 (13.01)^{abc}	3.65 (1.91)^{ab}	5.68 (13.79)^{abc}
V	6.28 (2.51)^{a}	21.43 (27.58)^{ab}	7.23 (2.69)^{a}	23.18 (28.78)^{bc}	3.71 (1.93)^{ab}	5.07 (13.01)^{abc}	3.25 (1.80)^{ab}	5.56 (13.63)^{abc}
VI	6.36 (2.52)^{a}	21.25 (27.45)^{ab}	7.53 (2.74)^{a}	23.06 (28.70)^{bc}	4.06 (2.01)^{ab}	4.94 (12.84)^{bcd}	3.39 (1.84)^{ab}	5.44 (13.49)^{abc}
VII	6.44 (2.54)^{a}	21.19 (27.41)^{ab}	7.33 (2.71)^{a}	23.18 (28.78)^{bc}	4.02 (2.00)^{ab}	4.94 (12.84)^{bcd}	3.88 (1.97)^{ab}	5.38 (13.41)^{abc}
VIII	6.52 (2.55)^{a}	20.56 (26.96)^{ab}	7.31 (2.70)^{a}	22.75 (28.49)^{bc}	4.08 (2.02)^{ab}	4.81 (12.67)^{cde}	3.64 (1.91)^{ab}	5.36 (13.38)^{abc}
IX	6.59 (2.57)^{a}	21.43 (27.58)^{ab}	7.68 (2.77)^{a}	22.31 (28.18)^{c}	4.22 (2.05)^{a}	4.63 (12.42)^{def}	3.57 (1.89)^{ab}	5.31 (13.32)^{abc}
X	6.45 (2.54)^{a}	21.00 (27.27)^{ab}	7.55 (2.75)^{a}	22.75 (28.49)^{bc}	4.09 (2.02)^{ab}	4.50 (12.24)^{efg}	3.56 (1.88)^{ab}	5.25 (13.25)^{abc}
XI	6.53 (2.56)^{a}	21.00 (27.27)^{ab}	7.28 (2.70)^{a}	21.69 (27.76)^{c}	4.16 (2.04)^{ab}	4.43 (12.15)^{efg}	3.90 (1.97)^{ab}	5.19 (13.17)^{abc}
XII	6.61 (2.57)^{a}	20.56 (26.96)^{ab}	7.58 (2.75)^{a}	22.19 (28.10)^{c}	4.19 (2.05)^{a}	4.31 (11.98)^{fg}	4.09 (2.02)^{ab}	5.19 (13.17)^{abc}
XIII	6.69 (2.59)^{a}	20.31 (26.78)^{bc}	7.63 (2.73)^{a}	22.75 (28.49)^{bc}	4.11 (2.03)^{ab}	4.25 (11.90) ^{g}	4.28 (2.07)^{ab}	5.12 (13.08)^{abc}
XIV	6.77 (2.60)^{a}	20.12 (26.65)^{c}	7.43 (2.73)^{a}	21.81 (27.84)^{c}	4.16 (2.04)^{ab}	4.25 (11.89)^{g}	4.38 (2.09)^{ab}	5.06 (13.00)^{bc}
XV	6.89 (2.62)^{a}	20.10 (26.64)^{c}	7.69 (2.77)^{a}	21.94 (27.93)^{c}	4.21 (2.05)^{a}	4.20 (11.83)^{g}	4.57 (2.14)^{a}	4.69 (12.45)^{c}
CD (0.05)	NS	0.55	NS	1.74	0.23	0.60	3.83	1.55
S.E(d)	NS	0.41	NS	0.36	0.28	0.14	1.62	0.39

**Mean of three replications*

Figures in parentheses are square root transformed values

Means followed by the same letter in a column are not significantly different by Tukey's HSD test. (P=0.05)

Table 6. Correlation of bait attraction to melon fruit flies with their pH and protein content

S. No.	Bait	Particulars	Correlation coefficient values
1.	Protinex bait	pH	+0.692**
		Protein content	-0.395
2.	Soybean bait	pH	+0.575*
		Protein content	-0.467
3.	Tomato bait	pH	+0.763**
		Protein content	-0.497
4.	Banana bait	pH	+0.114
		Protein content	-0.386

***Highly significant, *Significant*

which with the increase in pH of the bait, it's attraction to fruit flies was also increased. This positive correlation was insignificant in food baits (tomato and banana baits), significant in soybean bait and highly significant in proteinex bait.

In protein and food baits, protein content was slightly reduced with time however, it has not influenced the fruit fly catches significantly. Comparatively, protein content was very high in protein baits than the food baits which is the best suitable reason for explaining high fruit fly trap catches in protein baits than the food baits. Fanson et al*.* (2009) proved the importance of protein rich diets to the fruit flies as they observed increase in reproductive success and longevity of male fruit flies after feeding on protein diet. Meats and Kelly (2008) stated that female fruit flies were in need of protein between 5 to 7 days after the emergence.

All the baits showed positive correlation between their pH and attraction to fruit flies. This correlation was highly significant in proteinex and tomato baits, significant in soybean bait and insignificant in banana bait. Protein content of the baits and their attraction to fruit flies were negatively correlated however, this correlation was found to be insignificant.

The results of our study provide insight into the maximization of fruit fly catches through the use of protein and food baits. Replacing the baits is a key component for trapping more number of fruit flies in field conditions. As this study standardized the keeping period of the baits in fields, the results will be practically useful to the farmers in the management of melon fruit flies in an eco-friendly manner.

5. CONCLUSION

The protein baits (proteinex and soybean baits) should be replaced every 10–12 days, tomato baits every 13 days, and banana baits every 8 days. The higher pH and protein content of protein baits contributed to their greater effectiveness, making them a valuable tool in sustainable pest control strategies. Comparatively, protein content was very high in protein baits than the food baits which explains high fruit fly trap catches in protein baits than the food baits. Attraction to fruit flies is positively correlated with the pH of the bait. In proteinex and tomato baits, this correlation was highly significant while it is significant in soybean bait and insignificant in banana bait.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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