

Camu Camu [*Myrciaria dubia* (H.B.K.) Mc Vaugh]: a promising fruit from the Amazon Basin

Camu-Camu [*Myrciaria dubia* (H.B.K.) Mc Vaugh]: eine vielversprechende Frucht aus dem Amazonasbecken

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Summary

Thanks to its extraordinary high vitamin C content the edible fruits of the camu camu [*Myrciaria dubia* (H.B.K.) Mc Vaugh] shrub attract increasing attention worldwide for some years. This review article addresses the actual standard of knowledge about this species which is native to the Amazon basin. In detail, its natural habitat, its botanical and agronomical characteristics, the composition of its fruit pulp, the process optimisation of camu camu containing food products and their sensorial evaluation as well as their economic potential are reflected.

Keywords

Myrciaria dubia, camu camu, vitamin C, Amazon basin

Zusammenfassung

Seit einigen Jahren zieht die Frucht des Camu-Camu-Strauchs [*Myrciaria dubia* (H.B.K.) Mc Vaugh] wegen ihres außerordentlich hohen Vitamin-C-Gehalts vermehrt weltweites Interesse auf sich. Dieser Übersichtsartikel befasst sich mit dem aktuellen Wissensstand zu der im Amazonasbecken beheimateten Pflanzenart. Im Einzelnen werden Angaben zum natürlichen Lebensraum, den botanischen und agronomischen Charakteristika, zur Zusammensetzung des Fruchtfleisches, zur Optimierung der Verarbeitung sowie zu ihren ökonomischen Perspektiven erläutert.

Kennwörter

Myrciaria dubia, Camu-Camu, Vitamin C, Amazonasbecken

Natural habitat

The Amazon basin with an extension of nearly six million km² is the largest tropical forest area in the world. It occupies areas in six countries (Bolivia, Brazil, Columbia, Ecuador, Peru and Venezuela) representing one fifth of the available fresh water in the world. The existence of these forests is threatened by ongoing deforestation – up to now approx. 13 % of the original forests are lost. On the other hand it is known that this unique ecosystem is characterized by an unusual comprehensive biodiversity, both with respect to its fauna, with e. g. more than 3000 species of fish [1], as well as to its flora (approx. 55 000 species). Yet, up to now only a small fraction of these species has been studied profoundly enough to come to reliable assertions on their potential for sustainable use.

In the case of the native edible fruit bearing species (more than 150 different species are listed from *Cavalcante*, 1988 [2]), up to now only few obtained a noteworthy economic importance, e.g. Brazil nut and guaraná. Certainly, that may be explained by the fact that the great majority of Amazon fruits still remains insufficiently studied with respect to their chemical composition, potential health benefits, post harvest behaviour, processing to more durable food products,

crop growing conditions, possibilities of commercialization, etc. The camu camu [*Myrciaria dubia* (H.B.K.) Mc Vaugh] (*Fig. 1*), a shrub from the Myrtaceae family, is one of the promising Amazonian fruits, which has obtained increasing attention since the last years. The species occurs naturally in areas of periodic flooding, such as low lands around river courses and lakes. It can remain completely submersed for approximately five months. The greatest concentration of natural populations and varieties can be found in the Peruvian Amazon [3]. Also in the north western part of the Brazilian Amazon it occurs frequently; its distribution extends into Ven-



Fig. 1: Camu camu [*Myrciaria dubia* (H.B.K.) Mc Vaugh] with kind permission of Silva [6].

ezeuela and Columbia [3-5]. Since the camu camu is found in different countries, it is also designated by a variety of other popular names like camo-camo (Peru), caçari and araçá d'água (Brazil), guayabo (Colombia) and guayabato or guaiabito (Venezuela) [3, 5].

Botanical characteristics and agronomical conditions

Typically, the camu camu shrub achieves a height of 1 to 3 m. The fruits are globular, from 1.0 to 3.2 cm in diameter, with a thin shiny skin going from pink to deep red or even dark purple when completely ripe. The juicy, extremely acidic pink pulp surrounds one to four seeds per fruit, more commonly three, of a kidney-shape and from 8 to 15 mm in length and from 5.5 to 11 mm in width [4, 7]. More parameters for physical characterisation are listed in *Tab. 1*.

Parameter	Values
Fruit weight	8.28 g
Peel weight	1.18 g
Endocarp weight	5.76 g
Seeds weight	1.34 g
Density	1.022 g/mL

Tab. 1: Physical characteristics of camu camu fruit [5]

The harvest of camu camu fruit in naturally occurring stands is difficult - at harvest time (between December and March) the shrubs are usually partially flooded. It is carried out from canoes, once or twice per week, according to the stage of ripeness [3]. Trials for cultivation of camu camu in firm soil in some regions of the federal states Amazonas and Pará of Brazil seem to be fairly satisfactory [8, 9]. The camu camu cultivated in non-floodable land have a longer harvesting period, between November and May. From that point of view camu camu could become an interesting new crop for the small farmers in that region.

Chemical composition

The most distinctive feature of the camu camu fruit pulp attracting attention is its extremely high content of vitamin C. Different authors report ascorbic acid contents ranging from 1000 to 3000 mg/100 g in the pulp [5, 7]. Compared to other natural vitamin C sources, camu camu shows the highest contents, by far (see *Tab. 2*). According to the D.A.CH. [11] the Dietary Reference Intake (DRI) for vitamin C has been established at 100 mg/day for adults. As it can be seen in *Table 2*, a medium banana (about 100 g) is equivalent of 12 % of the DRI of vitamin C per day and a medium camu camu fruit (about 8 g) is equivalent of 200 %. To achieve the DRI for vitamin C from a single source, about 8 bananas or one half camu camu fruit must be consumed per day.

Fruit	Vitamin C (mg/100 g)
Banana	12
Apple	12
Pineapple	19
Blueberry	22
Passion fruit	24
Mango	37
Mandarin	30
Lychee	39
Grapefruit	44
Orange	49
Lemon	51
Papaya	8
Kiwifruit	71
Acerola	1700
Camu camu	3000

Tab. 2: Average vitamin C content of some tropical and subtropical fruits [3, 10]

Up to now, chemical analyses of camu camu are focused mainly on ascorbic acid. *Chávez Flores* [12] showed that the ascorbic acid content in the fruit skins is higher (up to 5 g/100 g) than in the pulp. Studies performed from *Villachica* [3], *Zapata* and *Dufour* [13], *Andrade et al.* [14] and *Justi et al.* [15] show that the ascorbic acid content of the fruit pulp depends on the degree of ripeness. Yet, there is discordance about the point of maximum vitamin C production. *Villachica* [3] and *Justi et al.* [15] found that the highest ascorbic acid concentration is in unripe and semi-ripe fruits whereas the results from *Zapata* and *Dufour* [13] and *Andrade et al.* [14] indicate that the maximum vitamin C content is in the ripe fruit.

Results of more extensive publications on the fruit composition are presented in *Tab. 3*. It can be observed that the variation in the composition between camu camu from different origin is not so high, with the exception of the vitamin C content. It is important to note that some influences like origin, rain abundance, soil quality, sunshine length as well as the method used in the determination of the ascorbic acid content may be factors contributing to the different values presented [16]. The high concentration of citric acid (about 1900 mg/100 g) is remarkable, which contributes also to the fruit's sour taste [13].

The mineral content in camu camu fruit is low in comparison with other fruit as indicated by the low ash values in *Tab. 3* (0.20 – 0.34 g/100 g); therefore, the nutritional relevance of element occurrence in camu camu is limited, in general. Results from *Yuyama et al.* [17] who studied the content of some elements in different camu camu populations are in agreement with those presented in *Tab. 3*.

The findings are similar for protein and proteinogenic amino acids. Due to the very low protein content (be-

Component per 100 g	Villachica [3]	Rodrigues [33]	Justi [15]	Zapata [13]
Water	94.4 g	93.28 g	94 g	
Energy value	17 cal			
Protein	0.5 g	0.49 g	0.4 g	
Total Carbohydrate	4.7 g	5.65 g	3.5 g	
Fibre	0.6 g	1.18 g	0.1 g	
Ash	0.2 g	0.24 g	0.3 g	
Lipids	0.2 g	0.34 g	0.2 g	
Citric acid				1.9 g
Fructose				0.951 g
Glucose				0.816 g
pH		2.89		2.56
°Brix		6.9 %		6.8
Acidity (g citric acid)		1.8		3.8
Vitamins				
Thiamine	0.01 mg			
Riboflavin	0.04 mg			
Niacin	0.062 mg			
Vitamin C	2994 mg	1355 mg	1410 mg	960 mg
Amino acids				63.7 mg
Serine				31.6 mg
Valine				28.9 mg
Leucine				19.9 mg
Glutamic acid				10.8 mg
4-Aminobutanoic acid				8.2 mg
Proline				4.3 mg
Phenylalanine				3.6 mg
Threonine				3.4 mg
Alanine				
Minerals and trace elements				
K			83.88 mg	71.1 mg
Ca	27 mg		15.73 mg	6.5 mg
Mg			12.38 mg	5.1 mg
Na			11.13 mg	2.7 mg
PO ₄				29.5 mg
SO ₄				13.2 mg
P	17 mg			
Al				0.21 mg
B				0.05 mg
Cu			0.2 mg	0.08 mg
Fe	0,5 mg		0.53 mg	0.18 mg
Mn			2.11 mg	0.21 mg
Zn			0.36 mg	0.13 mg
Cl				11.6 mg

Tab. 3: Composition of camu camu pulp

tween 0.4 and 0.5 %) the nutritional contribution of amino acids are almost negligible. However, the occurrence of 4-aminobutyric acid (GABA), a non proteinogenic amino acid, in high concentration is to be considered as remarkable. This compound is known to stimulate plant growth. Its concentration normally ranges from 0.5 mg/100 g to 3.25 mg/100 g [18].

Typically the higher levels of GABA (near 3.25 mg/100 g) are found in plant tissues when they had been exposed to stress [18]. From the extremely high

GABA concentration in camu camu fruit (8.2 mg/100 g) the hypothesis could be derived that partial submersion in the harvest season signifies an extreme stress situation and that the plants counter that by production of GABA. That hypothesis could be confirmed by studying camu camu from the new dryland cultivations. If their GABA content would be low, that parameter could be taken to distinguish between camu camu from wild stands and from cultivations.

According to Zapata and Dufour [13] the pink pulp colour of ripe fruits is based on by not yet identified anthocyanin pigments. Recently, Zanatta et al. [19] identified and quantified the anthocyanins from camu camu by HPLC-DAD, HPLC-MS/MS and NMR. The total anthocyanin content in the fruit was about 54 mg/100 g. The major anthocyanin identified was cyanidin-3-glucoside, representing an average of 89 %, followed by the delphinidin-3-glucoside that represents an average of 4.6 % from the overall anthocyanin content. The anthocyanins are not the only pigments responsible for the colour of camu camu. Some carotenoids were also identified by HPLC-DAD and HPLC-MS [20]. The major carotenoid identified was lutein followed by β -carotene and zeaxanthin. Neoxanthin, β -cryptoxanthin, β -carotene-5,6-epoxide and a (Z)-isomer of β -carotene were also identified, however in very low level. Both the high ascorbic acid content and the polyphenolic compounds classes anthocyanins and carotenoids should yield a very notable overall antioxidant capacity of the camu camu fruit. Results of own first studies are presented in a parallel publication in that journal (p. 375-362). Franco and Shibamoto [21] studied the occurrence of aroma compounds in camu camu fruits. They identified twenty one aroma compounds in the head space of the fruit. The majority of the compounds belongs to the terpenes (98 %), with α -pinene (66 %) and D-limonene (24 %) being those present in greatest abundance.

According to the description of Bauer [22] the odour of the camu camu is sweet, with plum, apricot, and strong peach note and the taste has a very strong front note of nutmeg, cherry and plum.

Process optimisation for camu camu containing food products

In the regions of its major occurrence, the fruit pulp is appreciated for preparing nectars, ice creams, jams and other processed products but due to its very sour

taste it is usually not consumed *in natura* [4, 23-26]. First own trials for making camu camu containing food products with respect to minimal ascorbic acid loss and optimal process performance were conducted [27]. It turned out that the mode of the clarification technique (microfiltration or ultrafiltration) does not significantly modify the degree of ascorbic acid losses. The process performance, given by the permeate flow as a function of time, was greatest with the microfiltration membrane (pore size: 0.3 μm). The juice, clarified by microfiltration, was concentrated by reverse osmosis and osmotic evaporation, respectively. Reverse osmosis was carried out using a composite film membrane with 95 % NaCl rejection. A concentrated juice of up to 26 °Brix was obtained when using 60 bar of pressure. Osmotic evaporation was carried out in a MC-30 laboratory unit; that process resulted in substantially higher juice concentrations of up to 60 °Brix. The juices concentrated by reverse osmosis showed a 12 % loss of ascorbic acid whilst those concentrated by osmotic evaporation showed a loss of < 10 %. That is to be considered as tolerable bearing in mind the high remaining absolute ascorbic acid concentration [28]. In conclusion, the optimum procedure for preparing clarified and concentrated camu camu juices is to use microfiltration for clarification and osmotic evaporation for concentration.

Recently, a study to estimate the effect of the air temperature in the kinetics of ascorbic acid thermal degradation in ripe camu camu was done by da Silva and co-workers [29]. They compared the loss of ascorbic acid during drying the fruit pulp to a moisture content of 10 g/100 g using different drying air temperatures (50, 60 and 70 °C). The lowest degradation of ascorbic acid (22 %) was obtained at 50 °C (necessary drying time: 300 min). When using an air temperature of 60 °C the drying time decreased to 240 min. But at the same time the ascorbic acid loss increased to 34 %. With a drying temperature of 70 °C the drying time was reduced further (180 min), and surprisingly the ascorbic acid loss (25 %) also decreased to a level near that of the 50 °C drying test. Consequently, authors suggest using drying air temperature of 50 °C or 70 °C for minimal ascorbic acid losses.

Sensory evaluation

For sensory evaluation acceptance tests of a camu camu containing soft drink and a yoghurt were performed. Both beverages were prepared with clarified camu camu juice and adjusted to a juice content of 40 %. In case of the soft drink the other main ingredient was water and in case of yoghurt it was natural yoghurt. Both beverages were equally sweetened. The soft drink received a mean score of 6.0 out of 9.0, both

for aroma and flavour, which signified that the judges liked the product slightly (Fig. 2a).

On the other hand, the yoghurt obtained a mean score of 8.0 for both attributes in the acceptance test, signifying that the judges liked the product a lot (Fig. 2b). From the results obtained it can be concluded that for the two analysed attributes, the yoghurt obtained greater acceptance than the soft drink, at a level of significance of 99 %. This result also indicates that camu camu juice is better accepted when mixed with another product by which the sour taste can be masked [30].

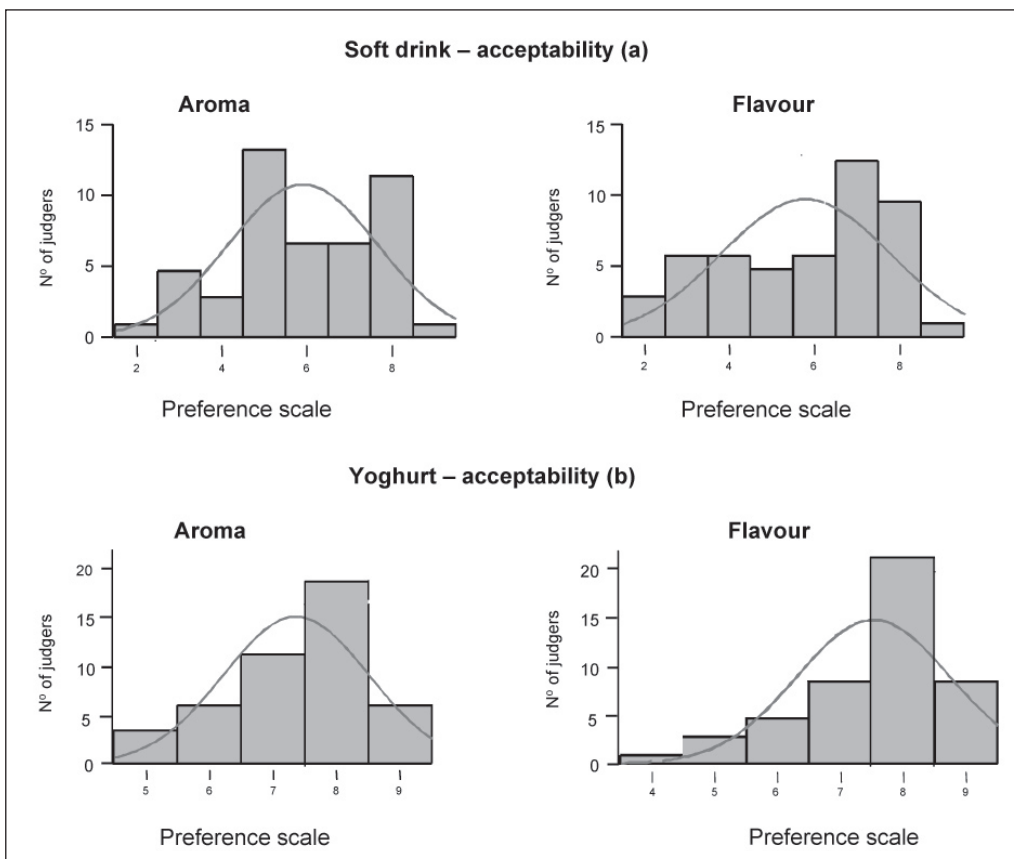


Fig. 2: Acceptability of camu camu soft drink (a) and camu camu yoghurt (b).

Economic potential

In the literature there are hints that the natural matrix (mainly fruits and vegetables) is favourable, if not essential, for the health related protective effects of ascorbic acid [31]. Against that background the camu camu fruit has a high economical potential as a natural source of vitamin C.

As long as camu camu was harvested only from flooded natural stands the annual production was very low. According to the "Organization de Estados Iberoamericanos para Educación la Ciência e la Cultura" it was about 8 t / year (in 1998). In the last years, due to the drastically increasing demand and due to the fact that camu camu can be cultivated easily, dry-land plantations in the Peruvian and Brazilian Amazon basin have been introduced successfully. Up to now, no reliable data on the actual amount on plantation area or commercialised amounts are available. However, it can be confirmed that harvested amounts are increasing substantially.

There is a considerable local demand for the camu camu fruit in Peru, where they are used to prepare juices, ice cream and liqueur [32]. In Brazil, frozen camu camu pulp is commercialized in big cities like São Paulo and Rio de Janeiro. Actually, Japan represents the major camu camu external market. The demands from USA and, for a short time, from Europe are increasing suchlike substantially that actually the current fruit production is not sufficient to satisfy the market. In Austria and Germany, for example, camu camu started to be commercialized as dried fruit pulps and water extracts in powder form and capsules, pure or as part of dietary supplements.

Conclusion

The camu camu fruit is, until now, an almost unknown tropical fruit with outstanding characteristics from the nutritional point of view. It presents a high potential to be explored as a functional food not only in its origin, the Amazon region, but also in the big markets of Europe and USA. However, more research work is necessary aiming the improvement of the productivity and the technological treatment as well as a deeper understanding of its health-related features.

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