Proceedings of 6th International Fruit Fly Symposium
6–10 May 2002, Stellenbosch, South Africa
pp. 405–407

Composition and efficiency of a larval diet containing alfalfa instead of yeast for rearing the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae)

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The essential dietary requirements and nutrient utilization for larvae of the Mediterranean fruit fly, *Ceratitis capitata,* are largely unknown. It seems that nutrient utilization of artificial diets is not very high, based on nutritional analyses of certain fruits and of artificial diets. Larval diets used today contain yeast, which is expensive and not widely available. In this study, a diet containing alfalfa was compared for composition and efficiency with a widely-used standard diet containing brewer's yeast. The parameters measured included egg hatch, pupae/g diet, pupal weight, pupal composition and adult emergence. The performance of the alfalfa diet was comparable with, or exceeded that of the yeast diet. The alfalfa diet yielded significantly more pupae/g diet than the yeast diet, although the nutrients of both diets were poorly utilized by the larvae. Alfalfa is considered a good alternative to brewer's yeast. More work is needed to determine the dietary properties, the nutrient utilization and the nutritional requirements of *C. capitata* larvae.

INTRODUCTION

The Mediterranean fruit fly, *Ceratitis capitata* (Wied.) (Diptera: Tephritidae), has been artificially reared and used for mass-production, research and other purposes, throughout the world. Its larvae develop in a wide variety of fruits and artificial diets. These fruits and artificial diets, although very different in chemical/nutritional as well physical/ecological parameters, are successfully tolerated and utilized by these larvae. The essential dietary requirements of the Mediterranean fruit fly (Medfly) are unknown, but gross calculations show that artificial diet utilization is very low. Chemical analyses of fruits in which larvae develop showed that most fruits are poor in most nutrients and low in energy, compared to the yeast-containing larval diets used today for rearing this insect. Yeast is expensive, however, and it is not widely available. These observations prompted research into diets containing a variety of low-cost and widely-available ingredients. This work reports on the composition and efficiency of a larval diet containing alfalfa instead of brewer's yeast.

MATERIALS AND METHODS

Alfalfa, in pellet form, was soaked in a portion of water containing sugar, sodium benzoate and citric acid for 10 minutes prior to adding in the mixer (Braun AG, Germany, Model KM-32) with the remaining amount of water. These ingredients were mixed well. Finally, wheat bran was added and mixed well to give a texture that was considered best for the larvae. Approximately 50 g of each test diet was placed in a plastic container (= replicate) of 9 cm diameter and 3 cm high with covers (KRIS-PAN Co, Greece), and three replicates per treatment were used. A control diet (Nadel 1970) was used in all experiments. The pH of both diets was approximately 5.

Eggs were obtained from Medflies of a local wild population maintained under standard conditions for over 60 generations. Twenty Medfly eggs per gram of diet were used for all experiments. Eggs were placed on the surface of the diet. To calculate the hatchability of eggs, 100 eggs per replicate were placed on a filter paper on the diet.

The proximate analyses of diets and pupae were done according to procedures described by AOAC (1980) and gross energy was calculated by an adiabatic bomb calorimeter. Statistical procedures were those of Steele & Torrie (1960) and Duncan's new multiple-range test was used to compare differences.

Table 1 shows the ingredient composition of the

Table 1. Composition of Mediterranean fruit fly larval diets.

Component	Control diet (%)	AA diet (%)
Water	54.5	50
Sugar*	17.5	15
Sodium benzoate	0.5	0.5
Citric acid	0.6	0.6
Brewer's yeast**	9	–
Wheat bran***	18	24
Alfalfa****	–	10

*Hellenic Sugar Industry, Greece; **Schwechat Brewery, Austria; ***ELVIZ Co., Greece; ****Viozokat Co., Greece.

Table 2. Analysis and energy content of control diet, AA diet, and pupae from these diets.

Component	Control diet (%)		AA diet (%)	
	Diet	Pupae	Diet	Pupae
Moisture	57.4	68.6	53.9	68.9
Protein	7.0	14.8	5.6	14.5
Lipids	1.1	7.5	1.3	7.2
Ash	1.7	2.9	2.3	3.0
NFE* (from 100)	32.8	6.2	36.9	6.4
Energy (Kcal/g)	1.31	1.57	1.31	1.57

*Nitrogen-free extract.

control and the experimental alfalfa diet (AA), and Table 2 the analysis and the gross energy content of the control diet, AA diet and pupae from these diets.

RESULTS AND DISCUSSION

Table 3 presents the results of Medfly growth on the alfalfa (AA) diet compared to the control.

The AA diet gave results equivalent to the control for egg hatchability, pupal weight and adult emergence. Pupal yield of the AA diet was significantly higher (38%) than that of the control. The higher number of pupae/g diet of the AA diet may be due to the better texture and/or nutrient utilization by the larvae than in the control.

The efficiency of conversion by the Medfly larvae for both diets is presented in Table 4.

The data show that Medfly larvae utilized the AA diet more efficiently than the control diet. The efficiency of conversion for the AA diet was about 32%, 30%, 51%, and 61% higher than for the control with respect to total diet, gross energy, sugar energy (if all energy came from sugar only) and protein, respectively. The data of this and of previous work (Manoukas & Zografou 1997; Chan *et al.* 2000; Manoukas & Zografou 2000) indicated that ingredient composition could improve efficiency of a diet and reduce cost, provided that standard dietary quality control procedures are followed (Manoukas 1991). The efficiency of con-

Table 3. Developmental parameters of Medfly reared on the control and AA diets.

Experiment/diet	Egg hatch (%)	No. pupae/g diet	Pupal weight (mg)	Pupal yield (mg/g diet)	Adult emergence (%)
Exp. 1/ Control	89 a	8.6 a	7.9 a	67.9 a	87 a
AA	97 a	13.9 b	7.8 a	108.4 b	90 a
Exp. 2/ Control	80 a	9.8 a	8.8 a	86.2 a	80 a
AA	78 a	11.8 b	8.3 a	97.9 b	78 a
Exp. 3/ Control	85 a	8.9 a	9.1 a	81.0 a	84 a
AA	90 a	12.1 b	8.5 a	102.9 b	87 a
Means of experiments					
Control	84.7 a	9.1 a	8.6 a	78.4 a	83.7 a
AA	88.3 a	12.6 b	8.2 a	103.1 b	85.0 a

Values in the same column followed by the same letter do not differ significantly at $P = 0.05$.

Table 4. Efficiency of conversion of larval diets by Medfly life stages (based on data in Tables 2 and 3).

Diet	Efficiency (%)				
	Total diet	Gross energy	Sugar energy	Protein	Ash
Control diet	7.8	9.3	18.1	16.6	13.5
AA diet	10.3	12.1	27.3	26.7	13.5

version shown in Table 4 was low for both diets compared to diets of other animals (e.g. rats, mice and chicks).

The quality of fruit flies produced by such practical diets should be determined in connection with their use and according to the procedures established by various organizations (e.g. FAO/IAEA, IOBC), institutes, industries and other related organizations. Further work is suggested in order to calculate the efficiency of conversion by Medfly larvae for the individual nutrients in practical diets. In addition, research is needed to determine the essential dietetic (nutritional and physico-chemical) requirements of Medfly for efficient rearing of standard-quality insects.

CONCLUSION

The alfalfa diet could be an efficient low-cost alternative for rearing Mediterranean fruit fly larvae for sterile release programmes, or for other purposes, provided that insect quality is monitored for such purposes.

ACKNOWLEDGEMENTS

I would like to acknowledge the European Union and the Greek Secretariat for Research and Development, for financing this work; ELVIZ, GR. and Viozokat S.A. GR. for the supplying ingredients.

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