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The use of fruit fly infested mamey fruit as human food

V. Melo-Ruíz*, N. Vargas-Martínez, K. Sánchez-Herrera, J. Rodríguez-Diego and R. Díaz-García

Universidad Autónoma Metropolitana Unidad, Xochimilco, División Ciencias Biológicas y de la Salud, Calzada del Hueso 1100, CP 04960 Mexico, Mexico; vmelo@correo.xoc.uam.mx

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SHORT COMMUNICATION

Abstract

The fruits of mamey, *Calocarpum mammosum* L., are often infested by the *Anastrepha ludens* L. fruit fly. The wasted fruits cause huge economic losses. The aim of this study was to investigate the nutritional value of mamey fruits when infested with larvae, and to propose their consumption. Mamey fruits were collected with and without the larvae in the city of Coatlán del Río, in Morelos, Mexico. A proximal nutrient analysis of the mamey pulp and *A. ludens* larvae were conducted. The organoleptic properties of ice cream from the mamey fruits with and without the larvae were tasted by a panel. The results obtained showed that the presence of larvae in the mamey fruits increases their nutritional value and the organoleptic study showed no difference between the clean and the infested products.

Keywords: larvae, mamey, nutrition, pest

1. Introduction

In Mexico, and worldwide, one of the pests that afflicts fruit crops and causes the highest economic losses is the fruit fly *Anastrepha ludens* L. (Sánchez, 2004) (Diptera: Tephritide). It develops in several fruit species in Mexico. Flies from the *Anastrepha* genus are endemic to the American continent and exclusive to tropical and subtropical environments. The genus is distributed from the south of the USA to the north of Argentina, including the Caribbean Islands. A total of 195 species have been described to date, and those with the highest economic importance are: *A. ludens* (Loew), *Anastrepha obliqua* (Macquart), *Anastrepha striata* (Schiner), and *Anastrepha serpentina* (Wiedemann). In Mexico, 32 species have been reported. These insect pests affect more than 30 fruit species with commercial value and 60 less important ones.

The diverse habits of the fruit fly allow it to breed and establish in different environments (Munro, 2005). The reproduction success of this species is based on the fact that a pregnant female can lay between 45 and 50 eggs (Soto-Manitiu, 1997) and as an adult it can live for up to 11 months (Weems *et al.*, 2008). This makes it easy for the organism to infest the fruits. The importance of this pest is highly relevant in areas in Mexico where mameys are grown, especially in the municipality of Coatlán del Río, in the state of Morelos. The presence of this insect was already described back in 1944 (Baker *et al.*, 1944).

The mamey fruit (order Ebenales, family Sapotaceae) is a berry, ovoid to ellipsoid, with a persistent calyx at the base. The fruits of most varieties range in length from 7.6 to 20.3 cm. The shell is thick and woody and reddish caramel. The pulp of the ripe fruits may be salmon, orange, red or red-caramel and has a smooth texture, ranging from fine-grained and uniform to finely granulate. Usually, the pulp contains very small amounts of fibres. It has a unique sweet taste, similar to almonds. Normally, the fruit contains one long elliptical seed but can have up to four seeds. The seed has a hard and shiny dark brown surface, and on the ventral side it has a narrow, light brown area. The seeds can be cut, and they may germinate inside very mature fruits.

The weight per fruit is between 300 to 500 g (Crane and Balerdi, 2005). The *A. ludens* female fly lays eggs on the fruit shell. The larvae, only 3 to 6, pass into the fruit and feed on the pulp (Figure 1). Although *A. ludens* is considered a pest, the larvae will actually increase the nutritional value of the pulp, mainly in the form of proteins and fatty acids. There are no techniques for eliminating this pest, although

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Early Proof

pesticides are used. This means that the crop is lost, as the caterpillar is not considered edible.

On the other hand the Food and Drug Administration (FDA, 1995) mentions levels of natural unavoidable defects in foods that present no health hazards for humans, e.g. the defect action levels for apple butter is 5 or more whole insects or equivalent per 100 g (AOAC 945.76) and in date material 5 or more insects per 100 g (MPM-V53). These 'food defect action levels' established maximum levels of natural or unavoidable defects in foods for human use that present no health risk. There are 3 to 6 *A. ludens* larvae in each mamey fruit of 300 to 500 g (Figure 1); therefore it is safe to consume mamey pulp that contains insect products, since those products present no health hazards for humans.

Certain foods have been prepared artisanally, such as popsicles, ice cream and jam, with fruit containing these larvae, but these are consumed locally (Figure 2). In addition, the intake of mango plagued with *A. serpentine* has been reported in a study, in which it is recommended as safe for consumption (Blanco and Melo, 2002; Melo and Alpizar, 2011).

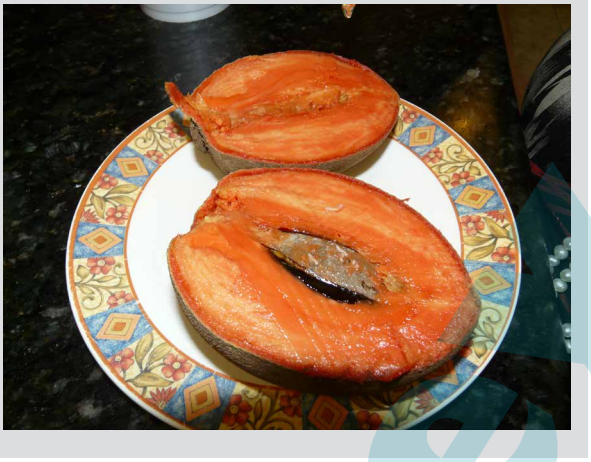

Figure 1. Mamey infested with the caterpillar *Anastrepha ludens* L.

Figure 2. Mamey popsicles containing the caterpillar *Anastrepha ludens* L., artisanally produced.

The objective of this research was to propose the consumption of mamey fruit infested with *A. ludens* in different preparations such as refreshing water or mamey ice cream, to avoid the high economic losses this pest causes, and to take advantage of the increase in nutritional value of the infested pulp.

2. Materials and methods

Sampling

A conventional sampling was conducted in late February 2016, in the municipality of Coatlán del Río, in the state of Morelos in Mexico, where mamey plantations are located. The collection was made directly from eight trees randomly selected, obtaining 10 kg of mature fruit, 6.8 kg with caterpillars, and 3.2 kg without the pest. In addition, 20 samples of the adult fruit fly were captured using traps. The samples were taken to the Food Science Laboratory at the Universidad Metropolitana, Xochimilco Campus, Mexico, Mexico. The taxonomic determination of the species was performed using samples of the adult fly (Morón and Terrón, 1998). From the mamey fruits with the pest, 350 g of caterpillars and 650 g of pulp were used for analysis; the rest was used to prepare artisanal ice cream.

Not all the mamey fruits from one tree were infested. The fruit weighed on average 500 g, of which the edible portion was 375 g, and the skin and seed 125 g. The larvae were on average 2 cm long. From the infested mamey fruits, 350 g of caterpillars and 650 g of pulp were used for analysis.

Moisture content was determined using the direct drying method. Homogenised samples were dried in an oven at 60 °C for 24 h to eliminate moisture. Dry samples were powdered in a mortar and passed through a 30 mesh size to obtain fine powder. The powdered samples were stored in plastic bags in a refrigerator until the protein, total minerals, lipids, and fibre analyses were performed.

Chemical analysis

With these samples, the proximal analyses of macronutrients were performed, separately, using AOAC techniques (1995). Ash was obtained by incinerating the dry samples at 650 °C in a muffle furnace for 6 h to a constant weight, to eliminate the organic matter.

Protein content was determined using the Kjeldahl method (AOAC method 945.01; AOAC International, 1995). One gram of sample was digested with 15 ml concentrated sulphuric acid, using an electrically heated aluminium

block digester. The resulting digest was diluted and then made alkaline with 50 ml, 40% sodium hydroxide. This was followed by rapid steam distillation of ammonia from the diluted digest into 25 ml 4% boric acid for manual titration with 0.2 N hydrochloric acid. A convention factor of 6.25 was used to convert the measured total nitrogen to protein content. All samples were analysed in triplicate and the results were expressed as g/100 g dry basis of sample (Osborne, 1985; Pearson, 1989).

Lipid content was determined by the semi-continuous solvent extraction method (AOAC method 934.01; AOAC International, 1995) as follows: sample (10 g) was extracted with 180 ml petroleum ether on a Soxhlet apparatus (Sigma-Aldrich, Mexico, Mexico) for 10 h. Petroleum ether was removed by evaporation and the lipid residue was weighed. All samples were analysed in triplicate and the results are expressed as g/100 g dry basis of sample.

Minerals were obtained by eliminating organic matter in a muffle at 650 °C for 3 h. Phosphorus was determined by triple acid digested extraction and colorimetrically determined AOAC (1995) methods, and calcium by titration with EDTA. Raw fibre (10 g) was determined by acid hydrolysis with sulphuric acid 0.255 N followed by alkaline hydrolysis with 0.313 N NaOH in a Labconco apparatus (Labconco Corporation, Kansas City, MO, USA). Sample was analysed in triplicate and results are expressed as g/100 g dry basis. Carbohydrate content on dry weight basis was calculated by difference (100 – (protein + lipids + ash + raw fibre)).

Ice cream preparation and organoleptic testing

Ice cream was prepared using infested fruits, in mass pulp/mass insects, relation (m/m) to 9:1 m/m, 8.5:1.5 m/m, 8:2 m/m, proportions, using 10 mamey fruits, 300 to 500 g each. The skin was discarded as well as the seed, and only the pulp or pulp with the pest was used to make the product.

An acceptance study using 7 levels from excellent to awful was performed. The ice cream was tasted by 25 untrained panellists. They were informed that ice cream was prepared with the pulp of the mamey fruit infested with caterpillars; the ratio used for the preparation was the 8:2 m/m. The product was presented for testing and the panellists were asked for their rating in terms of smell, taste, colour, and texture.

3. Results and discussion

About two thirds of the fruit and caterpillars is water (Table 1).When comparing the results of the macronutrient proximal analyses from the non-infested pulp with the *A. ludens* infested pulp, it was observed that the latter contains higher levels of proteins, lipids, and minerals, but lower levels of fibres and carbohydrates than the non-infested mamey (Table 2). This indicates that the consumption of larvae provides almost the same amount of proteins as powdered milk (34% m/m) (CODEX STAN 207-1999; CODEX Alimentarius, 1999). Although the mamey fruit has no significant levels of proteins, the high carbohydrate content makes this fruit an important source of energy for human beings (Stick and Williams, 2009). In terms of minerals, the samples of mamey fruits have higher concentrations of phosphorus and calcium compared to *A. ludens* larvae (Table 3).

The results of the organoleptic studies show that the properties of the ice cream are not modified when using infested mamey fruits instead of non-infested fruits, even when the panellists were informed that the ice cream was developed with caterpillar larvae (Table 4). In terms of the smell, taste, colour and texture, the panellists did not notice

Table 1. Humidity content of the mamey (*Calocarpum mammosum* L.) pulp and larvae (*Anastrepha ludens* L.) in the fruit.

	Mamey pulp (%)	Fruit fly (%)
Humidity	62.80	66.10
Dry sample	37.20	33.90

Table 2. Nutritional composition of the mamey (*Calocarpum mammosum* L.) fruit and the larvae (*Anastrepha ludens* L.) (g/100 g, dry base).[1,2]

Food	Non-infested mamey pulp	Larvae
Protein[3]	5.1	31.28
Minerals	3.6	4.12
Lipids	1.5	35.15
Fibre	5.4	0.15
N.F.E.	84.4	29.30

[1] Humidity of the samples: *C. mammosum* pulp: 62.80%; *A. ludens* larvae: 66.10%.
[2] N.F.E. = nitrogen-free extract = soluble carbohydrates.
[3] N: Kjeldahl × 6.25 = proteic nitrogen.

Table 3. Mineral content of the pulp of mamey (*Calocarpum mammosum* L.) and caterpillar larvae (*Anastrepha ludens* L.) (mg/100 g, dry base).

Determination	Mamey pulp	Larvae
Phosphorus	28	1.65
Calcium	45	1.94

Galley Proof

Table 4. Acceptance of ice-cream with mamey fruit infested with larvae.[1]

Classification hedonic scale	Panellists (%)
Excellent	15
Very good	78
Good	7
Not good nor bad	0
Bad	0
Very bad	0
Awful	0

[1] The taste trail of the 25 panellists agreed that there were no organoleptic differences between the ice creams with and without larvae in the mamey fruits.

Table 5. Ratio mass/mass (m/m) of nutritional composition of mamey pulp with insect larvae.

Macronutrients	Pulp	Pulp/ larvae 9:1 m/m	Pulp/larvae 8.5:1.5 m/m	Pulp/ larvae 8:2 m/m
Proteins	5.1	6.9	7.7	8.5
Lipids	1.5	4.1	5.2	6.9
Minerals	3.6	3.7	3.7	3.9
Fibre	5.4	5.4	5.4	5.4
Soluble carbohydrates	84.4	79.9	78.0	67.10

any difference. Therefore, infested mamey fruits can be used in the production of these products, thus preventing waste. It is important to mention that the nutritional properties of the mamey fruit increases when infested with *A. ludens*, which should be considered as an advantage when promoting its consumption (Table 5). In the production of products it has been demonstrated that the enrichment with mainly animal proteins gives it a better quality.

4. Conclusions

The *A. ludens* fruit fly, rather than being regarded as a pest in mamey fruits, can also be considered an organism whose presence enhances the nutritional properties of the fruit, as mentioned for *A. serpentina W (*Melo and Alpizar, 2005, 2011). Mamey fruits are in great demand, not only for consumption in its natural form, but also in preparations such as ice cream or popsicles, and as candied products. All these may be prepared with fruit fly larvae infested mamey fruits without diminishing their sensorial properties and while increasing their nutritional value. Marketing the fruit, in ice cream and other products, could decrease the economic losses caused by considering the infested fruits as waste.

References

AOAC International, 1995. Official methods of analysis. AOAC International, Washington, DC, USA.

Baker, A.C., 1944. A review of studies of the Mexican fruitfly and related Mexican species. USDA, Washington, DC, USA, 176 pp.

Blanco, Y. and Melo, V., 2002. Aprovechamiento de la pulpa de mango con gusano *Anastrepha serpentina* W. In: Proceedings of the 17th Congreso Nacional de ANMFEN, Mérida, Yucatán, Mexico.

CODEX Alimentarius, 1999. CODEX STAN 207-1999. Norma del CODEX para las leches en polvo y la nata (crema) en polvo. adaptada. Enmendada, 2010. Food and Agriculture Organization of the United Nations, Rome, Italy.

Crane, J.H. and Balerdi, C.F., 2005. El chicosapote o nispero en Florida. University of Florida, Gainesville, FL, USA.

Food and Drug Administration (FDA), 1995. The food defect action levels: levels of natural or unavoidable defects in foods that present no health hazards for humans. FDA, Silver Spring, MD, USA. Available at: http://tinyurl.com/jqktkhw.

Melo, V. and Alpizar, A., 2005. Uses of mango fruit with grubs, larvae of *Anastrepha serpentina* W. insect. In: Proceedings of the 18th International Congress on Nutrition, 20-23 September 2005, Durban, South Africa and of the 6th International Food Data Conference, 14-16 September 2005, Pretoria, South Africa.

Melo, V. and Alpizar, A., 2011. Beneficios del Mango Ataulfo *Manguifera indica* L. plagado con larva de *Anastrepha ludens* L. Entomología Mexicana, Vol. 10. Sociedad Mexicana de Entomología, Mexico, Mexico.

Morón, M.A. and Terrón, R.A., 1998. Entomología práctica. Instituto de Ecología, Mexico, Mexico.

Munro, D., Prieto, J., Covarrubias, J., Romero, A. and Figueroa, J., 2005. Paquete tecnológico para el cultivo de Mango en el estado de Colima. Paquetes tecnológicos para cultivos agrícolas, en el estado de Colima no. 003, Colima, Mexico.

Osborne, D.R., 1985. Análisis de nutrientes de los alimentos. Acribia, Zaragoza, Spain.

Pearson, D., 1989. Técnicas de laboratorio para el análisis de alimentos. Acribia, Zaragoza, Spain.

Sánchez, M., 2004. Mosca Mexicana de la fruta (*Anastrepha ludens* (Loew). Plagas Agrícolas, Chapingo, Mexico.

Soto-Manitiu, J., Chaverri, L. and Jirón, L., 1997. Notas sobre la biología y ecología de *Anastrepha obliqua* (Diptera: Tephritidae), plaga de plantas anarcardiaceas en américa tropical. I. formas inmaduras. Agronomía Mesoamericana 8: 116-120.

Stick, R.V. and Williams S.J., 2009. Carbohydrates the essential molecules of life. Elsevier, London, UK.

Weems Jr., H.V., Heppner, J.B., Steck, G.J., Fasulo, T.R. and Nation, J.L., 2008. Mexican fruit fly, *Anastrepha ludens* (Loew) (Insecta: Diptera: Tephritidae). University of Florida, Gainesville, FL, USA.