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Underutilized agroforestry food products in Amazonas (Venezuela): a market chain analysis

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Abstract The worlds' current food production system is focused on a limited number of crops. However, international food demand is increasingly looking for more diversified supplies. In the Venezuelan State Amazonas, the Piaroa indigenous people collect and cultivate several indigenous species with local, regional, national and even international potential. A participatory approach was used to select, in cooperation with these Piaroa people, a list of products for in-depth economic analysis and for introduction in agroforestry trials in a later phase. Seven agroforestry food products of this list were identified as underutilized. Primary data collected through consumer and trader surveys on the local markets and participatory exercises in selected Piaroa communities revealed that the main causes of underutilization are the general lack of transport, processing and market infrastructure in Amazonas; the lack of demand, due to a lack of product information; the lack of market information and cooperation between the different market chain actors; and the low productivity of the traditional slash and burn plots. Solutions to overcome the infrastructural constraints are sought by looking at the example set by a local NGO.

Keywords Piaroa people · Puerto Ayacucho · Resource to consumption approach

Introduction

Since the Green Revolution modern crop production involves a limited number of crops: 12 crops are responsible for 75% of the world's food production (Thies 2000). Although uninfluenced by the Green Revolution, the local diet in the Venezuelan State Amazonas is monotonous as well, consisting mainly of yucca and yucca derivates, such as cassava (yucca bread) and mañoco (yucca flour). However, the indigenous people living in Amazonas add proteins and vitamins to this carbohydrate rich diet by collecting and/or cultivating a large variety of Non Wood Forest Products (NWFPs[1]). These NWFPs

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[1] As there is no consensus on the exact definition of NWFPs, we use the FAO definition: NWFPs are "goods from biological origin, other than wood, derived from forests, other wooded lands and trees outside forests" (Dembner and Perlis 1999). The focus of this study is on food products only, for introduction in agroforestry trials; therefore, from section "Setting and methodology" onwards we use the more specific term agroforestry food products.

serve to diversify the diet and the production system, and hence have a risk-reducing function. Most of them can be identified as underutilized crops.

Underutilized crops (referred to also by other terms as minor, orphan, neglected, underexploited, underdeveloped, lost, new, novel, promising, alternative, local, traditional and niche crops, see Padulosi et al. 2002) are referred to by Gruère et al. (2006) as species (1) that are locally instead of globally abundant, (2) on which there is a lack of scientific knowledge concerning their physiology and agronomic and ecological properties, as well as on the properties of the plants' products, and (3) which have a limited current use relative to their economic potential. This economic potential can be private or public. The private value of an underutilized crop is its propensity to generate an income, absorb production shocks and its nutritional, medicinal or food diversifying potential for local producers or collectors. The public value is its contribution to agricultural biodiversity (e.g., ecosystem services), opportunity for future generations to generate an income or proper nutrition, and the maintenance of tradition and culture. This value is generated by positive externalities or by the mere existence of the species (Gruère et al. 2006). Economic factors explaining underutilization are the following:

- Underutilized crop product output markets may be missing due to exogenous and/or endogenous constraints. For example, capers (*Capparis spinosa L.*) are underutilized in Syria due to high transactions costs caused by a lack of information and trust among market chain actors (Giuliani et al. 2006). African garden egg (*Solanum aethiopicum L.*) is underutilized in Ghana due to its short shelf life (Horna and Gruère 2006);
- The market equilibrium may be suboptimal as a result of market imperfections, such as the need for processing infrastructure and organization, causing for instance a lack of caper supply in Syrian consumer markets (Giuliani et al. 2006);
- Market failures may generate a greater public than private value. For example, rice-bean (*Vigna umbellate (Thunb.) Ohwi & Ohashi*) is undervalued as a nitrogen-containing bio-fertilizer in the mountainous areas of Vietnam (Gruère et al. 2006).

The Amazon forest contains an enormous variety of plants, many of which have economic potential. Carzo and de Anda (1999) identify at least 45 Amazonian fruit plants with potential as new cultivated crops. The contribution of the Amazon region to the diversification of the world fruit market has been insignificant up until now, with the exception of *Theobroma cacao L.* (cacao), *Ananas comosus L.* (pineapple) and more recently *Bactris gasipaes Kunth.* (peach palm). In recent years some Amazonian fruit species have attracted the interest of farmers and industrial groups, such as *Solanum sessiliflorum Dunal.* (tupiro), *Theobroma grandiflorum (Willd. Ex Spreng.) Schumm* (copoazu) and *Euterpe oleracea Mart.* (manaca or açai).

Hence, some Amazonian NWFPs have been identified as underutilized crops, which sometimes has led to their successful commercialization. At the end of the 1980s, the production and commercialization of NWFPs was strongly promoted by the conservation–commercialization hypothesis. This hypothesis stated that the extraction and marketing of NWFPs would make the forest economically attractive to the local population and would thus reduce deforestation, as evidenced amongst others by the Cultural Survival Enterprise[2] (Clay 1992a, b). Similarly, the underutilized crop theory states that realizing the potential of underutilized crops will enhance the conservation of and research on the underutilized crop (Padulosi et al. 2002).

Critique on the idea of saving the rainforest by large-scale commercialization of NWFPs emerged in the mid-1990s. First, industrial substitutes can be developed to replace NWFPs (Pendelton 1992; Arnold and Ruiz Perez 1998). Second, demand can become so high that production switches to unsustainable monoculture plantations (Clay 1992b; Pendelton 1992) and/or lead to unsustainable exploitation of the resource base (Pendelton 1992; Peters 1996). Third, once an NWFP becomes a commercial success, the exploitation tends to be taken over by a rich elite, as in most developing countries the forest is considered a common good (Dove 1993), and/or the profits of NWFP collection are seized by this same elite (Marshall et al. 2003). Hence, it is advised not to focus on NWFP collection simply from the forest, but to introduce NWFPs in agroforestry systems (Michon

[2] The Cultural Survival Enterprise marketed NWFPs, such as Brazil nut (mixed in ice cream) in North America and Europe in the 1990s (Clay 1992a).

and deForesta 1996; Leakey et al. 2005) and to focus their commercialization on local markets (Arnold and Ruiz Perez 1998; Russel and Franzel 2004). Gruère et al. (2006) identify a commoditization risk for underutilized crops, and recommend a type of supply control, such as origin labeling, for the creation of niche markets. This is necessary to ensure that underutilized crops enhance local people's livelihoods and contribute to biodiversity conservation.

This paper aims to identify and analyze underutilized agroforestry food products for incorporation in ecological and economic sustainable agroforestry systems. In the remainder of the paper, first the setting of the research will be outlined, including the project framework and the research area. Then, the methodology used for selecting indigenous agroforestry food products and gathering primary information on these crops, is explained. Next, a number of agroforestry food products are identified as underutilized, following the conceptual framework of Gruère et al. (2006) outlined above. The same section provides a description of the marketing chains, present in the area, which leads to the identification of the factors causing underutilization of agroforestry food products in the Venezuelan Amazon in the fourth section. Finally, solutions are sought to improve the commercialization of the selected crops, locally as well as internationally.

Setting and methodology

Setting of the research

This paper reports on a case developed in the context of the Guyagrofor project. This EU financed project investigates shifting land uses under increasing population pressure among the indigenous and maroon people of the Guyana shield region in Brazil, Surinam and Venezuela. As a solution to the unsustainable land use shift, the project suggests the participatory introduction of improved agroforestry systems (Guyagrofor, 2005, Guyagrofor project guidelines, unpublished).

The case in this paper focuses on the Piaroa indigenous people of State Amazonas, located in the Venezuelan Guyana shield region (Fig. 1). The Piaroa people are the third most important indigenous group (14,494 persons), living in Amazonas (Allais 2004). Traditionally they practiced itinerant slash and burn agriculture, but as population (MPD 2001) and sedentarization increased,[3] this traditional agricultural system has become unsustainable. Fallow periods have been reduced too far to enable restoration of soil fertility, resulting in a declining productivity of the agricultural fields. Moreover Piaroa farmers need to walk ever further to establish new plots, sometimes entering the territory of other communities. The increasing population creates an increasing demand for food and hence for agricultural plots. At the same time, diminishing agricultural productivity increases demand for agricultural plots as well.

Ninety two percent of the Piaroa population lives in the districts of Autana, Atures and Manapiare; Autana, where the project villages are situated, has the largest percentage of Piaroa inhabitants. Atures harbors the capital of Amazonas, Puerto Ayacucho (Fig. 1). In Puerto Ayacucho almost all the State's commercial and administrative activity takes place. Eighty nine percent of the Amazonas population is concentrated in and around its capital. There are three agricultural markets in Puerto Ayacucho: the fish market, the municipal market and the 60 anniversary market. The markets function all weekdays, but on Saturday, the typical market day, they get crowded with indigenous farmer–traders from the immediate surroundings of Puerto Ayacucho. These traders start selling their produce from 5 am onwards to the mainly Creole inhabitants of Puerto Ayacucho.

Methodology

Three villages in district Autana were selected for the introduction of agroforestry trials and participatory research: Coromoto de Cuao, Raudalito Picure and Raudal de Danto (Fig. 1). The selection process was

[3] In the 1970s the Venezuelan government's Codesur program, or program for the development of the South, aimed at sedentarizing and integrating the indigenous people by providing concrete houses and health and educational services in fixed settlements near commercial centers. The Christian missions had started this process of sedentarization in the 1930s–1940s. The increased access to health care led to a demographic transition and a population explosion in the indigenous settlements. Population growth in these permanent settlements was enhanced by an active immigration of indigenous people, attracted by the services in the permanent settlements (Melnyk 1995).

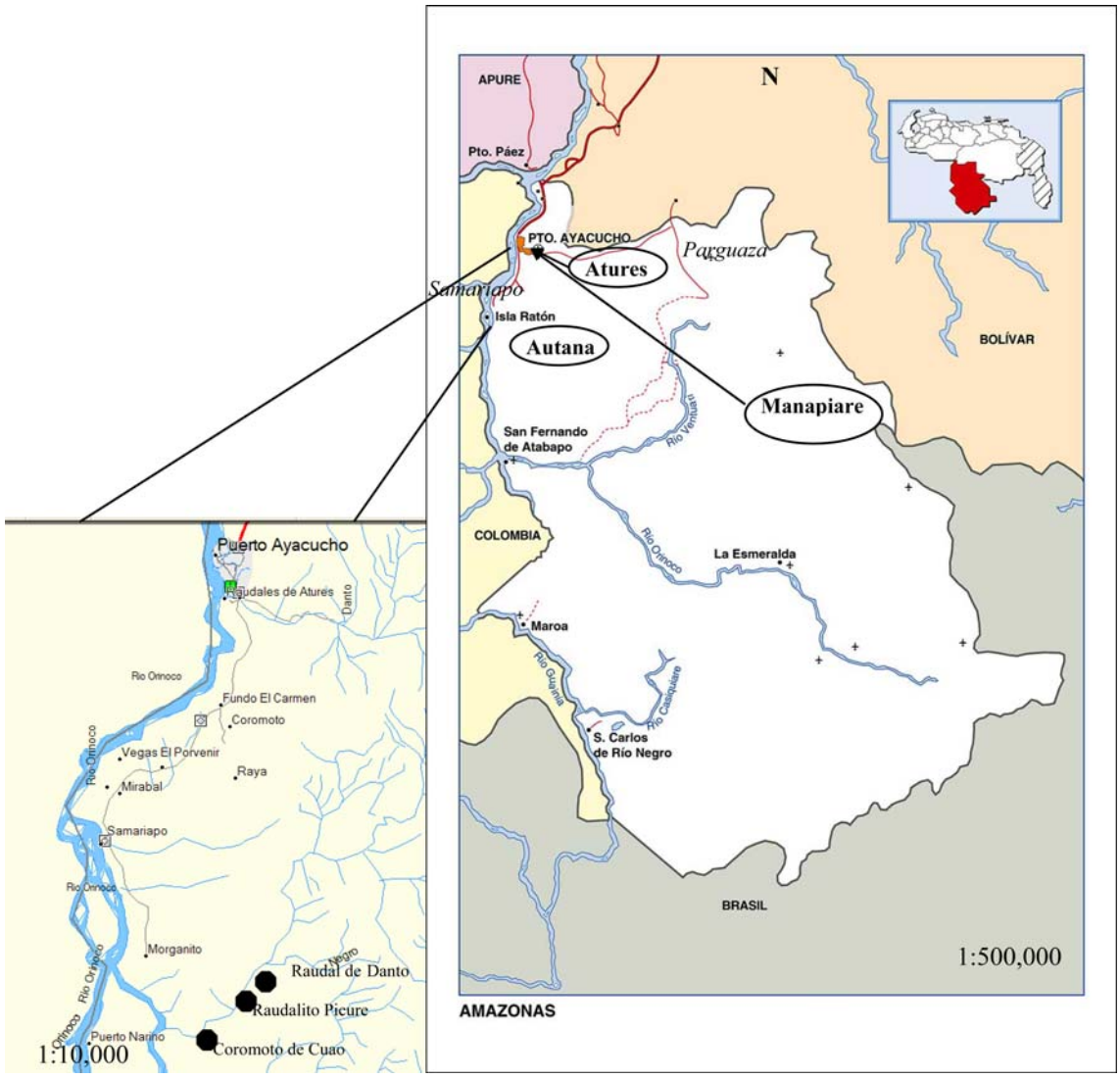

Fig. 1 Map of the study area: transport infrastructure in Amazonas and location of project villages. ——: big road; ——: smaller road; (Autana): district of State Amazonas; →: product flows to Puerto Ayacucho; *Samariapo*: area/village. *Source*: Acevedo (1999) and Mapsource (2004)

based on project-defined criteria, such as market proximity, representative population size, limited administrative and logistical problems for research activities, local interest for cooperation, and absence of other research or non-governmental organizations (Table 1). The three communities can be reached from Puerto Ayacucho by boat, via Samariapo (Fig. 1). Samariapo is the port of Puerto Ayacucho at a distance of approximately 60 km south of the city. It is the departure port for all boats to the hinterland of Amazonas. The Piaroa people of the project villages increasingly face uncontrolled fires and plagues, and declining agricultural productivity; they also need to walk ever further to establish new plots. These are all signs of the unsustainability of the current agricultural system.

Because primary information sources are important in research on underutilized crops, local stakeholder participation is fundamental for a successful analysis of market functioning (Giuliani et al. 2006). In this research we incorporated information from the producers in the project communities, from traders and consumers on the local markets and from representatives of CEPAI, an NGO involved in the

Table 1 General characteristics of project communities in Autana

Village name	Coromoto de Cuao	Raudalito Picure	Raudal de Danto
Time from Samariapo (h)	2.5	4	4.5
Population	169	44	194
Number of participants in exercises	51	17	44
Date of foundation	1968	1993	1977
Religion	Catholic	Evangelic	Evangelic
Average population growth rate/year (1990–2005)	2.38	n/a[a]	3.2

[a] The average population growth rate is not available for Raudalito Picure, as the village was founded only in 1993 by people originally living in Raudal de Danto

Source: ULA (2005, Guyagrofor first year project results, unpublished)

commercialization of indigenous products, and of Mercal, a state-led supermarket.

An initial list of 11 agricultural and agroforestry products was selected by a participatory flow chart and productive calendar (Table 2). Agricultural species were selected if they were produced in the three project villages and traded on the Puerto Ayacucho markets. All agroforestry species mentioned during the participatory exercises were included; moreover, manaca (*Euterpe precatoria Mart.*) and seje (*Jessenia bataua Mart.*) were added to this list, as they are traded substantially on the Puerto Ayacucho markets[4] (ULA, 2005, Guyagrofor first year project results, unpublished; Gillis 2006). Research efforts were than directed to the eight agroforestry species. The theory framework of Gruère et al. (2006) was applied to analyze the underutilization of these eight agroforestry species, as will be explained in the following section.

Rather than introduced species, only indigenous species were selected for in-depth economic analysis and introduction in agroforestry trials, and this for socio-economic as well as ecological reasons. A participatory approach, leading to the selection of indigenous species, enhances the Piaroas' knowledge system and hence aids in local community empowerment. Ecologically, through the incorporation of indigenous crops, the new agroforestry systems mimic the Amazon forest, and hence add to the worlds' biodiversity. The selection of indigenous crops creates the greatest potential for the conservation of the Amazonian biodiversity.

However, to ensure these agroforestry systems will be accepted, the selected agroforestry food products should lose their underutilized status. The agroforestry systems need to replace the unsustainable slash and burn plots. However, the agroforestry output of yucca, the Piaroas' staple, will be equal to or lower than in the traditional system; simultaneously, the agroforestry output will be higher.[5] As agroforestry production will become too high for proper consumption, the surplus needs to find a market, allowing income generation to compensate for the loss in yucca output. Agroforestry systems have been proven to be more labor intensive (Michon and deForesta 1996), such that the generated income needs to compensate for increased labor input as well. The income also allows the buying of productivity enhancing inputs or investments in production and commercialization infrastructure.

To identify the underutilized agroforestry food products and factors explaining their underutilization, we adopted the resource to consumption approach of Kaaria et al. (2000). This approach combines the production to consumption chain approach, describing the entire chain of activities from technologies used in production through the various stages of marketing to the final consumer, with a focus on natural resource management. This focus is obtained

[4] The participatory review focused on agricultural plots. Manaca and seje are gathered from the forest and hence were not mentioned in this process. These two species were also mentioned by Melnyk (1995) in her study on the marketing of NWFPs in the Venezuelan Amazon.

[5] This is because in the agroforestry plot the planting density of yucca will be lower, while the density of agroforestry species will be higher than in the normal slash and burn plots. Moreover, the increased productivity of yucca, due to increased soil fertility, will not in all agroforestry systems compensate for the reduced planting density.

Table 2 Selection procedure of species for in-depth study

Species	Daily seasonal farm production (kg) in			% of production commercialized in[a]			Presence on local markets	Type[b]
	Coromoto	Raudalito	Raudal	Coromoto	Raudalito	Raudal		
Corn (*Zea mays L.*)	25	120	100	60	66	0		A
Plantain (*Musa paradisiacal L.*)	16	0	100	56	0	50		A
Chili pepper (*Capsicum baccatum L.*)	2	0	20	50	0	0		A
Pineapple (*Ananas comosus L.*)[c]	8	32	30	38	63	66	×	A
Yam (*Dioscorea spp.*)	140	160	20	57	75	0	×	A
Yucca and derived products (*Manihot esculenta L.*)	120	600	100	50	0	0	×	A
Batata (*Ipomoea batata (L.) Lam.*)	60	0	0	50	0	0		A
Guama (*Inga edulis L.*)	10	0	65	100	0	66	×	AF
Temare (*Pouteria caimito Radlk.*)	60	120	30	50	0	0	×	AF
Peach palm (*Bactris gasipaes Kunth*)	60	50	200	50	0	25	×	AF
Amazon grape (*Pourouma cecropiifolia Mart.*)	0	80	200	0	0	50	×	AF
Copoazu (*Theobroma grandiflorum (Willd. Ex Spreng.) Schumm.*)	0	80	10	0	0	0	×	AF
Peach tomato (*Solanum sessiliflorum Dunal.*)	0	0	10	0	0	0	×	AF
Manaca (*Euterpe precatoria Mart.*)	n/a[d]			n/a			×	AF
Seje (*Jessenia batuau Mart.*)	n/a[d]			n/a			×	AF

[a] Project villages only commercialize occasionally on the Puerto Ayacucho markets. Smaller quantities are traded within the village or with neighboring villages

[b] Type of species: A = agricultural species; AF = agroforestry species

[c] 11 selected products for in-depth study in bold

[d] Manaca and seje are gathered from the forest in the project villages and hence were not mentioned in the PRAs as these focused on agricultural fields

Source: Based on ULA (2005, Guyagrofor first year project results, unpublished)

by including stakeholders in the decision process, amongst others by working in a participatory way. Hence, it reduces the commodity focus of the production to consumption chain approach. Unlike the resource to consumption approach, the research does not focus on gender issues (ULA, 2005, Guyagrofor first year project results, unpublished). In the area there is a strict traditional labor division. Men hunt (but decreasingly so), engage in extra-agricultural activities, cut and burn fields; women maintain the fields, plant and harvest, and process yucca. Commercial activities are performed sporadically as a couple.

A consumer and trader survey as well as interviews with key informants from Mercal and CEPAI were used to obtain insights into the functioning of the local marketing chains. Roughly 10% of the traders (42 people) and 49 consumers were interviewed on a Saturday morning in April 2006 respectively September 2005. Consumer and trader survey data were analyzed with Stata 5.0 at a 10% level of significance. Generally, a lower level of significance is accepted in the social sciences compared to the natural sciences due to the often unpredictable nature of social phenomena.

Amazonian agroforestry food products identified as underutilized crops

In this section we first identify selected agroforestry food products as underutilized, using the definition of Gruère et al. (2006). Consumer and trader survey results are then applied to construct the marketing

chains of the agroforestry food products sold on the Puerto Ayacucho markets. This market chain analysis will function as a basis to identify explanatory factors for underutilization in the next section. As Guyagrofor is an EU financed project, when dealing with international market opportunities, we focus on European markets.

Underutilization of selected agroforestry food products

The eight potentially underutilized selected agroforestry food products are copoazu (*Theobroma grandiflorum* (*Willd. Ex Spreng.*) *Schumm.*), seje (*Jessenia bataua Mart.*), peach palm (*Bactris gasipaes Kunth*), Amazon grape (*Pourouma cecropiifolia Mart.*), manaca (*Euterpe precatoria Mart.*), temare (*Pouteria caimito Radlk.*), guama (*Inga edulis Mart.*) and peach tomato (*Solanum sessiliflorum Dunal.*). General information on these crops, such as their local production system, current commercialization, parts used and properties can be found in Table 3. Underutilized crops are crops (1) that are locally abundant, but globally rare; (2) that are undervalued, i.e., their current public and private value is below its potential; and (3) for which there is a lack of research and information. Table 4 shows the results of the consumer and trader survey, giving an indication of the local demand for the eight agroforestry food products, their prices and supply.

The eight agroforestry food products under study are all typical Amazonian crops. They abound in the Amazon or the larger Latin and Central American region, but are virtually unknown in the rest of the world. All indigenous people in the Venezuelan Amazon cultivate and/or collect these agroforestry food products, which are unknown in the rest of Venezuela. Some exceptions exist. Palm leaves of manaca are occasionally used in the construction of thatches for bars and restaurants in large Venezuelan cities by a small Amazonian firm, employing indigenous people. Amazonian handicrafts sometimes reach Venezuelan tourist areas, such as Margarita (personal communication CEPAI). Temare is being tested in Australia for local production and fetches prices as high as 2.4 to 4.8 US$ per kg on the Brisbane markets, due to its good taste and exotic appeal (Chay-Prove 2004). The international markets for heart of palm from manaca and peach palm are slowly developing (Clay and Clement 1993; Mora-Urpí et al. 1997).

The public value of these species is not reflected in their current market valuation, as they all contribute to the worlds' agricultural and environmental (Amazonian) biodiversity, a global public good. Hence, the mere existence value of these agroforestry food products is high. Moreover, some of them, such as guama, generate positive environmental and agricultural externalities. Guama is an excellent nitrogen fixer, grows rapidly, produces high amounts of leafy biomass and is tolerant to acid soils (NFT 1993). Due to these positive traits the crop increases the productivity of other cultures when intercropped, and is ideally suited for agroforestry. By planting guama, the cultivation period of the slash and burn cycle can be extended, thereby indirectly reducing the pressure on the forest. Guama has, however, a low current and potential private value. Its fruits are poor in vitamins and almost every inhabitant of Amazonas has a guama tree in his home-garden. As a result, the fruits fetch low prices on the market (Table 4).

Except for guama and Amazon grape, all selected agroforestry food products are of great potential private value. Currently they are only of local importance as they allow diversification of the diet, have positive nutritional and medicinal properties and allow income generation. Melnyk (1995) calculated the potential net income from NWFPs in a small Piaroa village to be 941 US$/family/year.[6] Piaroa people of the project communities commercialize Amazon grape, peach palm, guama and temare within their village and on occasional visits to the Puerto Ayacucho markets. The highest agroforestry product variability can be found in Raudal de Danto (Table 2). The selected agroforestry food products add vitamins and proteins to the local diet, especially in remote villages with limited access to imported goods. For example, from manaca, a liquid rich in proteins and energy is obtained, which substitutes for bush meat and fish in the rainy season. Also seje fruit acts as a meat substitute. Other agroforestry food products, such as copoazu, Amazon grape, temare

[6] The net value of game, fish and arthropods, considered by Melnyk to be also NWFPs, were subtracted from the total net value to reach this value specific for plant products.

Table 3 Summary of information on selected agroforestry food products and factors causing their underutilization

Crops	Description species	Current production system	Current commercialization	Parts used	Properties	Factor(s) causing underutilization
Amazon grape (Pourouma cecropiifolia Mart.)	Shrub (7–15 m); supporting plant for peach palm	Collection secondary forest	Limited local	– Wood: charcoal – Fruit: fresh/juice	Limited shelf life	NOT underutilized: no potential public or private value
Copoazu (*Theobroma grandiflorum (Willd. Ex Spreng.) Schumm.)*	Shadow-loving shrub; family of *Theobroma cacao L.*	Collection primary forest—cultivation in secondary forest	Local + growing regional (Brazil) and international	– Fruit pulp: juices/ice-cream… – Seed: chocolate-like products – Fruit rind: manure	Shelf life (5 days without–15 days with refrigeration); fruit rich in Ca, P, Fe; suited pectin levels for jams and jellies	Market imperfections/missing output market: transaction costs, productivity, lack of research causing lack of supply
Guama (*Inga edulis Mart.*)	Nitrogen fixating tree (17 m), producing high amount of leafy biomass	Collection secondary forest—cultivation in homegardens	Local (fruits) — international use as nitrogen fixator in AF systems	– Fruit pulp – Fuel wood	Higher yields after Inga fallow; fruits low nutritional value	Market failure: lack of information on soil conserving traits
Manaca (*Euterpe precatoria Mart.*)	Single-stemmed palm	Collection primary forest	Local + growing regional (Brazil) and international market	– Fruit pulp: acai – Palm heart – Leaves for roofs	Fruits high energy and protein content; local substitute for meat in the rainy season; acai perishable	Market imperfections/missing output market: transactions costs, processing
Peach palm (*Bactris gasipaes Kunth.*)	Multi-stemmed palm	Homegarden—collection secondary forest—domesticated	Local—limited international potential	– Fruit: fresh/flour – Oil from mesocarp – Palmheart – Wood for parquet/handicraft	Fruit rich in vit. D; fruit needs boiling prior to cons.; limited shelf life; palm heart long shelf life	Market imperfections: suboptimal equilibrium: lack of demand; missing output market: limited shelf life—lack of cooled storage places
Peach tomato (*Solanum sessiliflorum Dunal.*)	Shrub	Homegarden—collection secondary forest—domesticated	Local	– Fruit: juice/fresh	High pectin level (jams/jellies); rich in Fe and vitamins; high shelf life (5–7 days, with refrigeration 30 days); resistant to transport	Market imperfections: suboptimal equilibrium: lack of supply
Seje (*Jessenia batuau Mart.*)	Single-stemmed palm	Collection primary forest	Local	– Fruit pulp: juice – Mesocarp oil	High in proteins; replaces meat in rainy season; well preservable oil	Market imperfections/missing output market: transactions costs, productivity
Temare (*Pouteria caimito Radlk.*)	Tree (10–35 m)	Collection secondary forest	Local + tests in Australia	– Fruit: fresh/ice-cream – Wood	Caramel-like taste; rich in vit. A, B3, C; shelf life 7–14 days	Market imperfections: suboptimal equilibrium

Source: Own design

Table 4 Results consumer and trader survey

Product	% of surveyed consumers buying	% of surveyed traders selling	Average quantity bought per week	Prices/kg[a]	% of weekly budget spent on[b]
Copoazu	35	24	1.37 fruits	0.93	7
Peach palm fruit	49	50	0.88 bunches	1.05	10
Manaca	86	64	3.91 kg	0.70	15
Guama	33	38	2.28 fruits	0.47	1
Seje	71	69	2.7 kg	0.70	10
Amazon grape	33	29	0.85 bunches	0.70	3
Temare	41	21	0.77 kg	0.93	4
Peach tomato	78	33	1.92 kg	0.93	10

[a] Prices in Bolivares were converted in US$, using the exchange rate on 1 October 2005, when the survey was performed

[b] In the survey we asked for the complete weekly budget spent on the markets. The amount bought of each product and its price allowed calculating the share of each product in the total budget

Source: Own analysis based on trader and consumer survey (ULA, 2005, Guyagrofor first year project results, unpublished; Gillis 2006)

and peach tomato add vitamins and variation to the monotonous yucca diet.

The potential private value of most of these products is however higher than its current value. First of all the local market is undersupplied for all products, except guama, as the percentage of consumers willing to buy is higher than the percentage of buyers selling the product (Table 4). Local demand would even be increased if consumers would be aware of the positive health benefits associated with these products. Second, larger markets could be established for most of these agroforestry food products, as they possess traits increasingly valued internationally. European consumption patterns are changing. The aging of the population and increased health concerns have intensified demand for food with low concentrations of fats, sugars and salts, and high concentrations of vitamins or other beneficial additives. In the food additive industry this has resulted in an upsurge in demand for natural additives and bio-active compounds, which reduce calorie, sodium, cholesterol and fat content (CBI 2005a). In the battle against obesity, European governments stimulate consumption of fruit and vegetables, such as the five-a-day program of the British government. This leads to an increasing demand for new, exotic fruit. Tropical fruit demand in the EU-25 has increased with 40% between 1995 and 2005 (FFTC 2004). People travel more and get easier into contact with other cultures through the media, foreign retail chains and immigrants. This increases the demand for exotic and ethnic ingredients. Amazon grape can however not benefit from this trend, as its limited shelf life and lack of processing options inhibit international commercialization. This means this crop has no potential international value.

A third characteristic, reinforcing the undervaluation of the selected crops, is the general lack of information and research on these species. The fruits of manaca for example contain a red pigment, anthocyanine, which can be used as a natural functional dye in the food industry, e.g., for yoghurt. Seje oil, extracted from seje fruits, strongly resembles olive oil, though with a higher content of unsaturated fatty acids (Clay and Clement 1993). Hence, it is a healthier and cheaper substitute for the Latin American imports of olive oil. Peach palm produces high quality palm hearts with a relatively long shelf life (Mora-Urpí 1997), which could be commercialized fresh on regional markets. Copoazu is highly valued within Amazonas for its taste; moreover, the fruits are rich in calcium, phosphor, iron and vitamin C. Copoazu fruits are in high demand in Brazil; there, production cannot satisfy demand leading to high prices (4.58 US$/kg) (Carzo and de Anda 1999). The high tannin content of peach tomato makes it ideally suited for the production of jams and jellies (Morton, 1987, Fruits of warm climates, unpublished). Although the international demand for jams and jellies is generally decreasing, the market for exotic jams and jellies is still increasing (CBI 2004). Peach tomato fruits are also ideally suited for the production

of baby food, as they contain high concentrations of vitamin B3 and iron.

Analysis of the local supply chains

To identify factors limiting the commercialization of the seven selected agroforestry food products, the marketing chains of the products sold on the Puerto Ayacucho markets are discussed in detail. This discussion is based on the results of the trader survey. Yucca derivates represent together with palm fruits the largest part of the consumer budget. Two supply areas are identified for the Puerto Ayacucho markets: Atures and Manapiare (Fig. 1). As the marketing chains for these two areas differ, they are subsequently discussed (Fig. 2).

Ninety two percent of the products from the initial list of 11 selected products sold on the Puerto Ayacucho markets are imported from Atures. Seventy four percent of these products come from communities north of Puerto Ayacucho at a maximum distance of 150 km and an average distance of 83 km. The main supply center is Parguaza, where CEPAI is active (Fig. 1). Indigenous farmer–traders living in Atures come to the Puerto Ayacucho markets, mainly the fish market, on Saturday by bus, taxi or a government or privately owned truck, which picks them up in their communities early in the morning. Upon arrival in Puerto Ayacucho they sell immediately to one of the permanent traders or they stay on the market for a longer time, to sell directly to consumers (Fig. 2). Permanent traders buy as much as they can from the indigenous farmer–traders, given their capital constraints, as everything is paid in cash.

The Atures indigenous producers are increasingly producing for the market, in larger (up to 3 ha) less diverse plots (Melnyk 1995; Lopez-Hernandez et al. 1997). This commercial production is enhanced by the proximity to the market. Transport costs range from 0 US$, when the vehicle belongs to a cooperative, to 2.27 US$ per person or charge, when traders come from the furthest regions in Parguaza. Almost all villages in Atures have easy access to Puerto Ayacucho via the road Samariapo-El Burro–Caicara, established in 1985. This contrasts with traders from other districts, who can only reach the market by boat via Samariapo. The importance of organization and external support is evidenced by the large amount of products imported from Parguaza, where CEPAI organized the farmer–traders in cooperatives. Moreover 21% of the farmer–traders are transporting together, buying products together or are involved in some other type of cooperation.

Eight percent of the products from the initial list of 11 selected products sold on the agricultural markets

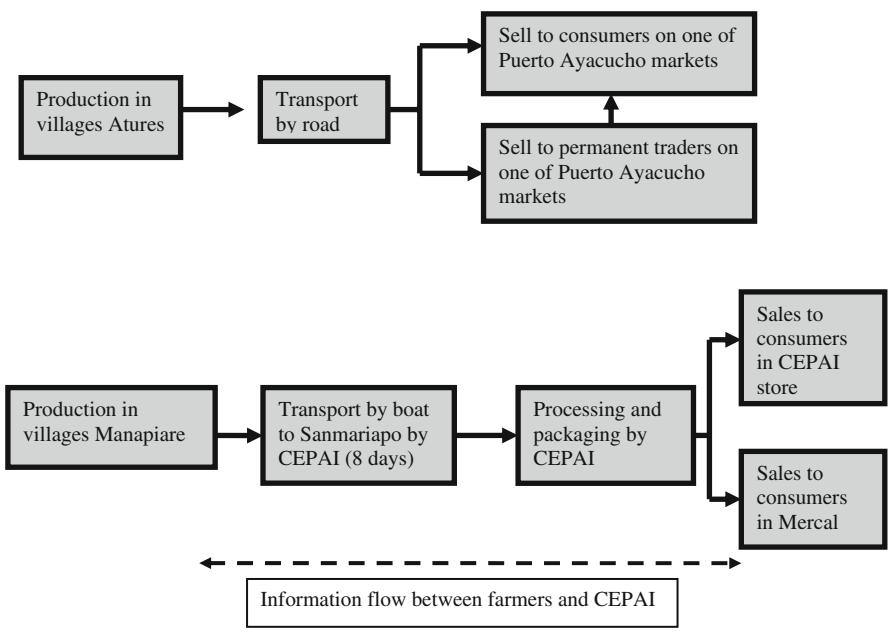

Fig. 2 Comparison of marketing chains for products coming from Atures and Manapiare. *Source:* Results of trader survey and interviews

of Puerto Ayacucho are imported from Manapiare. The only products sold on the Puerto Ayacucho markets from Manapiare are yucca derived products. However, in CEPAI and Mercal stores processed agroforestry food products from the same region are being sold as well, such as palm oil and cacao. Producers in Manapiare have been organized in cooperatives with CEPAI support. Storable products, such as mañoco, cacao and seje oil are transported to Samariapo once a minimum amount has been produced. CEPAI or Mercal boats pick up the produce in the villages when they receive a message by radio that all produce has been harvested (personal communication CEPAI). Economies of scale thus make the tedious and long transport (8 days) from Manapiare to the Samariapo harbor profitable. Part of the transformation takes place immediately after harvesting to increase storage time. Upon arrival in Samariapo the produce is transported to the CEPAI transformation centre, where it is processed and/or packaged. The products are then sold in the CEPAI store in Puerto Ayacucho or to Mercal, with whom CEPAI has an agreement. Mercal also buys fresh produce for own processing and packaging from CEPAI. The purchases from CEPAI are part of the social dimension of Mercal. This means they support local producers by buying products from them, even if this is an unprofitable operation (personal communication Mercal). As for all trade relations in the region, there are no written contracts between the involved parties about the quantities or quality to be delivered, or about the delivery time. However, we do find a better organized and longer marketing chain for the Manapiare region.

Factors explaining underutilization per species

To know selected agroforestry food products are underutilized, is not enough; we need to know why they are underutilized, such that solutions to realize their potential can be sought. According to Gruère et al. (2006) there are three possible reasons for underutilization: missing output markets, market imperfections and market failures. For each of the seven agroforestry food products identified as underutilized in section "Amazonian agroforestry food products identified as underutilized crops", the major underlying factors causing underutilization will be discussed. A summary of these reasons can be found in the last column of Table 3.

Guama is undervalued from a social point of view, as its public value is higher than its private value. The causal factor is a lack of information among the indigenous people about the crops' productivity-enhancing traits. To solve this type of underutilization due to market failure, information should be provided to the indigenous about the positive traits of guama, after which these traits can be demonstrated in field trials. Alternatively, the government may stimulate guama cultivation, e.g., through free provision of nurseries. Piaroa people in the project communities learned about the positive traits of guama and are now planting it in their secondary fallow, though it adds little to their diet or income in the short term.

Copoazu fruit used to be collected from the forest, but increasingly seeds are sought in the forest and planted in the fallow. There is a high demand for copoazu on the local market (Table 4), at a regional level (Brazil) and even internationally. Consumers on the Puerto Ayacucho markets complain about the lack of copoazu supply. CEPAI is trying to increase copoazu production in their project villages with limited success, due to lack of improved genetic material. Moreover, copoazu is planted in low densities in the fallow, as the agricultural system is focused on yucca production (15–40% of the surface of each field (Villarreal 2002)). Only what is left over after satisfying subsistence needs is sold on occasional visits on the market. Indigenous people, e.g., in Raudal de Danto, are however increasingly interested in market oriented production, influenced by success stories of copoazu production in Brazil. This low productivity is an endogenous factor causing a missing output market. Copoazu cannot be produced in the savanna area surrounding Puerto Ayacucho; it is imported from areas that can only be reached by boat. Hence there are considerable transport costs for copoazu producers in reaching the market, explaining the high price. In Table 1 the average travel time of the project villages to Samariapo is given; a one-way trip from Raudal de Danto to Puerto Ayacucho costs around 50 US$ (Gillis 2006). The expensive transport causes an exogenous limitation to commercialization. Copoazu seeds can be used in the production of white chocolate. In the Brazilian Amazon the seeds are already used for the production of cupulate, a chocolate like product. Further research is needed

to check whether copoazu can substitute cacao in chocolate production. This lack of research investment is again an exogenous limitation to reaching international markets.

Manaca fruit is collected from oligarchic stands in the primary forest, after which the surplus is occasionally transported in bulk to the Puerto Ayacucho markets. In Pará (Brazil), the largest production area of manaca,[7] production has been intensified in managed agroforestry systems, due to the upsurge in demand. Manaca is one of the best-selling agroforestry food products on the Puerto Ayacucho markets (Table 4); however, demand would increase if people were aware of the fruits' high protein content. To reduce transport costs, manaca fruit needs to be processed or the marketing structure needs to be changed. In Pará (Brazil) middlemen and transporters ensure the fruit is sold in time, after which it is processed on the market by specialized processors (Brondizio et al. 2002). Hence, there is a market imperfection: not only can demand be increased, but also supplies would be higher if the marketing chain would be better organized. At an international level manaca juice is emerging as a fashion food. Supplies are mainly sourced from Pará, where manaca grew in importance from a local product to a regional and finally international product. Due to this increased demand, research investments have been made in conservation technology. From the mesocarp, oil can be extracted with national market potential. However, the majority of the Venezuelan population lives in the coastal area at about 850 km from Puerto Ayacucho, only reachable by a road in bad condition. Again this is an exogenous factor causing a missing output market at a national level.

Peach palm and peach tomato were domesticated by the indigenous prior to the arrival of the Spaniards. Both species are now being cultivated in homegardens and secondary fallows. Just like all agroforestry food products peach palm fruits are transported in bulk, packed in palm leaves to the Puerto Ayacucho markets, where they are exposed on the ground for sale. Peach palm fruits easily damage during transport and have limited shelf life (2–3 days without refrigeration), so they need to be sold quickly. There are no cooled storage places on the market to allow longer conservation. None of the about 100 food stores (PNUD 1997) present in Puerto Ayacucho disposes of a cold chain guaranteeing the quality of fresh produce. Hence, consumers have no other option than to buy their supplies for a whole week on the Puerto Ayacucho markets each Saturday morning. Moreover, peach palm fruits compete with less damaged fruits from nearby communities. Hence, there is a missing output market for peach palm, caused by its limited shelf life, an endogenous factor, and lack of cooled storage places, and exogenous factor. Peach palm fruits are expensive, which could explain low demand. This low demand is further explained by the undervaluation of the nutritional value of these fruits (high vitamin D content). There is a high demand for peach tomato (Table 4), but a lack of supply. Peach tomato has a long shelf life (5–7 days without refrigeration) and resists transport well. Moreover, it is rich in iron and vitamins and its high pectin levels make it suited for the production of jams and jellies. The lack of supply can be explained by the lack of transport infrastructure in the hinterland of Amazonas and the focus of indigenous producers on yucca production.

Seje fruits are collected from oligarchic stands, after which they are transported in bulk to the Puerto Ayacucho markets. To increase the value of the fruit and its shelf life, as well as to save on transport costs, one could process the fruits into oil. Seje oil resembles olive oil and could substitute it. Moreover, CEPAI informants identified a high demand for this oil, because of its medicinal properties. To realize this potential more research is needed to increase processing efficiency. Modern improvement techniques and extensive germplasm prospecting could increase the yield of seje to two to three times the yield of the olive tree (Clay and Clement 1993).

Finally, temare is being produced in the secondary forest, from seeds collected in the primary forest. The fruits have a long shelf life (7–14 days without refrigeration) and are rich in vitamins. Moreover, they have a caramel-like taste. The demand for temare is again higher than the supply, because of the focus of the indigenous on yucca production and the costs of transport.

Processed agroforestry food products, such as jams and jellies, are sold in stores. However, indigenous

[7] In Brazil, manaca is called açai, and the fruits are harvested from *Euterpe oleracea Mart*., which is unlike *Euterpe precatoria*, a multi-stemmed palm.

processing hardly ever meets food hygiene standards (personal communication Mercal). Hence, indigenous producers selling their surpluses on the market face a difficult decision: to either sell immediately to one of the permanent traders surrounding the vehicle upon arrival in Puerto Ayacucho, or to sell to consumers at a 33–50% higher price, but at the risk of not being able to sell all. Research is needed on the development of local processing units, amongst others for the production of oils, so that value can be added locally. The lack of transport and processing infrastructure in combination with an ill-developed market infrastructure seriously constrains supplies. Permanent traders on the municipal and 60 anniversary market are the only ones possessing fixed stalls. Half of the traders on the municipal and 60 anniversary market also have a warehouse, while only 29% on the fish market have one. The average storage cost is 28 US$ per month to pay a watchman to guard the produce. The storage places are small concrete buildings of 4 m^2, without refrigerators or air-conditioning. Often products are stored at home, due to the lack of warehouses on the market. On all agricultural markets permanent traders have to pay taxes (18.8 US$ per month on average).

Improvement potential

Missing output markets are a serious problem, especially for those indigenous people not living in Atures. This means fundamental infrastructural investments are needed in Amazonas before any marketing intervention becomes feasible (Gruère et al. 2006). The regional government of Amazonas should invest in a new hygienic market infrastructure with more and cooled storage places. A type of transport system from the communities situated at the Orinoco River or one of its tributaries, to Samariapo, should be organized. Mercal trucks, currently only importing produce from other Venezuelan States, can be used to export Amazonian produce to the rest of Venezuela (personal communication Mercal). Investors can be attracted to provide local processing facilities, and investments should be made in research for and development of community level processing facilities. Once this fundamental infrastructure is in place, the market can be developed (Gruère et al. 2006) in three phases.

First, if demand is a limiting factor, as is the case for peach palm fruit, it should be increased by informing consumers and farmers on the products' characteristics and its potential uses. One possible way to achieve this is through trade fairs, which are amongst others organized by Banco-ex in Venezuela. Another option is to link up with government institutions, such as Mercal, or NGOs, such as CEPAI, which can inform the public about the positive traits of indigenous agroforestry food products. Hence, a first step is to conquer the local market.

Second, if supply mechanisms are a causal factor of underutilization, as was shown in the marketing system analysis above, the efficiency of these chains needs to be improved. The main obstacles to the project communities for commercialization of marketable surpluses are the long and expensive transport to the Puerto Ayacucho markets, the lack of market information, and the lack of processing infrastructure. These bottlenecks in local commercialization can be overcome by learning from the CEPAI example. CEPAI communities have resolved the transport problem in two ways. First, production is focused on non perishable products, such as cacao. If a product is perishable or one has to wait long for transport to arrive to the village, it is processed locally. Second, CEPAI communities are organized in cooperatives, such that together they reach a production level that makes transport profitable. This organization also gives them market power (Russel and Franzel 2004; Leakey et al. 2005). Farmers of the CEPAI communities are in constant radio contact with CEPAI headquarters in Puerto Ayacucho, allowing a better planning of production and commercialization (Fig. 2). Leakey et al. (2005) and Marshall et al. (2003) mention market information as a key factor in the successful commercialization of agroforestry food products. Leakey et al. (2005) consider partnerships between producer communities, NGOs and the private sector, such as the agreement between the Manapiare communities, CEPAI and Mercal, also as a key success factor.

Third, supply control is necessary to avoid the commoditization of the product and hence lowering of prices, once national and international markets are aimed for. Supply control can be reached by focusing on the niche fair trade and/or organic market. Opportunities exist for example in sales of sustainably produced palm hearts from manaca or peach palm. Both the fair trade and the organic market are growing in Europe, with annual growth rates of

respectively 42.3% and 5–15% (CBI 2005b), as consumers are increasingly concerned about the social and ecological impact of modern agriculture. Organic and fair trade certification asks for investments in certification and control systems to avoid high certification costs.

When processed products will be commercialized on the EU-25 market, the novel food law needs to be accounted for. Food products which were not legally on the EU market before 1997 are considered novel and have to go trough an extensive and expensive procedure in which they need to be demonstrated safe for consumption (CBI 2005a). This seriously hampers the commercialization of processed underutilized crops, as the procedure takes at least one year to finalize (CBI 2005c).

Conclusion

This paper analyzed the underutilization of Amazonian agroforestry food products in Venezuela. After a first participatory selection of 11 crops for in-depth economic analysis, seven of them were retained as underutilized agroforestry food products. Hence, these seven species have an unrealized public and private commercial value. On local markets there is a high demand for copoazu, manaca, peach tomato, seje and temare, not satisfied by current supplies. The supply shortage is caused by the low and declining productivity of the yucca-oriented subsistence-based slash-and-burn system; lack of transport infrastructure; and lack of research investments to increase productivity and processing efficiency. At the same time there is a low local demand for peach palm and guama, due to a lack of information at the producer and consumer end. The production potential of these underutilized agroforestry food products would be enhanced sustainably by cultivating them in agroforestry systems. By incorporating guama in these systems soil fertility would be retained, allowing a longer and more productive production cycle. At the same time the revenues earned by selling these underutilized agroforestry food products on the market allow substituting the reduction in yucca production by yucca purchases. However, to realize this potential, the barriers to the market will need to be reduced or overcome, following the example of CEPAI.

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