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Original

Proximal composition and fatty acid profile in *Cotinis columbica* Burmeister larvae

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ABSTRACT

Objetive. To determine the proximal composition and profile of fatty acids (FA) in *Cotinis columbica* Burmeister larva collected in the municipalities of Mogotes and Garzón, Bogotá, Colombia. **Materials and methods.** Six samples of *C. columbica* Burmeister larvae were collected during three months, from the municipalities of Mogotes and Garzón, Bogotá, Colombia (3 months x 2 = 6). The samples were subjected to proximal chemical analysis and AG analysis by gas chromatography with a flame ionization detector and capillary column. **Results.** In mogotes, 21.2 and 23.3% of fat and protein were found, respectively, while in Garzón values of 31.1 and 25.9% were found, there was no statistical difference (p≥0.05). Chromatographic analyzes determined 18 AG, from C4:0 to C22:2, c13.16. The t-student test showed significance (p<0.05) only in C10:0; through time (May, June and July) the values were higher in Garzón larvae. The contents of saturated, monounsaturated and polyunsaturated AG groups were between 30.20 and 36.92 (% w/w). **Conclusions.** The proximal composition and fatty acid profile were similar, except for C10:0, in the fat of *Cotinis columbica* Burmeister larvae from Mogotes and Garzón, Colombia.

Keywords: Gas chromatography; insects; lipids; Colombia (*Source: CAB Thesaurus*).

RESUMEN

Objetivo. Determinar la composición proximal y perfil de ácidos grasos (AG) en larva de *Cotinis columbica* Burmeister colectada en los municipios de Mogotes y Garzón, Bogotá, Colombia. **Materiales y métodos.** Se colectaron seis muestras de larva *C. columbica* Burmeister durante tres meses, proveniente de los municipios de Mogotes y Garzón, Bogotá, Colombia (3 meses x 2=6). Las muestras fueron sometidas a análisis químico proximal y análisis de AG por cromatografía de gases con detector de ionización de flama y columna capilar. **Resultados.** En mogotes se encontraron 21.2 y 23.3% de grasa y proteína respectivamente, mientras que en Garzón se tuvieron valores de 31.1 y 25.9%, no hubo diferencia estadística (p≥0.05). Los análisis cromatográficos determinaron 18 AG, desde el C4:0 hasta el C22:2, c13,16. La prueba t de Student arrojó significancia (p<0.05) sólo en

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C10:0; a través del tiempo (mayo, junio y julio) los valores fueron más altos en larvas de Garzón. Los contenidos de grupos de ÁG saturados, monoinsaturados y poliinsaturados estuvieron entre 30.20 y 36.92 (% p/p). **Conclusiones.** La composición proximal y el perfil de ácidos grasos fueron similares, excepto para C10:0, en la grasa de larvas *Cotinis columbica* Burmeister provenientes de Mogotes y Garzón, Colombia.

Palabras clave: Cromatografía de gases; insectos; lípidos; Colombia (*Fuente: CAB Thesaurus*).

INTRODUCTION

Insects are considered pests in modern agriculture; however, for centuries they have been part of human cuisine (1). Several studies report their nutritional composition and nowadays the presence of functional substances such as some bioactive lipids is of great interest (2). Independently of the recognition that insects have in environmental and sanitary aspects, the nutrition role in animals and humans is also considered (3), without this meaning that it is generalized and accepted throughout the world, especially in European countries and North America (1,3). The incorporation of insect meal in feed concentrates for animals does not alter the feed conversion rate, even in some studies it increases, this is due to the content of indispensable amino acids such as lysine, methionine and leucine (3,4).

There are more than 1600 species of insects used in human food; they are appreciated for their nutritional value as a source of vitamins, minerals and protein; however, their cultivation is still scarcely promoted (5).

The nutritional study of insects is of interest in countries of the American, African and European continents, including Brazil, Colombia, Ecuador, Mexico, Angola, Spain and Portugal (3,5,6,7,8,9,10).

In recent research, a priority aspect is to know the content of fatty acids (FA), particularly those with functional properties. For example, oleic acid (C18:1, c9), the main monounsaturated fatty acid, which is linked to anticancer activity, reduction of plasma cholesterol, improvement of the immune system and reduction of the risk of cardiovascular and inflammatory diseases (5).

In Colombia, there are several edible insects, one of which belongs to the genus *Cotinis* Burmeister (1842) with 28 species, whose distribution goes from the north of South America to the central part of the United States (11). Mexico has 18 species, of which 14 are endemic in diverse habitats, the United States has five species and Colombia registers three, one of them is the beetle *C. columbica* Burmeister, which belongs to the subfamily cetoniinae; however, there is little research on this species (11). The beetle *C. columbica* Burmeister is distributed throughout the Colombian mountain range (eastern, central and western) in dry and humid forest ecosystems. The larvae are found in rotting trunks, among the roots of epiphytes, tree holes, dung, detritus, anthills or decaying matter from abandoned rodent burrows (9). The indigenous inhabitants of the municipalities of the mountain range collect the larvae to consume as part of their diet (12).

Given the importance of the subject, the scarcity of information on nutritional composition and, in particular, on the fatty acid content of *C. columbica* Burmeister beetle larvae, the objective of this hereby study was to determine the proximal chemical composition and fatty acid profile of *C. columbica* Burmeister larvae from the municipalities of Mogotes (Santander) and Garzón (Huila), Colombia.

MATERIALS AND METHODS

Origin of samples. Samples of *C. columbica* Burmeister larvae were obtained from the municipalities of Mogotes (Santander) and Garzón (Huila), Colombia.

Mogotes is located in the Department of Santander, it has an area of 484 km^2, altitude 1700 meters above sea level, latitude 6°28’59’’ north, longitude 72°58’1” west. It borders to the northwest with the municipality of Curití, to the east and south with San Joaquín. Humid and rainy throughout the year with temperatures ranging from 15 to 22°C. October and November are the wettest months of the year. The distance from Mogotes to Bogotá is 242 km (13).

Garzón is located in the Department of Huila, between the Central and Eastern mountain ranges, it is bordered to the north by the municipality of Gigante, to the south by the municipality of Guadalupe, to the southwest by Altamira, to the east by the Department of Caquetá and to the west by the municipality of Agrado. It has an area of 580 km^2 which is equivalent to 29% of the total area of the Department of Huila. The altitude of the municipal seat is 828 meters above sea level and it is located at 2°11′57″ north latitude and 75°38′59″ west longitude. The average temperature is 24°C with 57% humidity. Distance from Garzón to Bogotá 424 km (14).

Sample collection. Larval samples were obtained during May, June and July 2021, at 30-day intervals. A total of 500 g of *C. columbica* Burmeister larvae cultured in Mogotes and Garzón were collected, making a total of 2 samples per month for three months (6 samples totaling 500 g each). The samples were weighed on a digital balance (Pocket Scale, China).

Larvae from Mogotes and Garzón were collected manually, one by one from the morete (*Mauritia flexuosa* L.) and chonta (*Acrocomia aculeata*) palms. The larvae from the municipality of Garzón were deposited in terrariums (cultivation site), according to technical information for larval breeding and methods used by farmers in the municipality (15), kept in wheat flour and fed with organic humus (banana peels, coffee and fruit) for 72 hours, due to the distance (430 km) that had to be traveled for their collection. The larvae collected were in their third stage before becoming pupae. They were washed with potable water and bleached in water at 85°C for 3 minutes, and then dried at room temperature in the sun (25°C). All samples were ground (Universal Landers mill, L14200, Colombia) and the resulting flour was packed in plastic bags, duly labeled, and then transferred in a cooler (~4°C) to the analysis laboratory.

Proximal chemical analysis (PCA) and fatty acid profile. A total of 150 g of ground larval samples were taken for PCA and fatty acid profile. Table 1 shows the analytical methods used in the determination of each compositional variable and fatty acid profile. In all cases, three repetitions were carried out, and the protocols of the reference methods of the Association of Official Analytical Chemists, used in different investigations, were followed (16,17,18,19,20,21).

Table 1. Methods employed in the proximal chemical analysis and fatty acid profile of *C. columbica* Burmeister larvae.

Variable	Method (Reference)
Carbohydrates	Mathematical by difference
Ashes	Calcination
Raw fiber	Acid/alkali digestion and calcination
Fat	Acid hydrolysis
Humidity	Oven drying
Protein	Kjeldahl
Total solids	Mathematical by difference
Fatty acid profile	Determination of fatty acid methyl esters by gas chromatography with flame ionization detector and capillary column

Analysis of fatty acids by gas chromatography with flame ionization detector. The determination of FA was carried out by means of their methyl esters, previously methylated with potassium hydroxide in methanol 2N and injected, in duplicate, to the gas chromatograph with flame ionization detector (21).

Chromatographic conditions. A Thermo Scientific TRACE 1300 Series gas chromatograph (Italy) with 105 m long fused silica capillary column, 0.25mm inner diameter and 0.2 µm film thickness (RTX-2330, Cat. No. 10729, USA) was used. Temperatures: 95 at 240, 245 and 230°C of the furnace, detector and injector, respectively. Temperature ramp: T1 = 95°C for 5 min, with 2.65°C x min increase until reaching T2 = 240°C and held for 30 min. The total run time was 81.17 min. Nitrogen was used as carrier gas at a flow rate of 2 mL/min; the injection was split type. The identification and quantification of the chromatographic signals (peaks) was carried out by the external standard method and using the Chromeleon™ Chromatography Data System (CDS) Software Thermo Scientific Version 7.2 (Italy). The standard used was a mixture of 37 fatty acids (Food Industry FAME Mix, 37 components, RESTEK No. Cat 35108 USA). The injection volume of the sample and standard was 2 µL.

Statistical analysis. The statistical program IBM® SPSS® version 24.0 for Windows (Armonk NY, USA) was used. The variables measured were those obtained from the proximal chemical analysis and fatty acid profile.

The study was descriptive for three months, with monthly observation. The data obtained were used to build a database that was submitted to exploratory analysis in order to observe the distribution behavior and, if applicable, outliers. Descriptive measures were obtained and Student's t-test was applied to compare the means of PCA and fatty acid variables of *C. columbica* Burmeister larvae from two municipalities. Significance was considered p<0.05, 95%.

General scheme of the work. Figure 1 shows the general scheme of the work.

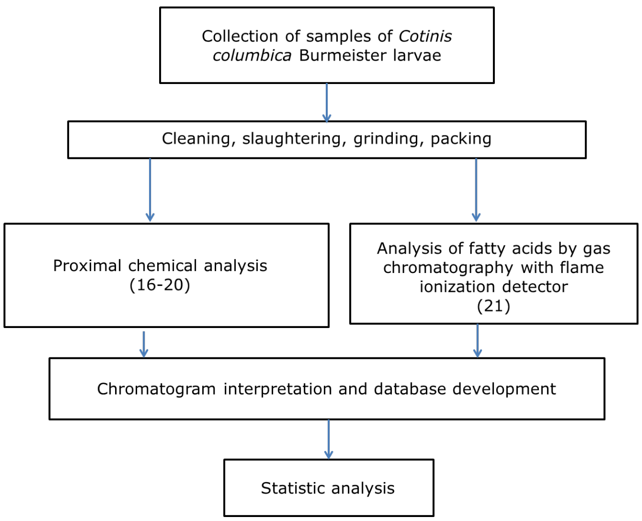

Figure 1. General scheme of the work for the study of the proximal composition and fatty acid profile in *C. columbica* Burmeister larvae from Mogotes (Santander) and Garzón (Huila), Colombia.

RESULTS

Proximal chemical analysis. Bromatological analysis of *C. columbica* Burmeister larvae from Mogotes and Garzón yielded values for carbohydrates, ash, raw fiber, fat, moisture, protein and total solids (Table 2). Significant percentages of protein and fat were found, being higher in larvae from Garzón (25.9 *vs.* 23.3% and 31.1 *vs.* 21.2%, respectively). Statistical analyses showed no significant difference (p≥0.05) in the means of all the variables analyzed. Data dispersion was greater in Mogotes, particularly in fat, moisture and total solids.

Pearson's bivariate correlation analysis found positive correlations in fat with carbohydrates and ash (the higher the fat content, the higher the carbohydrate and ash contents), protein with ash (the higher the protein content, the higher the ash content) and negative correlations of moisture with carbohydrates, ash and fat (the higher the moisture content, the lower the carbohydrate, ash and fat contents) (Table 3). No correlation was observed in raw fiber.

Table 2. Proximal chemical composition (dry base) of *C. columbica* Burmeister larvae from the municipalities of Mogotes and Garzón, Colombia.

Variable (%)	Mogotes $\overline{X}$±SD	Garzón $\overline{X}$±DE	Average
Carbohydrates	5.6a±6.9	6.2a±1.9	5.9
Ashes	3.0a±1.0	3.6a±0.5	3.3
Raw fiber	7.0a±2.6	9.6a±2.3	8.3
Grease	21.2a±10.8	31.1a±1.9	26.1
Humidity	39.8a±20.6	23.4a±5.6	31.6
Protein	23.3a±2.1	25.9a±1.4	24.6
Total solids	60.2a±20.6	76.6a±5.6	68.4

$\overline{x}$: arithmetic mean, SD: standard deviation. Different letters in means of the same row indicate statistical difference at 95%.

Table 3. Correlations of proximal chemical variables of *C. columbica* Burmeister larvae from the municipalities of Mogotes and Garzón, Colombia.

	CHOS	AS	RF	Fat	HU	PR	TS
CHOS	1						
Ashes	0.76	1					
FC	0.21	0.23	1				
Fat	0.82*	0.92*	0.46	1			
Humidity	-0.86*	-0.92**	-0.50	-0.99**	1		
Protein	0.42	0.91*	0.13	0.73	-0.71	1	
TS	0.86*	0.92**	0.50	0.99**	-1.0**	0.71	1

CHOS: carbohydrates; AS: Ashes; HU: Humidity; PR: Protein; RF: Raw fiber; TS: total solids.
*: significant correlation with p<0.05, 95% (bilateral); **: significant correlation with p<0.01, 99% (bilateral).

The fat distribution over time showed a greater tendency in larvae from Garzón, except in June, where a higher value was found for Mogotes (Figure 2). There was no significant difference (p≥0.05).

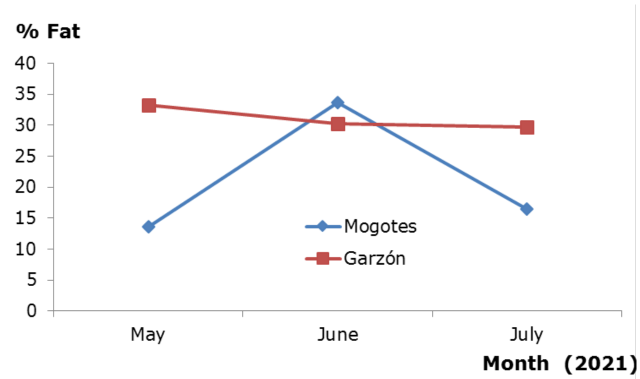

Figure 2. Fat content (%) in *C. columbica* Burmeister larvae from the municipalities of Mogotes and Garzón, Colombia, 2021.

Fatty acids. Chromatographic analysis detected and quantified 18 fatty acids (% w/w), saturated and unsaturated, in the fatty matter of larvae (Table 4) from both municipalities. C16:0, C18:1 c9 and C18: c9,12 were identified as majority FAs, with values in Mogotes of 24.11, 31.59 and 30.0 (% w/w) respectively and in Garzón 20.26, 32.35 and 29.86 (% w/w). The rest of the FA obtained values lower than 4.14 (% w/w). The Student's t-test for independent samples showed significance ($p<0.05$) in C10:0, with a higher value in Garzón (2.56 *vs.* 035 % w/w), the other FA did not show statistical significance ($p\geq0.05$). The contents of saturated, monounsaturated and polyunsaturated groups of FA ranged between 30.20 and 36.92 (% w/w), without reaching statistical difference.

In the fatty acid groups, the correlation was negative in monounsaturated fatty acids (MUFA) with saturated fatty acids and in polyunsaturated fatty acids (PUFA) with MUFA (Table 5). No correlation was observed between PUFA and SFA.

Figure 3 shows the C10:0 contents over time. Larvae from Mogotes registered values lower than 1 (% w/w) and those from Garzón were between 1.2 and 3.5. In both municipalities the trend was decreasing, with peaks in May; Garzón showed higher levels during the study (May, June and July).

Table 4. Mean fatty acid composition (% w/w) in *C. columbica* Burmeister larvae from the municipalities of Mogotes and Garzón, Colombia.

Fatty acid	Mogotes $\bar{X}$±SD	Garzón $\bar{X}$±SD
C4:0	0.09a±0.13	0.15a±0.21
C6:0	0.57a±0.59	1.18a±1.03
C8:0	0.67a±1.11	1.15a±2.00
C10:0	0.35a±0.32	2.56b±1.18
C11:0	0.37a±0.13	0.76a±0.30
C12:0	0.02a±0.03	0.03a±0.03
C13:0	2.01a±1.41	1.49a±0.82
C14:0	0.87a±0.71	0.95a±0.41
C16:0	24.11a±4.37	20.26a±4.99
C16:1, c9	1.26a±1.62	1.77a±2.17
C18:0	0.12a±0.10	0.22a±0.34
C18:1, c9	31.59a±3.72	32.35a±5.26
C18.2, c9,12	30.00a±1.12	29.86a±1.09
C18:3, c9,12,15	4.14a±0.78	3.62a±1.41
C20:2, c11,14	0.33a±0.33	0.44a±0.14
C20:3, c11,14,17	0.89a±0.69	0.57a±0.25
C22:0	1.05a±0.61	1.44a±0.77
C22:2, c13,16	1.57a±1.27	1.19a±1.20
Saturated	30.23a±1.93	30.20a±2.01
Monounsaturated	32.85a±2.50	34.12a±3.61
Polyunsaturates	36.92a±0.57	35.68a±1.70

$\bar{x}$: arithmetic mean, SD: standard deviation.
Different letters in means of the same row indicate difference at 95%.

Table 5. Correlations of fatty acid groups of *C. columbica* Burmeister larvae from the municipalities of Mogotes and Garzón, Colombia.

	SFA	MUFA	PUFA
SFA	1		
MUFA	-0.95**	1	
PUFA	0.71	-0.90*	1

SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids.
*: significant correlation with $p<0.05$, 95% (bilateral); **: significant correlation with $p<0.01$, 99% (bilateral).

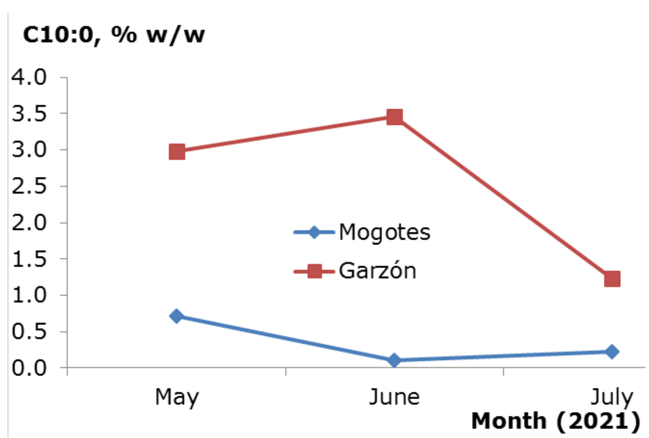

Figure 3. Distribution over time of C10:0 (% w/w) in *C. columbica* Burmeister larvae from the municipalities of Mogotes and garzón, Colombia, 2021.

DISCUSSION

Proximal chemical analysis showed similar contents in the percentages of carbohydrates, ash, raw fiber, fat, moisture, protein and total solids of *C. columbica* Burmeister larvae collected in the municipalities of Mogotes and Garzón (Table 1).

In the literature review, no references were found on the nutritional composition of *C. columbica* Burmeister larvae, so the values obtained in this work were contrasted with pupae and larvae of other species. Protein levels were lower than those found in silkworm pupae (*Bombyx mori* L.) from the Department of Cauca, Colombia (24.6 *vs.* 50.9% dry base) (3), differences that can be attributed to the humidity in larvae of this study, which showed an average of 31.6%, while for pupae it was 5%. In another investigation carried out in larvae and pupae of *Bombyx mori* L. in Hidalgo, Mexico, values of 13.0 and 60.1% wet base, respectively, were found (5). The values on dry base were 62.6 and 64.3%, respectively. These data show the higher protein concentration as the insect life cycle progresses and reveal that the moisture content is higher in larvae (79.2%) than in pupae (6.5%) (5). However, when the values of protein on dry base (larva *vs.* pupa) are observed, the values are very close (62.6 *vs.* 64.3%). Another study on *Pachymerus nucleorum* larvae reported 33.1% protein with 54.2% moisture (6). The reported protein contents account for the variability that exists in insect species and life cycle.

The fat content of larvae in this study was between 21 and 31% for Mogotes and Garzón, respectively, with an average of 26%, 13.5 percentage points lower than that found in silkworm pupae (39.5%) in Cauca, Colombia (3). The average fat content in this work can be considered low with respect to the Colombian study, but this consideration is relative, since the moisture content of the larvae was 36.1% and 5% in pupae, which means that the fat concentration is higher at lower moisture content. In Mexico, values for *Bombyx mori* L. larvae of 3.4 and 16.4% with 79.1 and 0% moisture, respectively, were reported (5), values well below those found in this investigation. In a Brazilian study, *Pachymerus nucleorum* larvae had a value of 37.9% fat with 54.2% moisture (6). This information and the negative correlation between moisture and fat (Table 2), explain the higher percentage of moisture with lower percentage of fat.

In the fat values through time, the Mogotes samples presented lower percentages with respect to Garzón (Figure 2) in May and July, with very close levels in June, without presenting statistical significance ($p \geq 0.05$). This is due to the fact that larval feeding in Garzón (Huila) was done during the quarantine process with wheat flour, biodegradable residues and organic humus (15).

The findings on proximal composition in this research and in different countries on different insect larvae show that variability is wide, not only in fat content, but also in most of the variables analyzed (3,5,6,10) (Table 6).

Table 6. Proximal composition (% dry or wet base) of larvae, pupae and insects in various countries.

Species	CHOS	AS	FC	FT	HU	P
Cotinis columbica Burmeister, L[1]	5.9	3.3	8.3	26.1	31.6	24.6
Bombyx mori L., P[2]	2.2	3.4	-	39.5	5.2	50.9
Bombyx mori L., L[3]	2.7	1.0	0.6	3.4	79.2	13.0
Tenebrio molitor, L[3]	4.2	2.8	6.9	38.3	0	45.8
Liometopum apiculatum, L[3]	18.2	3.3	1.7	34.3	0	49.1
Pachymerus nucleorum, L[4]	-	3.1	15.4	37.9	-	33.1
Triboleum castaneum, L[5]	18.9	1.1	1.9	6.4	56.3	15.3

CHOS: carbohidratos; AS: Ashes; FC: Raw fiber; FT: Fat; HU: Humidity; P: Protein; 1: este estudio; 2: (3) (Colombia); 3: (5) (México); 4: (6) (Brasil); 5: (10) (Portugal).

The bromatological characterization of *C. columbica* Burmeister larvae does not differ from data reported for 14 species of edible Coleoptera larvae in Africa, where the values of ash oscillated between 1.5 and 7.8%, raw fiber 1.5 and 28.1%, fat 11.8 and 66.6%, humidity 1.0 and 59.4% and protein 18.8 and 50.6% (22). These data reveal the dispersion that exists in each variable, which depends primarily on factors such as species, feed and climate (22).

Fatty acids. The methods of gas chromatography with capillary columns are used in the characterization of food fats, they are used in the determination of lipidic fractions such as sterols, triacylglycerides and fatty acids (23). In the present investigation, the contents (% w/w) of fatty acids (FA) were determined in *C. columbica* Burmeister larvae collected in the municipalities of Mogotes and Garzón, Colombia. Table 4 shows that the values of FA (% w/w) in the larvae of the two municipalities studied did not show statistical differences, except for C10:0. Visual inspection showed that the values of C10:0 during the study period were lower in Mogotes than in Garzón, with values below 1 (% w/w), while in Garzón they were in the range of 1.2 to 3.5 (% w/w) (Figure 3). This is probably due to the fact that the larvae in Mogotes fed naturally on the decomposing palm residues during the month of May, rainy season (winter), and temperatures between 15°C and 20°C; and in Garzón, the culture was in a terrarium and its feeding process was based on biodegradable residues, organic humus and wheat flour, rainy season (winter), and temperatures between 20°C and 24°C. In general, the FA profile with respect to other investigations carried out on insects around the world is variable, the number of FA ranges between 8 and 18, of course the profile is reported in different species and phases of the life cycle of insects so it is difficult to contrast these values, but it certainly provides information that should be valued, especially when studying the effect of geographical area and feeding. However, the high contents are characteristic for some FA, which makes it possible to typify the majority FA groups in insect fat (Table 7). In this study, the levels of palmitic (C16:0, 22.18 % w/w) and oleic (C18:1, 31.97 % w/w) in larvae of *C. columbica* Burmeister are notable, which coincide with those found in other countries such as Brazil (*Speciomerus ruficornis*), Ecuador (*Rhynchophorus palmarum* L.), Spain (*Hermetia illucens*), Peru (*Rhynchophorus palmarum* L.) and Korea (*Protaetia brevitarsis seulensis*) with ranges from 17.67 to 43.91 (% w/w), 32.19 and 62.17 (% w/w), respectively (Table 7). The proportions of SFA, MUFA and PUFA also show notable differences among nations, but there is similarity with the values for Spain.

Table 7. Fatty acid content (% w/w) in insects from various countries.

Fatty acid	This study	Brasil[1]	Ecuador[2]	Spain[3]	Perú[4]	Korea[5]
C4:0	0.12	-	-	-	0.26	-
C6:0	0.87	-	-	-	0.29	-
C8:0	1.82	-	-	1.1	0.28	-
C10:0	1.45	0.14	-	0.6	-	-
C11:0	0.56	-	-	-	-	-
C12:0	0.02	21.34	0.1	0.4	-	-
C13:0	1.75	-	-	-	-	-
C14:0	0.91	19.01	2.8	0.7	2.56	1.86
C15:0	-	-	-	1.6	-	0.60
C16:0	22.18	17.67	28.0	19.6	43.91	17.05
C16:1, c9	1.51	0.45	1.2	0.7	1.72	1.17
C16:3	-	-	-	-	-	0.31
C17:0	-	-	-	-	-	0.10
C18:0	0.17	4.16	5.9	6.5	5.16	1.69
C18:1, c9	31.97	32.19	59.2	36.1	43.01	62.17
C18.2, c9,12	29.93	4.81	1.1	26.0	0.76	4.92
C18:3, c9,12,15	3.88	-	0.3	1.4	0.29	0.19
C20:0	-	-	-	0.8	0.58	0.50
C20:1	-	-	-	0.3	-	-
C20:2, c11,14	0.38	-	-	-	-	-
C20:3, c11,14,17	0.73	-	-	-	-	-
C20:4		0.16		0.3		
C22:0	1.24		-	1.1	-	0.31
C22:2, c13,16	1.38	-	-		-	-
C22:5		-	-	0.6	-	-
Saturated	30.22	62.39	36.8	32.5	53.03	21.80
Monounsaturated	33.48	32.64	60.4	37.1	44.73	71.7
Polyunsaturates	36.30	4.97	1.5	28.2	1.05	5.73

[1](24), [2](7), [3](9), [4](25), [5](26).

The correlations showed that the higher the PUFA and MUFA content, the lower the SFA content (Table 5). This is evident since there is scientific evidence on the beneficial effects of some unsaturated fatty acids on the human organism; there are two groups of unsaturated fatty acids, omega-3 and 6 fatty acids and, depending on the position of the hydrogen atoms in the double bonds, they are identified as cis (hydrogen on the same side) or trans (hydrogen on opposite sides). The functional properties of FAs depend, in general, on the size of the hydrocarbon chain, number of double bonds, and cis or trans configuration (27,28). PUFA are the most beneficial for the human body, some of them cannot be synthesized by the body and are required to be provided through the diet (such as linoleic, C18:2 and linolenic, C18:3), so they are considered essential FA (27,28). It is reported that essential FA protect the heart because they have anti-arteriosclerosis, anti-inflammatory and anti-arrhythmic activity, through the modification of TLR4 signaling pathway activation, by suppressing dimerization in cell membranes, which leads to inhibition of TLR4 expression and increased mitigation of metainflammation, cardiovascular disease and risks of type 2 diabetes mellitus in obese humans (27,28). Likewise, the monounsaturated FA group, composed mostly of C18:1, is associated with anticancer activity, reduction of plasma cholesterol, strengthening of the immune system, and decreased risk of cardiovascular and inflammatory disease (29). In cultured human monocytes (THP-1), oleic acid (C18:1) was found to be responsible for the induction of hypomethylation and improvements in inflammation patterns (27). In addition, according to scientific studies (23, 29), the benefits of the consumption of short and medium chain FA are recognized, such as C4:0 which has an antitumor effect in prostate, breast and colon; C6:0, C8:0 and C10:0 are associated with inhibition of microbial and viral growth and dissolution of cholesterol deposits in *in vitro* tests and in test animals. Therefore, the values found in *C. columbica* Burmeister larvae are a basis for considering them as a natural and important source of short-and medium-chain FA, C81:1 (31.97 % w/w) and C18:2 (29.93 % w/w).

In conclusion, the proximal composition and fatty acid profile of *Cotinis columbica* Burmeister larvae from the municipalities of Mogotes (Santander) and Garzón (Huila), Colombia, were characterized. The composition and fatty acid values were similar, except for C10:0. *Cotinis columbica* Burmeister larvae are nutritionally attractive due to their concentrations of protein (24.6%), fat (26.1%) and essential fatty acids C18:1 (31.97 % w/w) and C18:2 (29.93 % w/w).

Conflict of interest

The authors of this paper declare that there is no conflict of interest with the publication of this manuscript.

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