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Proximate composition and free radical scavenging activity of edible fruits from the Argentinian Yungas

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Abstract: The proximate composition and free radical scavenging effect of native food plants gathered in the Argentinian Yungas have been assessed. Some 25 samples were collected for proximate analysis and free radical scavenging effect of their MeOH-soluble extracts. Total acidity, phenolics and solid content of 16 preserves prepared from native fruits have been determined. The samples belong to 13 different species corresponding to eight plant families, mainly Myrtaceae, Solanaceae and Ulmaceae. The highest organic acid contents (as citric acid) were found in the preserves of *Psidium guineense* and *Cyphomandra betaceae* with the lowest in *Sideroxylon obtusifolium* and *Myrciantes pungens*. Total phenolics in the preserves ranged from 0.34 g kg^{-1} DM in *Rhipsalis flocosa* to 7.30 g kg^{-1} DM in *Celtis iguanae*. The MeOH-solubles of the fruits/petioles as well as the preserves were assessed for inhibition of the enzyme xanthine oxidase (XO), decoloration of the free radical 2,2-diphenyl-1-picryl-hydrazyl (DPPH) and scavenging of the superoxide anion. The highest effect of the solubles towards the DPPH assay was observed for *M pungens* and *Rubus imperialis* before processing. None of the samples was effective as a XO inhibitor or superoxide anion scavenger. The best protein sources in our study were the fruits of *Carica quercifolia, Celtis iguanae* and *Sambucus nigra*.

Keywords: argentinian yungas; proximate composition; free radical scavenging activity; Myrtaceae; Solanaceae; *Rubus*; *Trichocereus*; *Gunnera*

INTRODUCTION

In rural settlements of the Yungas in northwestern Argentina, the population maintains a subsistence economy based on agriculture and farming as their principal activities and practice gathering for seasonal wild fruits, firewood and material for building and handicrafts.[1] In the moist forests in the upper Bermejo basin of the Provincia de Salta, Argentina, several plant species are gathered as food. Most of these are small fruits that are either consumed raw or made into sweets or preserves for trading or selling, being an income for rural people.

The use of cultivated food plants in rural Andean communities is well documented.[2–4] Native plants are important in the diet of the inhabitants living in large areas of northwestern Argentina from ancient times to the present. However, little is known on the proximate composition and free radical scavenging effect of native wild plants gathered as food sources in the Argentinian Yungas.

Following our studies on South American natural resources, we now report the proximate composition and free radical scavenging effect of selected fruits and petioles gathered in the Argentinian Yungas.

The study area

The work was carried out in the Upper Bermejo Basin, which is located near the Bolivian border to the north of the province of Salta, in the localities of Lipeo and Baritú, Santa Victoria district (64°45′W and 22°25′S).

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The localities are 1100 and 1500 m above sea level on water streams belonging to the Bermejo river basin. The area is included in the phytogeographic province of the Yungas (or mountain moist forests) (Neotropical Region, Amazonic domain). It is possible to distinguish two different environments in this region: the mountain subtropical forest and the temperate cloud forest[5] with characteristic floristic elements.[5,6] The climate is tropical continental, with warm rainy summers, and cold dry winters. The annual mean temperatures oscillate between 14 and 26.5 °C. Rainfall is centered between September and March and varies between 700 and 1400 mm per annum.[1,7]

At present, the population at Lipeo and Baritú comprises some 25 families with 160 inhabitants living in a subsistence economy based on shifting agriculture and intensive cattle breeding.

MATERIALS AND METHODS

Sources of chemicals

Xanthine oxidase (XO) derived from cow's milk, xanthine, the standard inhibitor allopurinol and gallic acid were purchased from Sigma Chemical Co (St Louis, MO, USA). DPPH, nitro blue tetrazolium dye (NBT), quercetin, catechin, ellagic acid were purchased from Aldrich Chemical Co (Milwaukee, WI, USA). Tannic acid was purchased from Merck (Darmstadt, Germany).

Plant material

The plant material under study was collected during an ethnobotanical survey carried out by one of the authors (N Hilgert) from October 2000 to May 2001. The collection was undertaken with the help of local people, mainly children and women, from the places they usually gathered the plant material for its use. The botanical source of the samples is presented in Table 1. Specimens of herbariums were prepared, which were placed in the Herbarium of the Museo de Ciencias Naturales de la Universidad Nacional de Salta (UNSa) (MCNS). All the samples were determined by N Hilgert with the cooperation of A Rotman for the Myrtaceae. Voucher numbers refer to N Hilgert collections. A representative sample of the fruits/petioles was dried in a convection oven and the dry material was used for the proximate analysis.

Preparation of preserves and sweets

Processing of the fruits to obtain preserves or sweets was undertaken as the fruiting time of most of the species under study was quite short and transport of ripe fruits to urban settlements is complex because of the relative isolation of the rural settlements. Preserves and sweets were prepared using local recipes. The fruits or petioles are washed and placed in a metal pan with sugar. The mixture is macerated for a variable time (from a couple of hours to overnight), mixed, placed in a stove and boiled for 1–2 h with occasional stirring until the consistence is considerate appropriate (Table 2).

Proximate analysis

Moisture, fat, fibre, ash and nitrogen contents were determined on a dry weight basis according to AOAC

Table 1. Plant family, scientific name and part of the edible species under study

Plant family	Scientific name, voucher specimen and common name	Plant part
Bromeliaceae	*Aechmea distichantha* Lem var *distichantha* (1499; 1517), 'Taraca', 'choclo choclo'	Fruit, fresh
Cactaceae	*Rhipsalis floccosa* subsp. *tucumanensis* (1511; 2024; 2191; 2449), 'Huasca huasca', 'rienda rienda'	Fruit, fresh
Cactaceae	*Rhipsalis lorentziana* Griseb (1462; 1509), 'Peinquillita'	Fruit, fresh
Cactaceae	*Trichocereus arboricola* Kimnach (1510; 2399), 'Cardón', 'pasacana'	Fruit, fresh
Caprifoliaceae	*Sambucus nigra* L subsp *peruviana* (Kunth) R Bolli (2142), 'Mololo'	Fruit, fresh
Caricaceae	*Carica quercifolia* (A St Hil) Hieron (2048; 2212), 'Higo amarillo', 'higuera del monte'	Fruit, fresh
Gunneraceae	*Gunnera apiculata Schindl* (2231), 'Querusilla', 'quirusilla'	Petioles; petioles made in sugar
Myrtaceae	*Eugenia uniflora* L (1101; 1503), 'Arrayán'	Fruit, fresh
Myrtaceae	*Psidium luridum* (Spreng) Burret (2611), 'Guayabilla', 'frutilla blanca'.	Fruit, fresh
Myrtaceae	*Myrcianthes pungens* (O Berg) D Legrand (2629), 'Guayabo negro', 'guayabo blanco'	Fruit, fresh
Myrtaceae	*Psidium* aff *guineense* Sw (2626; 2639), 'Arazay'	Fruit, fresh
Passifloraceae	*Passiflora tenuifila* Killip (2055; 2624), 'Granadilla', 'granada del campo'	Fruit, fresh
Rosaceae	*Rubus imperialis* Cham & Schltdl (2206; 2597), 'Mora'	Fruit, fresh
Sapindaceae	*Allophylus edulis* (A St-Hill, A Juss & Cambess) Radlk (2163), 'Chanchal', 'chalchal'	Fruit, fresh
Sapotaceae	*Sideroxylon obtusifolium* (Roem & Schult) TD Penn (2017, 2213; 2625), 'Mocán'	Fruit, fresh
Solanaceae	*Vassobia breviflora* (Sendtn) Hunz (953), 'Uchucho', 'pucanche'	Fruit, fresh
Solanaceae	*Solanum sisymbriifolium* Lam var *sisymbriifolium* (1983; 2145; 2637), 'Vila vila'.	Fruit, fresh
Solanaceae	*Cyphomandra betaceae* (Cav) Sendtn (2214), 'Chilto'	Fruit, fresh
Ulmaceae	*Celtis iguanea* (Jacq) Sarg (2148; 2405), 'Tala'	Fruit, fresh

Table 2. Percentual acidity[a], soluble solids[b] and total phenolics[c] in preserves and sweets from the Argentinian Yungas[d]

Plant family	Scientific name	Preparation and fruit:sugar ratio[e]	Acidity	Soluble solids	Total phenolics
Cactaceae	*Rhipsalis flocosa*	Preserve, 2:1	0.24 ± 0.01	59.7 ± 0.2	0.34 ± 0.01
Caprifoliaceae	*Sambucus nigra* var. *peruviana*	Preserve, 3:2	0.81 ± 0.02	68.0 ± 0.7	1.55 ± 0.04
Caricaceae	*Carica quercifolia*	Preserve, 1:1	0.36 ± 0.03	67.2 ± 0.3	0.52 ± 0.03
Myrtaceae	*Eugenia uniflora* (1)	Sweet, 1:1, without seed	0.62 ± 0.04	62.5 ± 0.5	3.84 ± 0.06
Myrtaceae	*Eugenia uniflora* (2)	Sweet, 1:1, without seed	0.70 ± 0.02	55.5 ± 0.6	2.02 ± 0.08
Myrtaceae	*Myrciantes pungens*	Preserve, 1:1, without seed	0.14 ± 0.01	70.2 ± 0.4	2.20 ± 0.05
Myrtaceae	*Psidium guineense*	Preserve, 2:1, without seeds and peel, ripe fruits	1.50 ± 0.03	42.5 ± 0.5	2.40 ± 0.07
Myrtaceae	*Psidium luridum*	Preserve; 2:1, with seeds and peel, ripe fruits	0.60 ± 0.03	59.5 ± 0.4	4.15 ± 0.04
Rosaceae	*Rubus imperialis*	Sweet, 1:1	0.59 ± 0.02	65.2 ± 0.5	2.15 ± 0.03
Sapotaceae	*Sideroxylon obtusifolium*	Preserve, 2:3	0.20 ± 0.01	72.3 ± 0.2	4.71 ± 0.06
Solanaceae	*Cyphomandra betaceae* (3)	Sweet, 3:2; without seeds and peel, ripe fruits	1.15 ± 0.02	64.1 ± 0.4	0.85 ± 0.02
Solanaceae	*Cyphomandra betaceae* (4)	Sweet, 3:2; without seeds and peel, unripe fruits	0.80 ± 0.02	57.3 ± 0.5	0.69 ± 0.02
Solanaceae	*Cyphomandra betaceae* (5)	Sweet, 3:2, whole fruit in syrup, bitter taste	0.50 ± 0.03	35.2 ± 0.4	0.75 ± 0.04
Solanaceae	*Solanum sisymbriifolium*	Preserve, 2:1; without seeds and peel	0.54 ± 0.03	61.5 ± 0.2	1.81 ± 0.03
Ulmaceae	*Celtis iguanae* (6)	Preserve, 2:1; without seed	0.55 ± 0.01	40.2 ± 0.3	7.30 ± 0.05
Ulmaceae	*Celtis iguanae* (7)	Preserve, 2:1; with seeds	0.60 ± 0.02	62.1 ± 0.3	2.00 ± 0.04

[a] As citric acid content.
[b] As percent sugar content.
[c] As gallic acid in $g\,kg^{-1}$ DM. Samples 1–7 correspond to different recipes.
[d] All preparates were made of fruits.
[e] w/w fruit/sugar ratio.

methods.[8] Crude lipid content of the samples was estimated by exhaustive Soxhlet extraction of a known weight of dried sample with light petroleum (bp 40–60 °C). The defatted residue was analyzed for protein, fiber, ash and non-nitrogenated compounds (carbohydrates). Crude protein and fiber content were determined by standard Kjeldahl conversion and acid detergent fiber techniques.[8] The carbohydrate content (excluding fiber) was obtained by subtracting the sum of protein, ash, fiber and crude lipids from the total dry matter.[8] Phosphate levels were determined colorimetrically by the ammonium molybdate complex method.[8] Total phenolic content of the plant and extracts was determined by the Folin–Ciocalteau technique using a calibration curve with tannic acid and gallic acid.[8]

Extracts

A representative sample of the fruits was collected in the field and each species was placed in containers filled with 98% ethanol to avoid decomposition.

Upon reception at the laboratory, the fruits were weighed, homogenized in methanol in a 1:5 weight/volume ratio. After 24 h at room temparature, the homogenate was filtered through cheesecloth, re-extracted for 24 h with methanol and filtered. The combined organic fractions were taken to dryness under reduced pressure and lyophilized. The free radical scavenging and xanthine oxidase inhibitory activity was assessed in those extracts.

Assays

Free radical scavenging activity

The free radical scavenging effect of the crude extracts was assessed by the decoloration of a methanolic solution of the 2,2-diphenyl-1-picryl-hydrazyl radical (DPPH).[9,10] The degree of decoloration indicates the free radical scavenging efficiency of the substances. A methanolic solution of DPPH served as a control. The percentage of DPPH decoloration was calculated as follows:

$$\begin{array}{c}\text{Decoloration}\\ \text{percentage}\end{array} = 1 - \frac{\begin{array}{c}\text{(absorbance with}\\ \text{compound)}\end{array}}{\text{absorbance of blank}} \times 100$$

Extracts were assessed at 100, 50 and $10\,\mu g\,ml^{-1}$. Values are presented as mean $\pm$ SD of three determinations. Catechin and ellagic acid were used as reference compounds.

Superoxide anion

The enzyme xanthine oxidase is able to generate O_2^- *in vivo* by oxidation of reduced products from intracellular ATP metabolism. The superoxide generated in this reaction sequence reduces the nitro blue tetrazolium dye (NBT), leading to a chromophore with maximum at 560 nm. Superoxide anion scavengers reduce the generation of the chromophore. The activity was measured spectrophotometrically.[11,12] Extracts were evaluated at $50\,\mu g\,ml^{-1}$. Quercetin was used as reference compound. The percentage of superoxide anion scavenging effect was calculated as follows:

$$\text{Percentage of scavenging activity}: \frac{E-S}{E} \times 100$$

where $E = A - B$ and $S = C - (B + D)$; A: optical density of the control; B: optical density of the control blank; C: optical density of the sample; D: optical density of the sample blank.

Xanthine oxidase activity
The XO activities using xanthine as substrate were measured spectrophotometrically as previously reported using a Shimadzu UV-160A instrument.[9,10] The crude extracts were evaluated at $50\,\mu g\,ml^{-1}$. Allopurinol was used as a reference inhibitor. The percentage of inhibition was calculated as follows:

$$\begin{array}{c}\text{Percentage} \\ \text{inhibition}\end{array} = \frac{(\text{control} - \text{control blank}) - (\text{sample} - \text{sample blank})}{(\text{control} - \text{control blank})} \times 100$$

Samples displaying activities less than 20% at $50\,\mu g\,ml^{-1}$ in the XO and superoxide anion are considered not promising as a source of active secondary metabolites or that the active compounds are present at very low concentration.

Statistical analysis
Results are expressed as the mean of the percentage of inhibition relative to the corresponding control ± SD Statistical significance was determined by Student's t test (unpaired t test), with the level of significance set at $p < 0.05$. Absorbance values with $p \geqslant 0.05$ were considered as no inhibition (NS).

RESULTS AND DISCUSSION

Total acidity, solid content and total phenolics (as gallic acid) of 16 preserves/sweets prepared from native fruits in the Yungas have been determined. Analyses presented in Table 2 correspond to the most common fruits preparations. The samples belong to 12 different botanical species corresponding to eight plant families. Most of the preparations belong to the Myrtaceae (5), Solanaceae (3) and Ulmaceae (2). The highest organic acid contents, calculated as citric acid, were found in the preserves/sweets of guava (*Psidium guineense*) and *Cyphomandra betaceae* (1.5 and 1.15%, respectively) with the lowest for *Sideroxylon obtusifolium* and *Myrciantes pungens* (0.2 and 0.14%, respectively). Total phenolics presented minimum values for the preserves/sweets of *Rhipsalis flocosa* ($0.34\,g\,kg^{-1}$ DM) and *Carica quercifolia* ($0.52\,g\,kg^{-1}$) to $4.71\,g\,kg^{-1}$ in *S obtusifolium* and $7.30\,g\,kg^{-1}$ in *Celtis iguanae*. Percentage soluble solid content is related to the fiber and seed content of fruits as well as to the processing method. This parameter showed high variability in different samples from the same plant species (55.5–62.5 for *Eugenia uniflora*, 57–64% for *C betaceae* and 40–62% for *C iguanae*). Maxima and minima for total solids were found in *S obtusifolium* (72.3%) and *C iguanae* (40%), respectively.

The results regarding the free radical scavenging effect of extracts obtained from 25 samples (19 species from 12 botanical families) are summarized in Table 3. None of the samples was effective as a XO or superoxide inhibitor since our selection criterion requires an inhibition ≥50% at $50\,\mu g\,ml^{-1}$. At $50\,\mu g\,ml^{-1}$ only the extractives of *Gunnera apiculata* and *E uniflora* displayed a weak activity towards the enzyme XO with an inhibition of 27 and 21%, respectively. The highest effect of the solubles towards the free radical DPPH was observed for *M pungens* and 'Guayabilla', both Myrtaceae, *Rubus imperialis* (Rosaceae), *Trichocereus arboricola* (Cactaceae) and *G apiculata* (Gunneraceae) before processing. According to our data, the best sources of free radical scavengers measured with the DPPH decoloration test are the fruits of *R imperialis*, some Myrtaceae, a Cactaceae and the unprocessed petioles from *G apiculata*.

According to the proximate analysis (Table 4), the best protein sources in our study are the fruits of *C quercifolia* ($222\,g\,kg^{-1}$), *C iguanae* ($170\,g\,kg^{-1}$), *T arboricola* ($149.1–150\,g\,kg^{-1}$), *Vassovia breviflora* ($150\,g\,kg^{-1}$) and *Solanum sisymbriifolium*. Additional studies are required to determine the amino acid composition of the proteins, including the essential amino acids. Highest nitrogen-free extract was found in fruits of *E uniflora* ($882\,g\,kg^{-1}$), *Aechmea distichantha* ($871\,g\,kg^{-1}$) and *M pungens* ($854\,g\,kg^{-1}$) while the fat content was higher in *C quercifolia* ($228\,g\,kg^{-1}$) and *Allophylus edulis* ($216\,g\,kg^{-1}$).

Food plants in the Yungas comprise cultivated and gathered species. Hilgert[1] reports 91 edible plants in Lipeo and Baritú, 17 of them being important food sources. From the 26 native or naturalized species consumed, only *Juglans australis* and *C betacea* are important in the diet. The remaining species are a complement, mainly gathered by children. At present, food in the Yungas is based mainly on carbohydrates. Corn (*Zea mays*), potatoes (*Solanum tuberosum* ssp *andigena*), noodles and bread are the main intake of the rural population. Maté (*Ilex paraguariensis*) is also extensively used as a drink. Before conquest and transculturation, the former inhabitants of the Yungas have had a better knowledge of the correct combination of food and its effects on health. Ramadori[13] examined the migratory agricultural practices and the corn production in Baritú and pointed out that the energy supply of corn is insufficient if not complemented with other food resources. The biodiversity in the Yungas offers a rich variety of native food plants that can be integrated in the daily diet or developed

Table 3. Percentage of activity relative to the corresponding control induced by methanolic extracts from edible food plants gathered in the Argentinian Yungas on the free radical DPPH

Scientific name	Plant family	Plant part	Decoloration of DPPH at sample concentration of		
			$100\,\mu g\,ml^{-1}$	$50\,\mu g\,ml^{-1}$	$10\,\mu g\,ml^{-1}$
Aechmea distichantha	Bromeliaceae	Fruit, fresh	20 ± 2	14 ± 2	NS[b]
Rhipsalis flocosa ssp *tucumanensis*	Cactaceae	Fruit, fresh	NS	NS	NS
Trichocereus arboricola	Cactaceae	Whole fruit, fresh	40 ± 3	35 ± 2	26 ± 3
Trichocereus arboricola	Cactaceae	Fruit, edible part	76 ± 4	40 ± 3	24 ± 3
Rhipsalis lorentziana	Cactaceae	Fruit, fresh	13 ± 3	11 ± 3	NS
Sambucus nigra	Caprifoliaceae	Fruit, fresh	49 ± 4	47 ± 3	13 ± 2
Carica quercifolia	Caricaceae	Preserve	7 ± 2	NS	NS
Carica quercifolia	Caricaceae	Fruit, fresh	15 ± 2	13 ± 2	NS
Gunnera apiculata	Gunneraceae	Petioles	89 ± 3	60 ± 3	19 ± 3
Gunnera apiculata	Gunneraceae	Petioles, made in sugar	11 ± 2	8 ± 2	NS
Eugenia uniflora	Myrtaceae	Fruit, fresh	20 ± 3	13 ± 3	NS
Psidium luridum	Myrtaceae	Fruit, fresh	93 ± 2	89 ± 3	26 ± 2
Myrciantes pungens	Myrtaceae	Fruit, fresh	96 ± 3	94 ± 3	58 ± 2
Psidium guineense[a]	Myrtaceae	Fruit, fresh	56 ± 2	30 ± 2	6 ± 1
Psidium guineense[a]	Myrtaceae	Fruit, fresh	58 ± 2	32 ± 3	8 ± 2
Passiflora tenuifolia	Passifloraceae	Fruit, fresh	24 ± 3	14 ± 3	NS
Rubus imperialis[a]	Rosaceae	Fruit, fresh	85 ± 4	59 ± 2	20 ± 3
Rubus imperialis[a]	Rosaceae	Fruit, fresh	96 ± 3	95 ± 4	28 ± 3
Allophylus edulis	Sapindaceae	Fruit, fresh	33 ± 3	30 ± 2	7 ± 2
Sideroxylon obtusifolium	Sapotaceae	Fruit, fresh	47 ± 2	34 ± 2	8 ± 1
Sideroxylon obtusifolium	Sapotaceae	Fruit, preserve	20 ± 3	10 ± 2	NS
Vassobia breviflora	Solanaceae	Fruit, fresh	25 ± 2	16 ± 1	7 ± 2
Solanum sisymbriifolium	Solanaceae	Fruit, fresh	21 ± 3	10 ± 2	NS
Cyphomandra betaceae	Solanaceae	Fruit, fresh	16 ± 2	7 ± 2	NS
Celtis iguanae	Ulmaceae	Fruit, fresh	5 ± 2	NS	NS

[a] Different collections.
[b] NS: not significantly different from the controls.

into new cultivars. Some of the plants included in the present study are also used in traditional medicine.

The fruits of many Myrtaceae are widely used as food. Four species are the most usually gathered in the Argentinian Yungas: *M pungens, Psidium* aff *guineense, P luridum* and *M mato*. The fruits are eaten either raw or made into preserves or paste. Some of them, including *P* aff *guineense* and *M pungens* are known to be useful in relieving gastrointestinal problems and diarrhea.[1,4,14] According to Charpentier[15] the fruits of *E uniflora* contain sugars, starch, iron and fiber with high phosphate, calcium, vitamin C and provitamin A content. The ripe fruits of many cactaceae are appreciated as food. The *Trichocereus* and *Rhipsalis* species under study are also used as medicine.[7] The edible use of the petioles of *G apiculata* was reported for the Departamentos Santa Victoria and Orán (Salta, Argentina).[1] The petioles of *G chilensis* and *G tinctoria* are eaten by the Mapuche Indians in Argentinian Patagonia and Chile.[16] The fruits of *C quercifolia* have limited consumption by virtue of its high latex content.[1,2]

The ripe fruits of *S sisymbriifolium* Lam var *sisymbriifolium* are considered digestible while the fruits of *A edulis* are eaten in moderate amounts, because it is believed that an excess produce cystitis.[1] It has been reported that if the fruits of *S obtusifolium* are eaten in excess they can produce irritation in the mouth.[3] Charpentier[15] reported the proximate composition and provitamin A and C content of the fruit, recommending the addition of half a lemon for each kg fruit to neutralize the latex. *Sambucus nigra* L subsp *peruviana* and *R imperialis* are widely consumed and used to prepare sweets and preserves.[3]

The beneficial effects of secondary metabolites from *S nigra* comprises antiviral and immunomodulatory effects[17,18] as well as antidiabetic[19] and diuretic effects.[20] The fruits of the Caricaceae, *C quercifolia,* are appreciated for the preparation of preserves. The closely related *C papaya* is widely cultivated for its edible fruits, consumed either raw or made into sweets and preserves. Free radical scavengers and antimicrobial activity have been reported for the unripe papaya fruit.[21]

Little information is available on the proximate composition of native food plants occurring in the Argentinian Yungas. The nutritional value of wild *Bumelia obtusifolia* and *E uniflora* fruits collected in the Argentinian Chaco has been published.[22] In general, the fruits under study presented higher macronutrient contents than cultivated plants, with the exception of proteins, although contributing more energy than commercial cultivars and high provitamin A content in *E uniflora* ($11.98\,mg\,100\,g^{-1}$).

Guava fruits are widely consumed in tropical and subtropical countries. The fruit is also used in

Table 4. Proximate analysis of edible plants gathered in the Argentinian Yungas on a dry weight basis: mean values

Plant family and scientific name	Moisture ($g\,kg^{-1}$)	Protein ($g\,kg^{-1}$)	Fat ($g\,kg^{-1}$)	Fibre ($g\,kg^{-1}$)	Ash ($g\,kg^{-1}$)	Nitrogen-free extract[a] ($g\,kg^{-1}$)	Phosphate ($mg\,kg^{-1}$)	Calcium ($g\,kg^{-1}$)	Iron ($mg\,kg^{-1}$)	Potassuim ($g\,kg^{-1}$)	Sodium ($g\,kg^{-1}$)
Bromeliaceae											
Aechmea distichantha	130	75.3	30.0	70	23.0	871	4020	0.900	0.100	2.21	1.56
Cactaceae											
Rhipsalis flocosa ssp *tucumanensis*	121	73.2	15.6	320	26.0	565	1540	1.398	0.120	2.00	1.127
Rhipsalis lorentziana	125	120.0	12.8	120	43.5	703	3340	0.550	0.155	2.238	0.290
Trichocereus arboricola (fresh fruits)	120	149.1	119.2	230	59.0	443	4160	0.350	0.095	4.913	1.953
Trichocereus arboricola (edible part of the fresh fruits)	100	150.0	78.0	320	10.0	442	4610	0.152	0.095	2.885	1.114
Caprifoliaceae											
Sambucus nigra	120	167.0	59.0	290	37.0	447	4280	0.767	0.198	1.593	0.640
Caricaceae											
Carica quercifolia (preserve)	110	94.0	89.6	190	72.0	554	4310	0.261	0.099	5.87	0.188
Carica quercifolia (fresh fruits)	95	222.0	228.3	250	52.0	248	4450	1.150	0.105	2.432	0.110
Gunneraceae											
Gunnera apiculata (petioles)	967	114	14.6	315	45.0	511.4	4120	0.546	0.119	2.06	2.160
Gunnera apiculata (petioles made in sugar)	744	7.8	2	168	5.7	816.5	3518	0.261	0.099	3.52	0.188
Myrtaceae											
Eugenia uniflora	778	52	7.7	30	27.7	882	1800	0.350	0.095	0.754	1.953
Myrciantes pungens	100	45.0	26.2	60	15.0	854	1360	0.900	0.100	2.051	2.061
Psidium guineense	92	62.3	14.0	430	22.0	477.0	950.0	2.479	0.228	4.47	2.425
Psidium luridum	120	66.0	26.0	260	28.0	620	4150	0.512	0.092	2.44	0.043
Passifloraceae											
Passiflora tenuifolia	100	103.1	39.0	280	42.5	535	3480	0.546	0.119	4.76	2.150
Rosaceae											
Rubus imperialis	852	38	20.9	250	25.2	697	3390	0.020	0.100	1.926	0.127
Rubus imperialis	130	124.0	24.0	250	15.0	697	3390	0.020	0.100	1.926	0.300
Sapindaceae											
Allophylus edulis	115	120.4	216.0	180	28.0	455	2067	0.156	0.105	3.182	0.495
Sapotaceae											
Sideroxylon obtusifolium	110	86.0	57.0	120	21.0	716	1530	3.010	0.310	2.520	0.529
Sideroxylon obtusifolium	96	65.6	52.0	100	36.8	745.6	1940	4.213	0.302	2.50	2.94
Solanaceae											
Cyphomandra betaceae	100	87.0	36.0	129.0	58.5	689.5	2320	0.577	0.219	8.00	1.538
Solanum sisymbriifolium	120	134.0	81.1	62	42.6	680	5550	0.224	0.113	3.31	0.589
Vassobia breviflora	95	150.0	42.0	70	18.0	720	4312	0.967	0.215	5.852	0.589
Ulmaceae											
Celtis iguanae	110	170.0	50	220	240	320	912.0	86.16	0.298	3.60	3.07

[a] By difference.
The relative standard deviations of these analysis were approximately ±5%.

traditional medicine for its astringent effect and has been assessed for biological effect. The fruit pericarp of *P guineense* present antimicrobial effect towards pathogenic microorganisms[23] and the pulp and peel contains naturally occurring antioxidants as well as dietary fiber.[24] In an evaluation of four commercial guava jams in Venezuela[25] the following data were reported: titratable acidity 0.59% (as citric acid); degree Brix = 67.24; reducing sugars = 55.28% and total sugars of 62.28%.

The antioxidant properties of Mediterranean and tropical fruits has been reported.[26] Passion fruit (*Passiflora* sp) was the most active HOCl scavenger among the tropical fruits and also presented a strong effect on hydrogen peroxide. Several studies deal with the phenolic content and antioxidant activity of *Rubus* species,[27,28] cyclooxygenase inhibition and anthocyanidin glycosides;[29] effect of processing and storage on the phenolics of *R idaea* jams,[30] free radical scavenging effect of fruit juice of thornless blackberries (*R* sp) and raspberries (*R idaeus* L and *R occidentalis* L)[31] as well as its variation among cultivars and developmental stage.[32]

The flavonoid and anthocyanin distribution in *C betacea* fruits has been reported.[33]

The influence of domestic processing and storage on the flavonol content in berries,[30,34] as well as on the radical scavenging activity and phenolic content,[30,35] has been recently reported. The flavonol content of red raspberry slightly decreased with processing and more markedly during jams storage.[30] Some compounds, such as free ellagic acid, increased during storage. Their release could be explained from the thermal decomposition from ellagitannins. Strawberry processing to produce jams decreases total ellagic acid content by 20% and flavonols by 15–20%, respectively.[30]

Cooking strawberries with sugar to make jam resulted in minor losses of quercetin and kaempferol (15–18%). The decrease in quercetin content during storage of bilberries and lingonberries but not in blackcurrants or red raspberries was reported by the group of Häkkinen.[34] Losses of antioxidant were lower when the fruits were cooked without crushing. Part of the antioxidants could also be leached into the water fractions when the plant parts were previously boiled.

A comparison of the fresh, jam and acid hydrolyzate of berries had similar total phenolics content but the free radical scavenging effect, measured by the DPPH method was higher for the hydrolyzates for all of the berries types.[35]

Loss of antioxidants by leaching into the water fractions during cooking and storage can explain the lower free radical scavenging effect of the *G apiculata* and *S obtusifolium* extracts after processing into sweets or preserves.

CONCLUSIONS

Sustainable development is one of the major tasks to ensure long-term management of the natural resources in the Yungas and increase wealth of the rural population settled in the area. Government effort focused on the identification of local resources which can increase income with minimal negative effects in the Yungas environment.

The proximate composition and free radical scavenging effect of selected native food plants gathered in the Argentinian Yungas have been assessed. Most of them are consumed fresh but also made into preserves, sweets or paste for trading. Treatment of the samples to obtain sweets and/or preserves reduces the free radical scavenging effect of its methanolic extracts. Furthermore, there was not a clear relationship between antioxidant activity and content in polyphenols. As the recipes used in the Yungas have variations and the fruit/sugar ratio as well as the cooking time are variable, large differences in the total phenolic content and antioxidant activity of the sweets and preserves have to be expected.

Additional studies are necessary to determine if the observed activity is related to phenolic compounds or other secondary metabolites are responsible for the free radical scavenging effect of the extracts. The identification of the polyphenols responsible of the antioxidant activity should be considered for the future.

Further studies are advisable to assess the modification in the content of active compounds during fruit or petiole processing as well as to identify new promising species as potential cultivars.

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