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ARTICLE

Chemical Characterization of *Jarilla caudata* Seeds from Mexico

Juan Francisco Zamora Natera[1,*], **Mario Felipe González González**[1], **Javier Vioque**[2], **Julio Girón-Calle**[2] and **Manuel Alaiz**[2]

[1]Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara, Camino Padilla Sánchez No. 2100, Zapopan, Jalisco, 45101, México

[2]Instituto de la Grasa (C.S.I.C.), Campus Universidad Pablo de Olavide, Carretera de Utrera km 1, Sevilla, 41089, España

*Corresponding Author: Juan Francisco Zamora Natera. Email: jfzamora@cucba.udg.mx

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ABSTRACT: *Jarilla caudata* Standl. (Caricaceae) is a wild herbaceous plant native to Mexico recognized for its edible fruits. It is considered to be the closest taxonomically species to *Carica papaya* L. (Caricaceae), whose seeds have good nutritional and functional properties. This study analyzes and compares the seed chemical compositions of *J. caudata* and *C. papaya* to study the nutritional and functional potential of *J. caudata* seeds. The analysis of the proximate composition was based on standard methods. High-performance liquid chromatography was used to determine the free amino acid profile, gas chromatography to quantify the fatty acid content, and inductively coupled plasma–optical emission spectrometry to measure minerals. Both *J. caudata* and *C. papaya* seeds have high protein (24.03% to 26.94%) and lipid (21.32% to 25.07%) content. The mineral study indicated high potassium, calcium, iron, and zinc content. Minor functional compounds present, with similar contents in *J. caudata* and *C. papaya* seeds, were soluble sugars, phytic acid, polyphenols, and pectin. The main fatty acid in seed oil was oleic acid (C18:1), with 61.4% in *J. caudata* seeds and 72.6% in *C. papaya* seeds. Among free amino acids, leucine with 6.9/100 g free amino acids and phenylalanine with 13.6/100 g free amino acids were the most abundant in the seeds of *J. caudata* and *C. papaya*, respectively. Polyphenols of *J. caudata* and *C. papaya* seeds showed similar antioxidant activity. *J. caudata* seeds may represent a useful source of nutritional compounds for food and feeding, and functional compounds with antioxidant activity.

KEYWORDS: Caricaceae; fatty acids; free amino acids; minerals; polyphenols; proteins

1 Introduction

There is growing interest in using plant seeds as sources of nutrients to meet the increasing demand for food and also as a source of functional compounds [1]. There is abundant information regarding the chemical composition of commonly cultivated crops, including legumes, cereals, and oilseeds [2]. Seeds from local cultures and/or wild fruit are also of interest as sources of nutritional and functional compounds [3]. For instance, protein, oil, carbohydrate, and mineral constituents of fruit seeds from wild plants have been considered suitable for food formulations [4,5], and as a source of functional compounds, flavonoids, phenolic acids, carotenoids, alkaloids, and glucosinolates, with health-promoting properties [6,7].

Jarilla caudata is an herbaceous perennial plant belonging to the family Caricaceae. This plant is close taxonomically to *Carica papaya*. The fruit of *C. papaya* is widely consumed and recognized for its nutritional and health-promoting properties [8]. Molecular data support the relationship of *C. papaya* to a Mexican/Guatemalan clade of the genus *Jarilla* [9]. This clade includes three herbaceous *Jarilla* species (*J. heterophylla*, *J. chocola*, and *J. caudata*) that grow in the northwest of Mexico. These three species are all appreciated for their edible fruits. However, *J. caudata* is the most popular one in local communities, and its fruit is collected from the wild and locally consumed as immature as fresh snacks with salt and lemon.

The green fruit of *J. caudata* has been chemically characterized and is rich in proteins, macrominerals, and carbohydrates [10]. The chemical composition of *C. papaya* seeds and fruits has been analyzed showing good nutritional and pharmacological properties [11,12]. However, studies on *J. caudata* seeds are lacking. Hence, due to the close taxonomic relationship with *C. papaya*, *J. caudata* seeds may be as well rich a source of nutritional and functional compounds as *C. papaya* seeds. The objective of this work was to analyze and compare the chemical composition of *J. caudata* and *C. papaya* seeds in terms of their proximal composition, fatty acids, mineral content, free amino acids, and antioxidant activity.

2 Materials and Methods

2.1 Plant Material

Mature fruits of *J. caudata* plants were collected in November 2023 from several populations in Tizapan (Jalisco, Mexico), (N20°072′77.2″; W103°03′21″) and 1546 m above sea level. Seeds were manually recovered from the ripe fruits, washed with water to eliminate pulp residues, and dehydrated in a forced air oven at 45°C until constant weight. Seeds were ground with a hammer mill with a size 60 sieve, packaged in polyethylene bags, and stored at 5°C until analysis. Plants were identified and a voucher specimen of *J. caudata* (No. 221029) was deposited at Luz Maria Villarreal de Puga herbarium, located at Centro Universitario de Ciencias Biológicas y Agropecuarias belonging to the University of Guadalajara (Guadalajara, Jalisco, México). *C. papaya* seeds were taken from fruits obtained in a local market and processed as described for *J. caudata* seeds.

2.2 Proximate Analysis

Moisture, ash, lipid, and protein (%N × 6.25) content were determined according to approved standard methods of the Association of Official Analytical Chemists: methods 925.09, 923.03, 920.85, and 920.87, respectively [13]. Acid and alkaline digestion were used to determine crude fiber, while total carbohydrates were estimated by difference according to the following equation:

Total carbohydrate (%) = 100 − (% Ash + % Moisture + % Protein + % Fat + % Fiber).

The energy value was calculated according to FAO [14] following the equation:

kcal/100 g = (% available carbohydrates × 4) + (% proteins × 4) + (% fats × 9).

Additionally, soluble sugars were determined according to the Dubois method [15]. Pythic acid was determined following a colorimetric method [16]. Pectins were determined as galacturonic acid equivalents [17], and total polyphenol contents were measured with the Folin-Ciocalteu method [18].

2.3 Mineral Composition

Seed flours (0.5 g) were digested with 4 mL of 7 M HNO_3 and 4 mL of 30% (w/w) H_2O_2 in a microwave oven at 600 W power for 1 h. After digestion, the solution was diluted with ultrapure water to 25 mL in a volumetric flask [10]. Minerals were determined by inductively coupled plasma–optical emission spectrometry (ICP-OES) with an Optima 4300 DV (Perkin Elmer) spectrometer. Operating conditions were as follows: power, 1200 W; plasma flow gas, 14 L/min; auxiliary gas flow, 0.2 L/min; nebulizer gas flow, 0.9 L/min.

2.4 Fatty Acid Analysis

Seed flours were extracted with hexane in a Soxhlet for 8 h. The oil extract was dried over anhydrous sodium sulfate, and the solvent was evaporated using a vacuum rotary evaporator. Oil content was determined gravimetrically. Fatty acids were analyzed by gas chromatography as their methyl esters [19]. A standard mixture of olive, rapeseed, and sunflower oils was used for identification and quantification, by the internal normalization method.

2.5 Free Amino Acid Content

Free amino acids were analyzed by reversed-phase high-performance liquid chromatography after their extraction with ethanol (60%) and derivatization using diethyl ethoxymethylenemalonate [20].

2.6 Polyphenols Reducing Power

The reducing power of *J. caudata* and *C. papaya* seed flour polyphenols was determined according to Oyaizu [21]. In microplates, 0, 0.5 1, 1.25, and 1.5 µg polyphenols/well were evaluated. Reducing power was measured at 700 nm in a microplate reader (Scientific Multiskan GO Spectrophotometer, Thermo Fisher Scientific). Increases in the reaction mixture's absorbance indicate higher reducing capacity.

2.7 Statistical Analysis

Student *t*-test was used to analyze and compare data means between the groups (two different seed types) at 0.05 probability, using Minitab Statistical Software.

3 Results

3.1 Chemical Composition of J. caudata Seeds

Chemical composition of *J. caudata* and *C. papaya* seeds is shown in Table 1. Protein and lipids were the main components in both *J. caudata* and *C. papaya* seeds, although significative higher in *J. caudata* than in *C. papaya* (26.94% vs. 24.03%, and 25.07% vs. 21.32%, respectively).

Table 1: Chemical composition of *J. caudata* and *C. papaya* seeds (g/100 g dry weight)

Compounds	*J. caudata*	*C. papaya*
Humidity	6.61 ± 0.12^{a}	4.88 ± 0.12^{b}
Ashes	5.09 ± 0.03^{b}	6.53 ± 0.03^{a}
Proteins	26.94 ± 0.02^{a}	24.03 ± 0.12^{b}
Fiber	21.87 ± 0.19^{b}	27.01 ± 0.29^{a}
Lipids	25.07 ± 1.72^{a}	21.32 ± 2.03^{b}
Soluble sugars	2.40 ± 0.07^{a}	1.54 ± 0.02^{b}
Pectins	0.97 ± 0.26^{a}	1.20 ± 0.02^{a}
Phytic acid	2.93 ± 0.02^{b}	3.25 ± 0.06^{a}
Polyphenols	0.035 ± 0.001^{a}	0.039 ± 0.001^{a}
Free amino acids	0.091 ± 0.011^{b}	0.495 ± 0.021^{a}
Carbohydrates (by difference)	14.42 ± 2.03^{a}	16.25 ± 2.03^{a}
E.V. (kcal/100 g)	401.39 ± 1.23^{a}	353.22 ± 1.19^{b}

Note: Between species on any row, means followed by the same letter are not significantly different ($p < 0.05$). Each value is the mean ± standard error of three replicates. E.V.: energy value.

On the contrary, *C. papaya* seeds were richer in fiber (27.01% vs. 21.87%) and carbohydrates (16.25% vs. 14.42%) than *J. caudata* seeds, while ashes content were similar in both plants (6.53% and 5.09%, respectively). Other compounds present in minor amounts were soluble sugars, phytic acid, pectins, and polyphenols. Only soluble sugars contents differed significantly between *J. caudata* and *C. papaya* seeds (2.40% and 1.54%, respectively). Energy values differed significantly between the two samples, with 401.39 kcal/100 g for *J. caudata* seeds and 353.22 kcal/100 g for *C. papaya* seeds. Seeds with 400 to 600 kcal/100 g E.V. are considered an appropiate source of energy for human nutrition.

3.2 Mineral Composition of J. caudata Seeds

Mineral composition of *J. caudata* and *C. papaya* seeds is shown in Table 2. In both plants, potassium was the most abundant macromineral, followed by sulfur, phosphorus, magnesium, and calcium. Only potassium and calcium contents differed significantly between the two seeds.

Table 2: Macro and microminerals content in *J. caudata* and *C. papaya* seeds

Macrominerals (g/100 g flour)	***J. caudata***	***C. papaya***
Potassium	1.42 ± 0.08^{b}	1.98 ± 0.1^{a}
Sulfur	1.38 ± 0.10^{a}	1.02 ± 0.09^{b}
Phosphorus	0.67 ± 0.04^{a}	0.72 ± 0.02^{a}
Magnesium	0.45 ± 0.02^{a}	0.47 ± 0.01^{a}
Calcium	0.33 ± 0.05^{b}	0.79 ± 0.06^{a}
	Microminerals (mg/100 g flour)	
Iron	10.5 ± 0.14^{a}	9.14 ± 0.10^{b}
Zinc	4.38 ± 0.07^{a}	4.01 ± 0.08^{b}
Manganese	3.86 ± 0.09^{a}	4.12 ± 0.05^{a}
Boro	2.00 ± 0.09^{a}	1.79 ± 0.12^{a}
Copper	0.81 ± 0.03^{a}	0.88 ± 0.05^{a}

Note: Between species on any row, means followed by the same letter are not significantly different ($p < 0.05$). Each value is the mean of three replicates ± standard error.

Potassium contents were significantly higher in *C. papaya* than in *J. caudata* seeds (1.43/100 g vs. 1.98/100 g). Also, calcium contents were 100% higher in *C. papaya* than in *J. caudata* seeds (0.79/100 g vs. 0.33/100 g). Among microminerals, iron was the most abundant in both seeds, followed by zinc, manganese, and boro. Zinc and iron values were higher in *J. caudata* than in *C. papaya* seeds, although these differences were not significative different. Copper contents were low in both species, with values of 0.81 mg/100 g in *J. caudata* and 0.88 mg/100 g in *C. papaya*. Sodium was not detected in the two seeds.

3.3 Fatty Acids Composition of J. caudata Seed Oil

Seed oil fatty acid composition is shown in Table 3. Unsaturated fatty acids represented 81.29% and 79.15% of the seed oil in *J. caudata* and *C. papaya* seeds, respectively. Oleic acid was the majoritary fatty acid in *J. caudata* (61.37%) and *C. papaya* (72.59%) seed oil. Other fatty acids in minor amounts were palmitic and linoleic acid.

Table 3: *J. caudata* and *C. papaya*. seeds oils fatty acid composition (g/100 g oil)

Fatty acids	*J. caudata*	*C. papaya*
Myristic a. ($C_{14:0}$)	0.14 ± 0.007[a]	0.13 ± 0.005[a]
Palmitic a. ($C_{16:0}$)	13.93 ± 0.62[b]	16.07 ± 0.74[a]
Palmitoleic a. ($C_{16:1;\omega7}$)	0.05 ± 0.00[a]	0.04 ± 0.00[a]
Hexadecenoic a. ($C_{16:1;\omega9}$)	0.22 ± 0.01[a]	0.19 ± 0.01[a]
Margaric a. ($C_{17:0}$)	0.08 ± 0.001[a]	0.12 ± 0.002[a]
Heptadecenoic a. ($C_{17:1}$)	0.05 ± 0.00[a]	0.05 ± 0.00[a]
Stearic a. ($C_{18:0}$)	4.08 ± 0.21[a]	4.42 ± 0.23[a]
Oleic a. ($C_{18:1;\omega9}$)	61.37 ± 3.07[b]	72.59 ± 3.89[a]
Vaccenic a. ($C_{18:1;\omega11}$)	1.01 ± 0.062[a]	1.42 ± 0.054[b]
Linoleic a. ($C_{18:2}$)	17.91 ± 0.75[a]	4.18 ± 0.21[b]
Linolenic a. ($C_{18:3}$)	0.39 ± 0.002[a]	0.31 ± 0.001[a]
Arachidic a. ($C_{20:0}$)	0.28 ± 0.002[a]	0.11 ± 0.00[b]
Gadoleic a. ($C_{20:1}$)	0.28 ± 0.002[a]	0.37 ± 0.003[a]
Behenic a. ($C_{22:0}$)	0.20 ± 0.001[a]	0.00 ± 0.00[a]
P/S index*	0.978	0.215
∑ SFA**	18.72	20.85
∑ MFA***	62.98	74.55
∑ PFA****	18.30	4.49
Atherogenic index	0.23	0.22
Thrombogenic index	0.59	0.55

Note: *P/S index: Polyunsaturated fatty acids/saturated fatty acids. **% Total saturated fatty acids. ***% Total monounsaturated fatty acids. ****% Total polyunsaturated fatty acids. Between species on any row, means followed by the same letter are not significantly different ($p < 0.05$). Each value is the mean of three replicates ± standard error.

Hence, palmitic acid was the most abundant saturated fatty acid in both plants, followed by stearic acid. Other fatty acids such as palmitoleic, gadoleic, and linolenic acid were found in low percentages (<1%). The P/S index was higher in *J. caudata* seeds than in *C. papaya* seeds (0.978% vs. 0.215%). The atherogenic index and thrombogenic index values were similar in the two oil samples (Table 3).

3.4 Free Amino Acid Composition

Free amino acid composition of *J. caudata* and *C. papaya* seed flour is shown in Table 4. The essential free amino acid content of *J. caudata* seeds was 23.14/100 g, while in *C. papaya* seeds was 49.47/100 g. The nonessential amino acid contents of *J. caudata* seeds and *C. papaya* seeds were 73.24/100 g and 58.69/100 g, respectively.

All essential amino acids except leucine and threonine were present at significantly higher levels in *C. papaya* than in *J. caudata* seeds. Methionine and tryptophan were not detected in *J. caudata* seeds. Methionine was found in low quantities (0.12/100 g) and tryptophan was not detected in *C. papaya* seeds. Among non essential amino acids, alanine, aspartic acid, and serine contents were higher in *J. caudata* than in *C. papaya* seeds. The opposite was observed with tyrosine, arginine, glutamine, asparagine, and valine contents, which were higher in *C. papaya* than in *J. caudata* seeds. Glutamic acid, glycine, proline, and tryptophan were not detected in either of the two seed samples.

Table 4: Free amino acid composition (g amino acid/100 g flour) of *J. caudata* and *C. papaya* seed flours

	J. caudata	*C. papaya*
	Essential amino acids	
Histidine	0.97 ± 0.04[b]	5.34 ± 0.13[a]
Isoleucine	1.46 ± 0.15[b]	6.29 ± 0.01[a]
Leucine	6.69 ± 0.15[b]	8.89 ± 0.01[a]
Lysine	2.58 ± 0.07[a]	1.12 ± 0.01[b]
Methionine	0.00 ± 0.00[a]	0.12 ± 0.01[b]
Cysteine	0.00 ± 0.00[a]	0.00 ± 0.00[a]
Phenylalanine	5.09 ± 0.04[b]	13.61 ± 0.04[a]
Threonine	2.67 ± 0.08[a]	1.22 ± 0.00[b]
Valine	2.30 ± 0.26[b]	4.92 ± 0.05[a]
Tryptophan	0.00 ± 0.00[a]	0.00 ± 0.00[a]
Tyrosine	1.38 ± 0.03[a]	8.08 ± 0.03[a]
Total	23.14	49.479
	Non-essential amino acids	
Alanine	3.68 ± 0.03[a]	1.09 ± 0.04[b]
Proline	0.00 ± 0.00[a]	0.00 ± 0.00[a]
Arginine	9.44 ± 0.24[b]	14.06 ± 0.15[a]
Glutamine	1.92 ± 0.01[b]	11.56 ± 0.08[a]
Glutamic acid	40.39 ± 0.26[a]	3.73 ± 0.09[b]
Glycine	1.16 ± 0.03[a]	0.69 ± 0.01[b]
Asparagine	8.07 ± 0.06[b]	12.16 ± 0.14[a]
Aspartic acid	9.99 ± 0.29[a]	5.20 ± 0.04[b]
Serine	2.21 ± 0.16[a]	1.92 ± 0.17[b]
Total	71.86	50.61

Note: Each value is the mean ± standard error of two replicates. Between species on any row, means followed by the same letter are not significantly different ($p < 0.05$).

3.5 Antioxidant Activity of J. caudata Seed Polyphenols

The reducing power of *J. caudata* and *C. papaya* seed polyphenols at increasing concentrations is shown in Fig. 1. Both extracts showed increasing reducing activity with the increment in concentration from 0 to 1.5 μg/well. The reducing power of the two polyphenol extracts was similar, and was significantly higher only for *J. caudata* polyphenols at 0.5 μg/well.

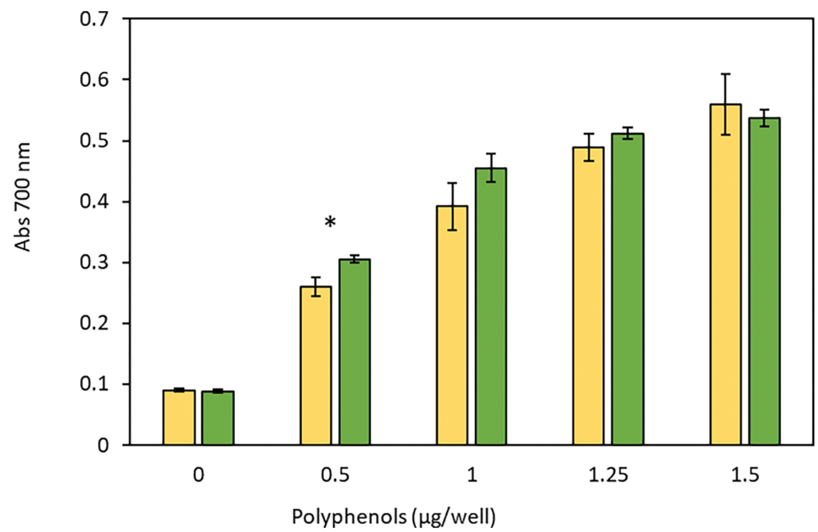

Figure 1: Reducing power of *J. caudata* (green bars) and *C. papaya* (yellow bars) seed polyphenol extracts. Results are the mean ± standard deviation of three determinations. *Significant difference in activity between *J. caudata* and *C. papaya* at the same extract concentration ($p < 0.05$)

4 Discussion

J. caudata fruit seeds show good nutritional properties, with high contents of macronutrients such as proteins and lipids. Hence, *J. caudata* seeds showed protein contents similar to protein-rich seeds such as legumes [22]. *J. caudata* seeds also contain more protein than do seeds of other consumed wild species, such as *Okenia hypogaea* (Nyctaginaceae), *Opuntia joconostle* (Cactaceae), and *Ditaxis heterantha* (Euphorbiaceae). Their lipid contents were also high although lower than the reported for seeds of Mexican plants such as *Jatropha curcas* (Euphorbiaceae) and *Ricinus communis* (Euphorbiaceae) [23–26]. It also showed higher protein contents than seeds of other plant species used as food [27,28]. Protein, lipid, and carbohydrate contents were similar to those of *C. papaya* seeds [29]. Hence, *J. caudata* seeds are highly nutritious, with protein and oil contents similar to those reported for oilseeds such as rapeseed and sunflower seeds [30,31]. As has been reported for *C. papaya* seed proteins, *J. caudata* seed proteins could be exploited as an alternative feed ingredient for poultry and might become a source of proteins and lipids for human nutrition [32]. *J. caudata* seeds are low in sugars in comparison with other seeds. Hence, from the perspective of consumers, they could also be suitable for people with special needs, such as diabetics, and on special diets [33]. It is known that high levels of sugar in seeds not only provide calories as energy to the human body but can also improve cooking quality [34]. Phytic acid contents were slightly higher in *C. papaya* than in *J. caudata* seeds (3.25% and 2.93%, respectively). These values are higher than the reported for other seeds of wild and cultivated species (from 0.87% to 1.70%). Phytic acid is often considered an antinutritional compound because it can bind minerals and proteins, thus decreasing their bioavailability. However, its chelating property may also be positive as an antioxidant and an anticancer agent [35]. The pectin content in *C. papaya* seeds was slightly higher than in *J. caudata* seeds (1.20% vs. 0.97%, respectively). A value of 2.05% pectin in *C. papaya* grown in India has been reported [36]. Polyphenol contents were low in comparison with those from seeds of different *C. papaya* varieties (0.12/100 to 1.43/100 g) [37].

Macro and micro minerals are of great importance in the human diet, although they comprise only 4.6% of human body weight [38]. The mineral composition of fruit pulp has been reported for several species, but there are few studies on seeds mineral contents. Regarding the *Caricaceae* family, the mineral composition of the fruit of *Jacaratia spinosa*, *J. caudata*, *Vasconcellea quercifolia*, and *C. papaya* have been reported [10,39,40]. However, studies on seeds are limited to *C. papaya* and have been designed to understand their potential as a functional feedstuff and some of their functional properties [32]. The macro and micromineral composition of *J. caudata* and *C. papaya* seeds were similar except for potassium, calcium, and zinc. Potassium, phosphorus, and calcium contents were higher than those of other oilseeds such as peanuts, almonds, corn, and sunflower [2]. However, studies to determine the bioavailability of these minerals in *J. caudata* seeds are needed.

Lipids are among the most important nutrients for humans. As with most plant seed oils [41], *J. caudata* and *C. papaya* seed oil showed a predominance of unsaturated fatty acids, with oleic acid being the main one. Thus, the fatty acid profile observed in *J. caudata* seed oil is similar to that reported for edible oils such as canola, sunflower, and olive in terms of the high percentage of unsaturated fatty acids. In addition, the oleic acid content was very high in both species, and similar to that reported for olive oil, the edible oil with the highest oleic acid percentages [42]. Other fatty acids in high amounts in the seeds of *J. caudata* were linoleic and palmitic acids. The contents of saturated and unsaturated fatty acids were similar for *J. caudata* and *C. papaya* seeds. The main difference between both species was observed in the content of linoleic acid, which was higher in *J. caudata* seed oil, resulting in a higher polyunsaturated/saturated fatty acid ratio in *J. caudata* seed oil. In *C. papay*a, the second most abundant fatty acid was palmitic acid, as has been reported elsewhere [43,44]. In related taxa such as *Vasconcellea quercifolia*, oleic acid was also the main fatty acid representing 58.2% of the total, and palmitic acid was also the second most abundant acid, as reported for *C. papaya* seed oil [39]. Atherogenic and thrombogenic indexes were similar for both species. These indexes were lower than those reported for animal fats and plant oils such as palm and coconut oil, and closer to plant oils such as olive oil [45]. Hence, from a nutritional point of view, the seeds of *J. caudata* may be an interesting source of good quality oil due to its high content of oleic acid and unsaturated fatty acids. Because of the similar fatty acid composition of *J. caudata* seed oil, it is also a potential biomass source for renewable energy production that could be used to diversify and promote the bioenergy sector [46].

Plants are a rich source of amino acids, and the abundance of individual amino acids in plants is of great importance, especially in terms of food. Free amino acids are important biologically active compounds. There is no report on the content of free amino acids in seeds of wild *Caricaceae* species, but our results indicate that the free amino acids profile of *J. caudata* seeds is similar to that of *C. papaya* seeds. A total of 16 free amino acids were detected in *J. caudata* seeds and 17 in *C. papaya* seeds. These data agree with those reported in the literature [36]. Individual free amino acid contents differed in their abundance among the seeds studied. For example, phenylalanine and leucine were the essential amino acids most abundant in both seeds (13.61 vs. 5.09 and 8.89 vs. 6.69 g/protein, respectively); although their contents were higher in *C. papaya*. All essential amino acids, except threonine and lysine, were more abundant in *C. papaya* seeds than in *J. caudata* seeds. Arginine and asparagine were the most abundant nonessential amino acids in *C. papaya* seeds, while glutamic acid, arginine, and aspartic acid were the most abundant in *J. caudata* seeds. This agrees with previous reports that the most abundant amino acids in plants are glutamic acid and aspartic acid [47]. Differences in the individual concentrations of free amino acids between *J. caudata* and *C. papaya* seeds may be due to the more limiting growing conditions of *J. caudata* in the wild where the soil fertility is low. In contrast, *C. papaya*, being a cultivated species, is cultivated in favorable growth conditions with water and nutrient supply. Hence, fertilizers play an important role in fruit quality, including sugar and amino acid content [48]. A study on pear trees reported that the concentrations of both essential and non-essential amino acids increased significantly when N supply increased [49].

Polyphenols are among secondary compounds observed in plant seeds. Polyphenols are considered bioactive compounds with health-promoting properties, being antioxidants and antiproliferatives. Our results here indicate that *J. caudata* and *C. papaya* seed extracts have moderate antioxidant effects compared with those of seed extracts from other wild species [50]. Although polyphenols with recognized antioxidant activity, such as p-hydroxybenzoic and vanillic acid have been reported in *C. papaya* seeds [51].

5 Conclusion

In conclusion, *J. caudata* fruit seeds constitute an interesting source of nutritional and functional compounds. The chemical composition of *J. caudata* seeds is similar to that of *C. papaya* seeds. The main compounds showed acceptable properties for their exploitation in human nutrition, the oil was very rich in unsaturated fatty acids. *J. caudata* and *C. papaya* polyphenols showed similar antioxidant activity. These results show that *J. caudata* seeds may be of interest for their application for food or feeding. This plant is consumed for its green fruit in salads. The mature fruit is also used to make juices and sweet beverages and the seeds are discarded. However, these seeds could be employed as a source of proteins and oils in human and animal nutrition. Further work to study the organoleptic properties and nutrient bioavailability of *J. caudata* seeds is needed.

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Availability of Data and Materials: The data that support the findings of this study are available from the corresponding author, Juan Francisco Zamora Natera, upon reasonable request.

Ethics Approval: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest regarding the present study.

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