The Pharma Innovation Journal 2021; SP-10(12): 1406-1410

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(12): 1406-1410

www.thepharmajournal.com
Received: 18-10-2021
Accepted: 24-11-2021

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Effect of ph, weight and volume of protein and natural food baits in trapping melon fruit flies in bitter gourd

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Abstract
Field experiments were conducted to evaluate the efficiency of aqueous solutions of protein baits including Proteinex, soybean, yeast and casein added with ammonium acetate (5%), jaggery (10%), borax (2%) and malathion (0.001%) and natural food baits including tomato, banana, bitter gourd, pineapple and guava added with jaggery (10%), yeast (0.5%), borax (2%) and malathion (0.001%) in trapping melon fruit flies, *Zeugodcaus cucurbitae*. Among the fruit flies caught in the traps, majority were females proving the fact that females were attracted more towards the protein sources than males because females need comparatively more protein for their development and sexual maturation. The protein baits were effective in attracting fruit flies when compared to natural food baits. This may be due to the consistency in the pH of the protein baits which was around 5-6 throughout the week whereas in natural food bait it raised from 4 – 6 in one week. The response of fruit flies towards the traps increased with increase in pH. The weight and volume reduced gradually in protein and food baits hence, the bait should be added with10-15ml thrice a week to keep up the turgidity and aqueous consistency of the bait.

Keywords: *Zeugodacus cucurbitae*, natural food bait, protein bait, pH, weight, volume

Introduction
India is the world's second largest producer of vegetables. India occupies a significant position in the export and trading of vegetables in the worldwide market owing to a growth in the global demand for vegetables (Mittal, 2007) [10]. Bitter gourd (*Momordica charantia*) is an important cucurbitaceous vegetable crop and is also known as bitter melon, balsam pear, bitter cucumber and is reflected as a prized cucurbit vegetable. This is also considered as a medicinal crop since it is rich in ascorbic acid, iron and dietary fibre. Bitter gourd was cultivated in an area of 1.01 lakh hectares in India with a production of 12.92 lakh metric tonnes during 2019-2020 (Anonymous, 2020-21). Fruit flies (Tephritidae: Diptera) are one of the most destructive pest of not only bitter gourd but all the cucurbits. Kumar *et al.* (2006) [6] reported maximum fruit fly infestation of 77.03% in bitter gourd crop. Several methods have been employed to reduce the infestation of fruit flies. However insecticide control is not effective against these insects because of their hidden nature. The maggots enter into the fruit; remain inside and their feeding makes the fruit inedible and unmarketable. So “attract and kill strategy” has gained importance in the successful management of fruit flies. Tackling the fruit fly population build up in horticultural crops included aerial and ground. Attractiveness of baits to fruit flies depends on their physical and chemical properties like pH, weight, volume etc., which affect the consistency and odour emittence properties of the bait. The studies of Mazor *et al.* (1987) [8] observed that in olfactometer choice experiments, increase in pH of acidic protein baits boosted the attractiveness of laboratory reared female of *C. capitata* and this was attributed to the release of ammonia and other volatiles from the baits. Weight and volume of the bait also play an important role in the attraction of the fruit flies as they affects the thickness of the bait, which in turn affects the fruit fly catches.

Materials and Methods
Baits were prepared using protein powders such as Proteinex, soybean, casein and yeast powder @10% added with jaggery (10%), ammonium acetate (5%), borax (2%) & citric acid (0.5%) and natural food like tomato, banana, pineapple, guava and bitter gourd added with jaggery (10%), borax (2%), yeast (0.5%) and citric acid (0.5%). The traps were installed in fields in 1-1.5 m height hung in pandal. pH, weight and volume of protein and food baits were recorded daily upto 7 days simultaneously trap catches were also noted in these traps for 7

days. Weight of the baits was recorded daily in a weighing balance, pH was noted with the digital portable pH meter and the volume was measured using a measuring cylinder. Effect of changes in pH, weight and volume of the baits on the number of fruit fly catches was investigated to optimize these parameters for maximum attraction of fruit flies.

Result

Effect of pH of the baits on fruit fly trap catches

Protein baits maintained a pH of around 5.0 throughout the week from the day of preparation (5.2 in soybean bait) to the last day (5.9 in proteinex bait). In these traps, number of fruit flies trapped was uniform throughout the week (2 fruit flies/ trap in I and VI day after bait preparation). In food baits, initially the pH was low and is around 3.5 in bitter gourd. However it gradually increased from 4.0 to 6.0 in a period of 7 days. A gradual increase in pH was observed from 3.5 (I day after bitter gourd bait preparation) to 5.7 (VII day after pineapple bait preparation) in a week period. As the pH increased food bait traps, a rise in the number of fruit fly catches was observed. Food baits reached to the pH of 5.0 on 4^{th} to 5^{th} day of the week during which the trap catches were maximum (2 fruit flies/ trap/ day in tomato bait). From the present study, it was clear that the fruit flies were caught mostly in the traps at a pH of 5.4 (± 0.7) (Tables 1 & 2). When comparing the protein and food baits, protein bait traps attracted more melon fruit flies. This trapping efficiency of the protein baits may be attributed to the stability in their pH in the range of 5.0 to 6.0 from the first day of their preparation itself (Fig. 1 & 2). Less number of fruit fly catches in food baits can be understood in terms of low pH levels in food baits during the first three days after preparation.

Table 1: Evaluation of changes in pH, weight and volume of protein baits

Days after preparation	Bait parameters			No. of fruit flies attracted
	pH	Weight (g)	Volume (ml)	
Soybean bait				
I	5.5	200	226	0.0
II	5.4	181	207	0.0
III	5.2	167	184.2	1.0
IV	5.45	147	160	2.0
V	5.35	132	142	2.0
VI	5.35	124	132	2.0
VII	5.25	110	124	0.0
Proteinex bait				
I	5.85	200	221	2.0
II	5.4	184	204	1.0
III	5.8	172	173	0.0
IV	5.6	146	150	1.0
V	5.7	121	137	2.0
VI	5.85	113	128	2.0
VII	5.9	103	110	1.0
Yeast bait				
I	5.6	200	230	0.0
II	5.6	191	217	0.0
III	5.35	182	183	1.0
IV	5.7	166	166	1.0
V	5.4	143	147	1.0
VI	5.55	129	132	0.0
VII	5.7	113	118	1.0
Casein bait				
I	5.5	200	238	0.0
II	5.55	191	215	0.0
III	5.4	187	187	1.0
IV	5.55	171	171	0.0
V	5.65	145	164	1.0
VI	5.5	131	154	1.0
VII	5.55	116	124.2	0.0
Negative control				
I	5.45	200	165	0.0
II	5.6	176	152	0.0
III	5.55	167	146	1.0
IV	5.3	143	121	0.0
V	5.65	132	117	0.0
VI	5.45	121	111	0.0
VII	5.5	112	107	0.0

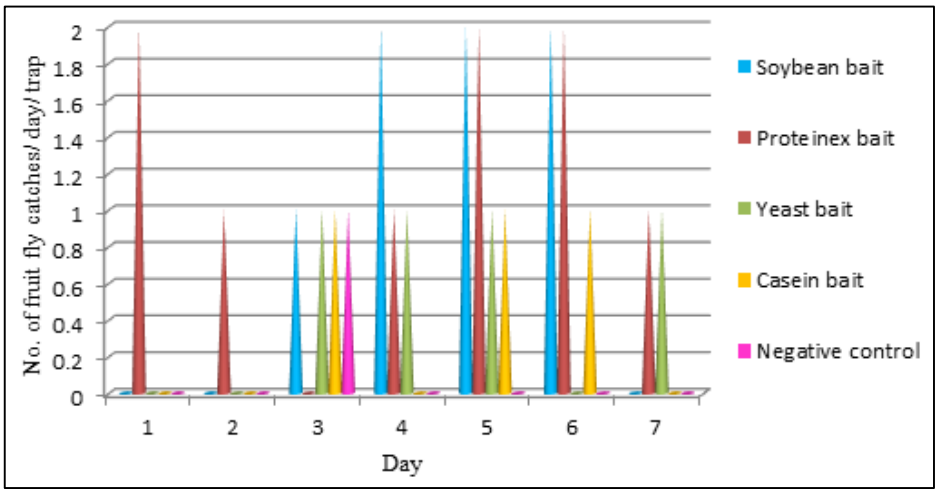

Fig 1: Comparison of fruit fly catches in protein baits/ trap/ day

Table 2: Changes in weight, volume and pH of food baits

Days after preparation	Bait parameters			No. of fruit flies attracted
	pH	Weight	Volume	
Banana bait				
I	3.8	200	179.6	0.0
II	4.2	186	168	0.0
III	4.4	164	159.3	0.0
IV	4.5	142	134.4	1.0
V	4.5	123	125	1.0
VI	4.8	104	102	1.0
VII	5.3	88	95	1.0
Tomato bait				
I	4.5	200	181	0.0
II	4.4	174	168	0.0
III	4.4	147	143.2	0.0
IV	4.6	121	120.6	1.0
V	4.7	105	105	1.0
VI	5.1	85	91	1.0
VII	5.3	75	79	2.0
Guava bait				
I	4.1	200	175	0.0
II	4.3	175	161	0.0
III	4.3	164	147.6	0.0
IV	4.5	143	130.2	0.0
V	4.7	123	111	0.0
VI	5.1	104	96	1.0
VII	5.3	85	82	0.0
Pineapple bait				
I	3.6	200	182	0.0
II	3.7	163	151.4	0.0
III	4.2	145	133.4	0.0
IV	4.5	117	112.4	0.0
V	4.1	106	95.0	0.0
VI	4.7	87	84	0.0
VII	5.7	70	68	1.0
Bittergourd bait				
I	3.5	200	183	0.0
II	3.5	186	182	0.0
III	3.8	165	164.3	0.0
IV	4.7	141	146.2	0.0
V	5.6	132	132	0.0
VI	5.6	100	108	1.0
VII	6.3	88	89	0.0
Negative control				
I	4.7	200	172	0.0
II	4.7	181	152.2	0.0
III	5.3	169	141	0.0
IV	4.6	131	111.3	0.0
V	4.9	112	110	0.0
VI	5.7	98	97.3	0.0
VII	5.2	72	83	0.0

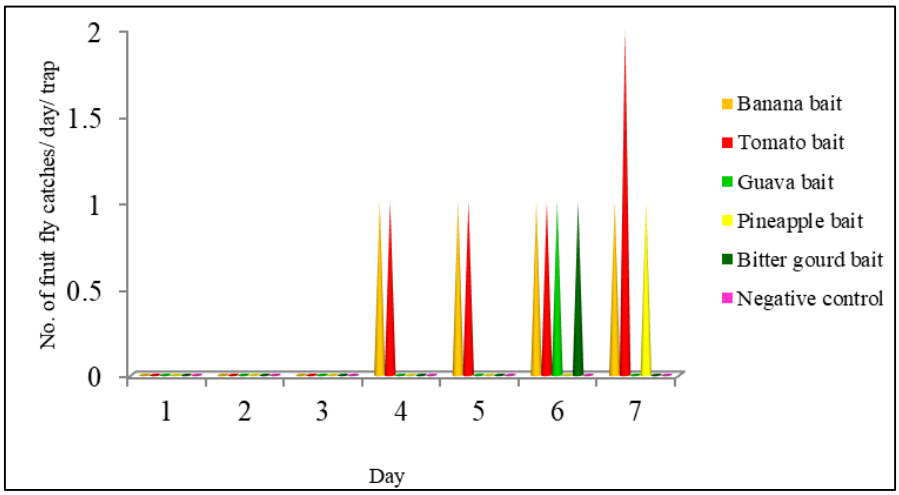

Fig 2: Comparison of Fruit fly catches in natural food baits/ trap/ day

Effect of weight and volume of the baits on trap catches

Weight and volume of protein baits reduced gradually with the time. Weight of protein baits reduced @ range of 8.0g (soybean bait) to 26.0g (proteinex bait) per day. Volume of the protein baits reduced @ of 7.0ml (casein bait) to 34ml (yeast bait) per day. Weight and volume of the food baits also gradually decreased over a week period of time. Food baits lost weight @ 10.0g (banana & tomato baits) to 37.0g (pineapple bait) per day and volume @ 7.0ml (banana bait) to 27.0 (pineapple bait) per day.

Discussion

Our studies showed that the attractiveness of protein and natural food baits to fruit flies increased with increase in pH. Several studies on Guava fruit fly, *Anastrepha striata* (McPhail 1939) [9] and Caribbean fruit fly, *Anastrepha suspensa* (Sharp 1987) [11] has revealed that attractiveness of different enzymatic hydrolysates for these species can be improved by increasing the pH. Bateman and Morton (1981) [2] also reported that raising the pH of yeast protein hydrolysate mixture (NBS) significantly increased its attractiveness for the Queensland fruit fly (*Dacus tyroni*). Mazor *et al.* (1987) [8] observed that increase in the pH of protein baits boosted the attractiveness to Mediterranean fruit fly, *Ceratitis capitata*. Findings of Heath *et al.* (1994) [5] were also in close agreement with our findings that the attraction of food and protein baits increased with the increase in pH. The research work of Duyck *et al*., 2004 [3] figured out the same that the torula yeast with high pH *i,e.,* 10.5 captured more *Z. cucurbitae* than standard torula yeast with 9. Varikou *et al*., 2014 [2] reported that the release of ammonium increased with increase in pH and attracted more *B. Oleae* in protein baits. Our research findings also denoted that maintenance of bait in liquid state is very important to maintain the release of odour from the bait. Lucci Freitas *et al*., 2014 [7] reported that exposure of bait in field conditions made the baits dry and decreases its attractiveness. Studies of Epsky *et al.,* 1993 [4] also stay close to the point that under warm environmental conditions, liquid protein baits frequently dry up quickly and therefore must be replaced every few days to maintain the attractiveness of the bait.

Conclusion

The study concluded that the attractiveness of food and protein baits increased with increase in pH and reduced with decrease in weight and volume. Eventhough, the baits prepared were in liquid state and kept under shade in pandal, protein baits were consistency effective in trapping fruit flies due to their stability in pH around 5. On food baits, trap catches increased with pH. Evaporation reduced the water content of the bait and made it thick. This reduced the liquid consistency of the bait and resulted in thickening of bait and in turn gradual reduction of weight and volume of both protein and food baits with the time. So adding of 20 to 50ml of water based on the consistency of bait in alternate days is crucial in maintaining the trapping efficiency of baits.

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