Ethnohistoric review of amylolytic fermentation in Amazonia

Revisão etnohistórica da fermentação amilolítica na Amazônia

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Abstract: In South America's lowlands, it was believed that fermentation processes for amylaceous substances were performed only with the inoculation of salivary amylase in the mash. In 2004, Henkel identified a unique fermentation process that was not previously known in the Americas: fermentation performed with the inoculation of an amylolytic mold, *Rhizopus* sp. Amylolytic fermentation is an important way to transform and enrich carbohydrates and is widely used in the eastern and southeastern Asia for the enhancement of beverages and food. To verify if this process was unique, extensive research has been carried out by analyzing reports by missionaries, travelers, and anthropologists to search for hints of a larger diffusion of such processes. This research made it possible to verify that the use of amylolytic molds was widespread throughout the Amazon basin, from Rio Napo and the upper Amazon to Guianas and Orinoco. In addition, it was possible to verify that *Rhizopus* sp. was not the only mold employed. It is probable that the other molds used were *Monascus* sp. and *Aspergillus* sp. This leads us to believe that the fermentation processes in the Amazon basin were likely more varied than previously thought, and are worthy of deeper studies.

Keywords: Amylolytic fermentation. *Manihot esculenta*. *Zea mays*. *Rhizopus* sp. *Monascus* sp. *Aspergilus* sp.

Resumo: Acreditava-se que nas terras baixas da América do Sul, os processos de fermentação de substâncias amiláceas eram realizados apenas com a inoculação de amilase salivar no produto. Em 2004, Henkel identificou um processo de fermentação único que não era conhecido anteriormente nas Américas: fermentação realizada com a inoculação de um bolor amilolítico, *Rhizopus* sp. A fermentação amilolítica é um mecanismo importante para transformar e enriquecer carboidratos e é amplamente utilizada no oriente e sudeste da Ásia para o preparo de bebidas e alimentos. Para verificar se esse processo era único, uma extensa pesquisa foi realizada, analisando relatórios de missionários, viajantes e antropólogos para buscar indícios de uma maior difusão de tais processos. Esta pesquisa permitiu verificar que o uso de bolores amilolíticos foi difundido em toda a bacia amazônica, desde o rio Napo e o alto Amazonas até as Guianas e o Orinoco. Além disso, foi possível verificar que *Rhizopus* sp. não foi o único bolor empregado. É provável que os outros bolores utilizados tenham sido o *Monascus* sp. e o *Aspergillus* sp. Isso nos leva a acreditar que os processos de fermentação na bacia amazônica eram provavelmente mais variados do que se pensava anteriormente e merecem estudos mais aprofundados.

Palavras-chave: Fermentação amilolítica. *Manihot esculenta*. *Zea mays*. *Rhizopus* sp. *Monascus* sp. *Aspergilus* sp.

Barghini, A. (2020). Ethnohistoric review of amylolytic fermentation in Amazonia. *Boletim do Museu Paraense Emílio Goeldi. Ciências Humanas, 15*(2), e20190073. doi: 10.1590/2178-2547-BGOELDI-2019-0073

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Recebido em 25/07/2019

Aprovado em 17/02/2020

> Leer, por lo pronto, es una actividad posterior a la de escribir: más resignada, más mas civil, más intelectual. (Borges, 1954, p. 8)

INTRODUCTION

South America's fermented beverages have always been a feature described extensively by its earliest chroniclers and later by travelers and anthropologists. In the case of sugary fruit, fermentation was obtained through wild yeasts. In the case of amylaceous substances, such as corn (*Zea mays*) and manioc (*Manihot esculenta*), it was generally believed that fermentation was obtained only through the inoculation of salivary amylase after chewing. Only in the Andes was fermentation also obtained through the pre-germination of corn (*chicha de Jora*) in addition to chewing. In order to avoid misunderstanding, we will use the term manioc (bitter or sweet) for the raw material, and cassava only to designate manioc formed in bread.

Anthropological and archeological studies (Cooper, 1949; Cutler & Cardenas, 1947; La Barre, 1970; Moore, 1989) have detailed the processes, but never supplemented with biological analyses. Schwerin (1971), in a detailed review of the process of manioc fermentation in South American low lands including the mapping of traditional manioc processing techniques, wrote: "nutritional analysis needs to take native methods of preparation into account if we are to fully understand the nutritional balance of any group under study" (Schwerin, 1971, p. 23). Unfortunately, the only in-depth analyses were made on the manioc detoxification process (*e.g.* Ampe & Brauman, 1995; Dufour, 1995; Montagnac et al., 2009; Padmaja & Steinkraus, 1995). Despite extensive anthropological studies on the subject, until a few years ago the biological study of these processes was limited. A global review of cereal fermentation processes carried out in 1999 (Haard et al., 1999) pointed out that, while extensive studies on fermentation processes existed for Africa and countries in the Asia-Pacific region, for Latin America "over the past 15 years relatively little experimental work has been conducted in this field. Furthermore, over the past five years, there has been practically no published data on the subject" (Haard et al., 1999, p. 112). With a growing interest in fermentation processes, some studies have been carried out recently on the processes still in use among indigenous populations, which offer a new point of view on the meaning of fermented beverages. For example, laboratory analyses (Almeida et al., 2007; Colehour et al., 2014; L. Ramos, 2013; Gomes et al., 2009) revealed that traditional fermented beverages in many cases were not alcoholic or had a low alcohol concentration. This confirms what many chroniclers and anthropologists wrote, that fermented beverages were primarily a food and not a drink meant to inebriate (Barghini, 2018).

An important laboratory analysis was conducted by (Henkel, 2004, 2005) in which he experimentally verified that a traditional Wapishana fermented beverage was obtained through double fermentation: a solid-based amylolytic fermentation with *Rhizopus* sp. combined with a liquid-based ambient yeast fermentation. Up until this study, it was believed that amylolytic fermentation was only used in Asia. Since Henkel's articles, seven documents appeared online that show that the same process described among the Wapishana is still in use in native groups between the Guianas and the upper Rio Negro (Rigo, 2013; Wapichana, 2013; L. Ramos, 2013; Rival, 2016, 2015; Villas-Bôas, 2016; Ramos Amaral, 2019). Unfortunately, currently native populations are strongly influenced by Western society, and it is increasingly difficult to reconstruct traditional processes. For this reason, it is necessary to try to reconstruct those processes starting from summary descriptions of ancient witnesses, even if these accounts are often biased by an ethnocentric perspective.

Amylolytic mold fermentation is easy to identify in travelers' reports because the term 'mold' is used in most descriptions. In most cases, the double fermentation - the first with a dry (or wet or humid) base and the second with a liquid base- represents a clearly distinguishable feature. A short description of the traditional process and new amylolytic fermentation will help to clarify the difference.

The processes of making fermented beverages in the South American low lands follow different paths.

The basic principle in all processes is to introduce salivary amylase into the mash to facilitate the transformation of complex carbohydrates into monosaccharides. In the case of maize, the grains can be reduced to ground flour (Cutler & Cardenas, 1947), or the grains can even be chewed whole until they are reduced to a mash (Orbigny, 1859, p. 466). In the case of manioc, processes are more complex. As shown by Schwerin (1971), cassava can be roasted, boiled, grated, fermented, or made into bread.

Once the first preparation is made, part of the material is chewed, inoculating the mash with salivary amylase, and is then mixed with the rest of the mash in a container in which water is added and generally boiled several times, boiled sweet potatoes may be added. Once cooled, the mash is left to ferment in a liquid state for a period ranging from one to several days. Salivary amylase allows the reduction of complex carbohydrates into monosaccharides. Depending on the duration of fermentation, the final product may have an alcohol content of less than one percent or may reach four to six percent alcohol (Steinkraus, 1983; Campbell-Platt, 1987; Barghini, 2004). The common element among the wide array of processes used is the fact that there is no intermediate stage between the chewing phase and mixing the chewed material with the rest of the product.

In the case of fermentation with amylolytic molds, the process is different. After its preliminary preparation, the mash is inoculated with a mold and is left to ferment for a few days in a dry, or rather in a humid, base. The mold, with its amylolytic proprieties, breaks complex carbohydrates into monosaccharides, allowing subsequent fermentation. Once the mash is covered with mold, it is dissolved in water, where it undergoes alcoholic fermentation or lactic acid fermentation, this time in liquid form. In a few cases, the fermentation is limited to the amylolytic phase, when the moist mash produces a high-grade alcoholic liquid. This is the process followed in Japan, China, and southeastern Asia for the production of fermented rice-based beverages (Lee, 1999).

Most of the documents are not detailed enough to accurately reconstruct the production sequences. The processes probably followed variations between different ethnic groups. It is possible to reconstruct in principle the sequences of traditional wild yeast fermentation and of the two large families of amylolytic processes: direct amylolytic fermentation and double fermentation with amylolytic fermentation added by fermentation with wild yeasts in water. The first sequence reflects the processes of the *Montaña* region, to which Souza (1875) and Martius (1868 [1820]) may be added, the second reflect the Guianese tradition (Figure 1 to 3).

Since the procedures for the two processes are very different, it is possible to identify amylolytic fermentation in the descriptions of missionaries, travelers, and anthropologists, even when their testimony is not very accurate.

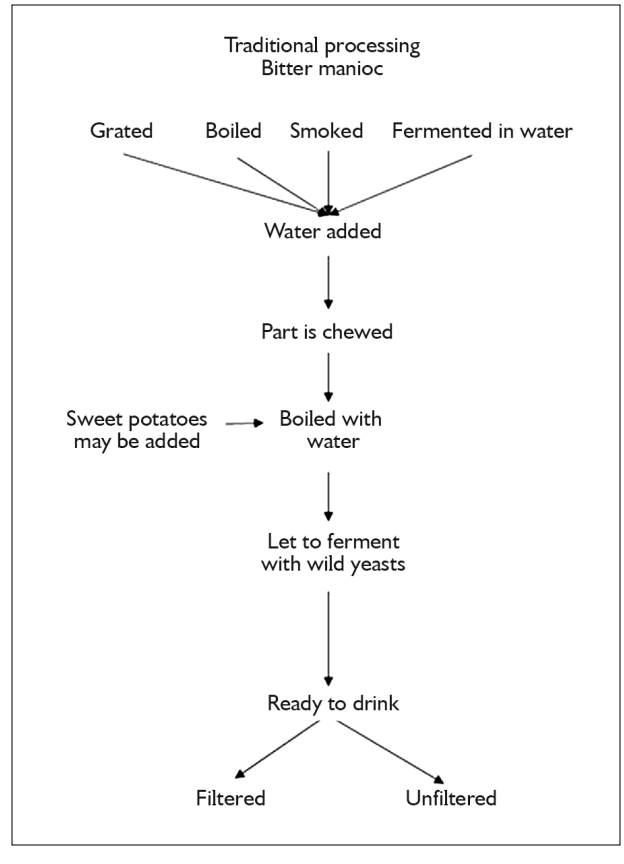

Figure 1. Traditional processing.

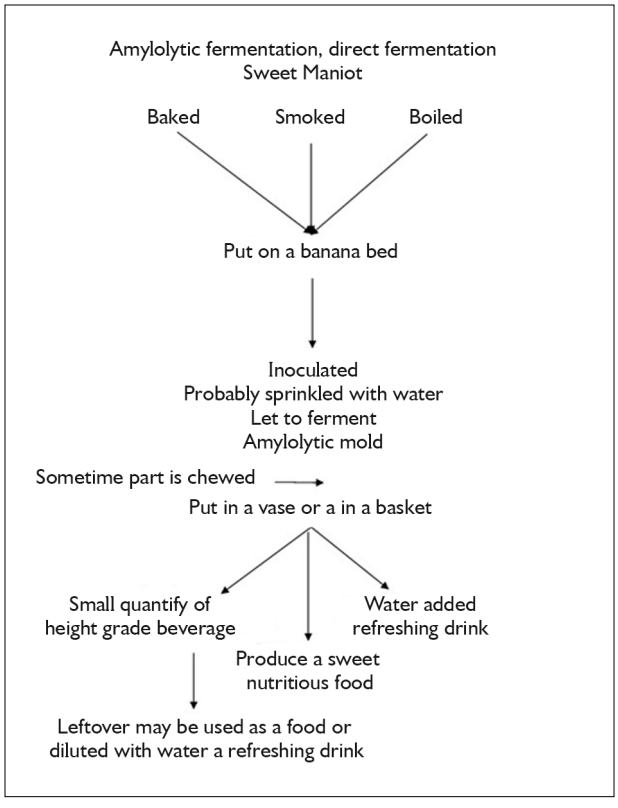

Figure 2. Amylolytic fermentation, direct fermentation.

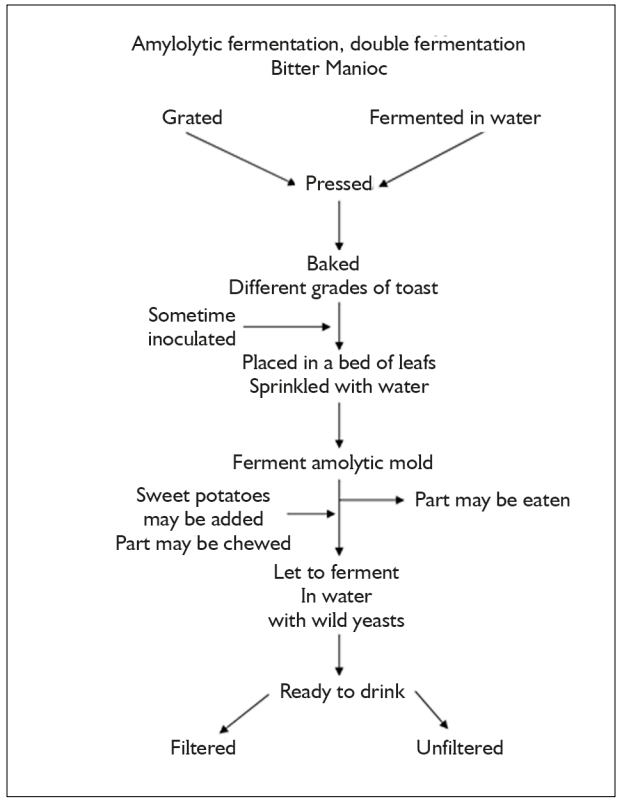

Figure 3. Amylolytic fermentation, double fermentation.

METHODOLOGY

In the context of a broader study of South America's fermentation practices, the author carried out extensive research using large reference texts, such as Steward's "Handbook of South American Indians" (1948-1959), Murdock's "Atlas of World Cultures" (1981), and Roth's An "Introductory study of the arts, crafts, and customs of the Guiana Indians" (1924), and Roth (1929) looking for processes that could be identified as amylolytic fermentation. Once the occurrence had been identified, access to the original source of the information, in the original language when possible, provided a more detailed description of the process. When this article was practically ready, it was possible to find Erikson's anthology of recipes of South American beers "La pirogue ivre. Bières traditionnelles en Amazonie" (2004) (which was also recommended by two peer reviewers), in which 6 additional occurrences of amylolytic fermentations were encountered. Some of the information was extracted from texts not quoted in these volumes.

The research was executed in seven languages: English, French, Spanish, Portuguese, Italian, German, and Latin. Research in the original languages has a double meaning. On the one hand, for many of the texts consulted there is no English translation, so reading the original text is the only way to access the detailed report. On the other hand, the analysis of these texts is fundamentally hermeneutic because the processes are not always described in a manner transparent to the reader. Anthropological analysis is often used to distinguish two types of descriptions, *emic*, or the perspective of the social group studied, and *etic*, or the perspective of the observer (Harris, 1976). In reality, the analysis of texts is more complex. Native culture is filtered through the cultures of

the observers, each one has his own view of the world. Only by understanding the two subjective perspectives can we effectively understand the processes. It is true, in some cases, that the reference to amylolytic fermentation is direct; however, in other cases, only the careful reading of the texts allows a correct attribution.

The description of a fermentation process can be very detailed. Henkel (2004, 2005), for example, divides the process into 30 distinct phases. Since the description of the processes is not based on detailed testimonies, a synthetic codification has been created. In this study, the information contained in the analyzed sources were coded according to the following scheme:

1. Author: the author of the report.
2. Date: date of publication of the report. When the publication took place after the death of the author, the presumed date of the observation is used.
3. Raw material: main material used in fermentation, sweet manioc, bitter manioc and corn (*Zea mays*).
4. Preparation: the preliminary preparation. In the case of bitter manioc most, but not all of the processes start with the production of cassava bread.
5. Chewing: if the raw material undergoes a preliminary chewing.
6. Inoculum: if the inoculation of mold is explicitly indicated.
7. Color: color of the mold.
8. Local 1: location in which the amylolytic fermentation is performed.
9. Leaves: species of leaves used to cover the mash during fermentation.
10. Duration 1: duration of the amylolytic fermentation.
11. Chewing: if the mash is chewed before the second fermentation.
12. Local 2: location of the second fermentation.
13. Duration 2: duration of the fermentation in liquid form.
14. Name: name given to the product by the indigenous communities.
15. Name of the ethnic group.
16. Linguistic group
17. Geographical area, follows Steward's classic division (1948-1959): Tribes of the *Montaña* and Yungas, Tribes of the Western Amazon Basin and Tribes of the Guianas (Gillin, 1948).

RESULTS

The results of the codification of the different occurrences of amylolytic fermentation are reproduced in Table 1, and their geographic distribution is documented in Figure 4.

The localization of the different processes as well as the linguistic group to which the processes belong is not always identifiable with certainty. Especially in ancient texts, one must essentially rely on the probable contacts of the observer, which however are not always clearly indicated, as in the case of Gumilla (2001 [1791]), Gilij (1780-1784), Daniel (2004 [1750]). When was not possible to identify the exact localization of the occurrence, it was represented with a square. In other cases, as for Fusée-Aublet (1775) and for Peckolt (1878), the indication is generic. When we come to more recent testimonies, such as Koch-Grünberg (1923 [1911]), rather than the identification of an ethnic group it is necessary to think about the identification of an area, since, directly or indirectly it seems that all the different ethnic groups encountered, by direct affirmation of the witness (*eg*. Koch-Grünberg, 1923 [1911]; Farabee, 1924; Ramos Amaral, 2019) practiced a similar process.

Since the reports do not come from researchers trying to document a process - as actually happens in the later texts (Henkel, 2004, 2005; Rival, 2015) - the descriptions are synthetic, and most of the listed variables cannot be determined.

It was possible to identify 43 preparations from 32 authors. A review of some of the original citations is important to understand that the described processes are indeed amylolytic fermentation. For this reason, some of the original reports will be quoted to show the limitations and the value of the original descriptions. Translations, when not otherwise stated, are by the author of this article.

Table 1. Amylolytic fermentation in Amazonia - list of occurrences. (Continue)

Number	Author	Date	Raw material	Preparation	Chewing	Inoculation	Color	Place	Leaves	Duration 1	Chuwing	Direct fermentation	Local	Duration 2	Name	Tribe or region	Linguistic group	Geografic region
1	Rochefort	1667	Bitter manioc	baked	no	=	red	hut	cassava	3-4	=		banano	=	Oüicou	Antilles	Arawak	Antilles
2	Grillet & Bechamel	1698	Bitter manioc	baked	no	=	=	hut	n/s	=	=		clay pot	5-6	Palinot	Guiana	Carib	Guianas
3	Maroni	1889 [1738]	Sweet manioc	boiled	no	y	red	hut	platano	4	=	yes	clay pot	n/s	Chaburaza	Napo	Kichwa	Montaña
4	Daniel	2004 [1750]	Bitter manioc	n/s	no	=	=	ruf	palma	=	=		clay pot	=	Mocororó	Santarem	Tupi ?	Parà
5	Gumilla	2001 [1791]	Bitter manioc	baked	no	=	=	=	platano	=	=		clay pot	=	Berría	Orinoco	Arawak O.	Guianas
6	Gilij	1780-1784	Corn	boiled	no	=	red	barbacot 1	n/s	=	=		clay pot	1 _ 2	Paratì	Orinoco	Arawak O.	Guianas
7	Gilij	1780-1784	Bitter manioc	baked	no	=	red?	barbacot 1	leaf	=	=		=	=	Paia	Orinoco	Arawak O.	Guianas
8	Gilij	1780-1784	Bitter manioc	tosted	no	=	red?	barbacot 1	leaf	=	=		=	=	Pajàuaru	Orinoco	Arawak O.	Guianas
9	Gilij	1780-1784	Bitter manioc	burned	no	=	red?	barbacot 1	leaf	=	=		=	=	Jaràchi	Orinoco	Arawak O.	Guianas
10	Ferreira	1888 [ca. 1792]	Bitter manioc	baked	no	=	=	ground	embauba	4-5	=		clay pot	=	Pajauarú	Makuxi ?	Carib	Guianas
11	Fusée-Aublet	1775	Bitter manioc	baked	no	=	=	=	=	=	=		=	=	Paya	Guianas	Guianas	Guianas
12	Fusée-Aublet	1775	Bitter manioc	baked	no	=	Purpurine	=	=	=	=		=	1	Kouapaya-vouarou	Guianas	Guianas	Guianas
13	Martius	1868 [1820]	Bitter manioc	baked	no	=	=	sand	banana/ embauba	=	=	yes	=	3-5	Pajauarü	Kurripako	Arawak	Western Amazon Basin
14	Osculati	1854	Platano/S.M.	baked	no	y	scarlatto	=	ayapanga	=	=	yes	=	=	Palanda-ayu	Napo	Kichwa	Montaña
15	Peckolt	1878	Bitter manioc	baked	no	=	=	=	=	=	=		=	2-2	Paya	Amazonia	Amazonia	Amazonia
16	Peckolt	1878	Bitter manioc	baked	no	=	purpurine	=	=	=	=		=	=	Voua-paya	Amazonia	Amazonia	Amazonia
17	Crevaux	1883	Corn	boiled	no	´=	yellow green	hut	banana	15-20	no		canoa	1_4	Chicha	Colombia	Colombia	Western Amazon Basin
18	Souza	1875	Bitter manioc	baked	no	=	egg yolk-brown	=	cassava	3 or 4	=	yes	clay pot	2-3	Pajauaru	Ticuna	Ticuna	Western Amazon Basin
19	Koch-Grünberg	1921 [1905]	Bitter manioc	baked	part	=	=	hut	=	=	=		=	1	Payaurú	Tukano	Tukano	Western Amazon Basin
20	Koch-Grünberg	1923 [1911]	Bitter manioc	baked	no	=		ground	banana	4	=		gourd	1	Paráckali	Makuxi	Carib	Guianas
21	Koch-Grünberg	1923 [1911]	Bitter manioc	baked	no	=		barbacot 1	banana	3	=		gourd	1	Payuá	Taulipang	Carib	Guianas
22	Karsten	1923	Sweet manioc	rosted	no	y	=	hut	banana	3	yes	yes		3	Sangúcha Shiki	Jibaro	Chicham	Montaña

Table 1. (Conclusion)

Number	Author	Date	Raw material	Preparation	Chewing	Inoculation	Color	Place	Leaves	Duration 1	Chuwing	Direct fermentation	Local	Duration 2	Name	Tribe or region	Linguistic group	Geografic region
23	De Booy	1918	Corn	lime-treated ?	no	=	=	sun	=	long	=		canoa	1-2	Chicha	Motilon	Chibchan	Montaña
24	Farabee	1924	Bitter manioc	baked	no	=	withe	dark place	banana	4	=		clay pot	2	Paricari	Makuxi	Carib	Guianas
25	Farabee	1924	Bitter manioc	baked	no	=	=	cross beams	banana	=	=		=	=	Paiwai	Caribe	Carib	Guianas
26	Farabee	1924	Bitter manioc	baked	no	=	withe	dark place	Palm banana	=	=		=	=	Paricari	Wai Wais	Carib	Guianas
27	Conzemius	1932	Corn	boiled	no	=	gray	smoke	Calathea insignis	months	=		ground	`3-4	Puput sili	Miskito	Kiskito	Nicaragua
28	Rouse	1948-1959	Bitter manioc	baked	=	=	=	=	=	=	=		=	=	no name	Guyana	Carib	Guianas
29	Grenand	1972	Bitter manioc	baked	=	=	=	=	=	=	=		=	=	Meyupapa	Wayapi	Tupi	Guianas
30	Elias et al.	2000	Bitter manioc	baked	no	y	=	=	=	2	=		=	=	Papakiri	Makuxi	Carib	Guianas
31	Henkel	2004	Bitter manioc	baked	no	y	withe	dark place	eliconia	3	=		vassel	1-35	Parakari	Wapichana	Arawak	Guianas
32	Henkel	2005	Bitter manioc	baked	no	y	withe	dark place	eliconia	4	=		vassel	1-36	Parakari	Wapichana	Arawak	Guianas
33	Wapichana	2013	Bitter manioc	baked	no	y		dark place	banana	3	no		=		pajuarú	Wapichana	Arawak	Guianas
34	L. Ramos	2013	Bitter manioc	baked	no	y	=	=	banana	=	=		vassel	several days	pajuarú	Makuxi	Carib	Guianas
35	Rival	2015	Bitter manioc	baked	no	y	=	=	cassava	=	=		=	=	Parakari	Makuxi	Carib	Guianas
36	Rival	2015	Bitter manioc	baked	no	y	withe	dark place	cassava	3	=		eliconia	=	Parakari	Makushi	Carib	Guianas
37	Villas-Bôas	2016	Bitter manioc	baked	no	y	=	dark place	banana	4	=		vassel	3-6	Paiauaru	Ticuna	Ticuna	Western Amazon Basin
38	Breton	1999 [1665]	Bitter manioc	half baked	no	no	red	=	banana	8	no		banana	2 months	Ouïcou	Antilles	Arawak	Antilles
39	Journet	2004	Bitter manioc	baked	yes	no	=	=	musacea	2	no		vassel	2	Iaraaki	Curripaco	Arawak	Western Amazon Basin
40	Guppy	1958	Bitter manioc	Baked	no	y	=	=	banana	4 or 5	no		vassel	3 or 3	Piracarri	Way-Way	Carib	Guianas
41	Bilhaut	2004	Sweet manioc	smoked	no	y	red	basket	allu panga	4 or 5	yes	yes		2	Allu aswa	Zapara	Kichwa	Montaña
42	Ramos Amaral	2019	Bitter manioc	baked	no	y	=	near fire	banana	=	=		=		Parakari	Ingarikó	Carib	Guianas
43	Rigo	2013	Bitter manioc	Baked	no	y	=	=	banana	=	no		vassel	1 or 2	Paiauaru	Ticuna	Ticuna	Western Amazon Basin

The symbol = means that the variable is not specified in the text.

Bol. Mus. Para. Emílio Goeldi. Cienc. Hum., Belém, v. 15, n. 2, e20190073, 2020

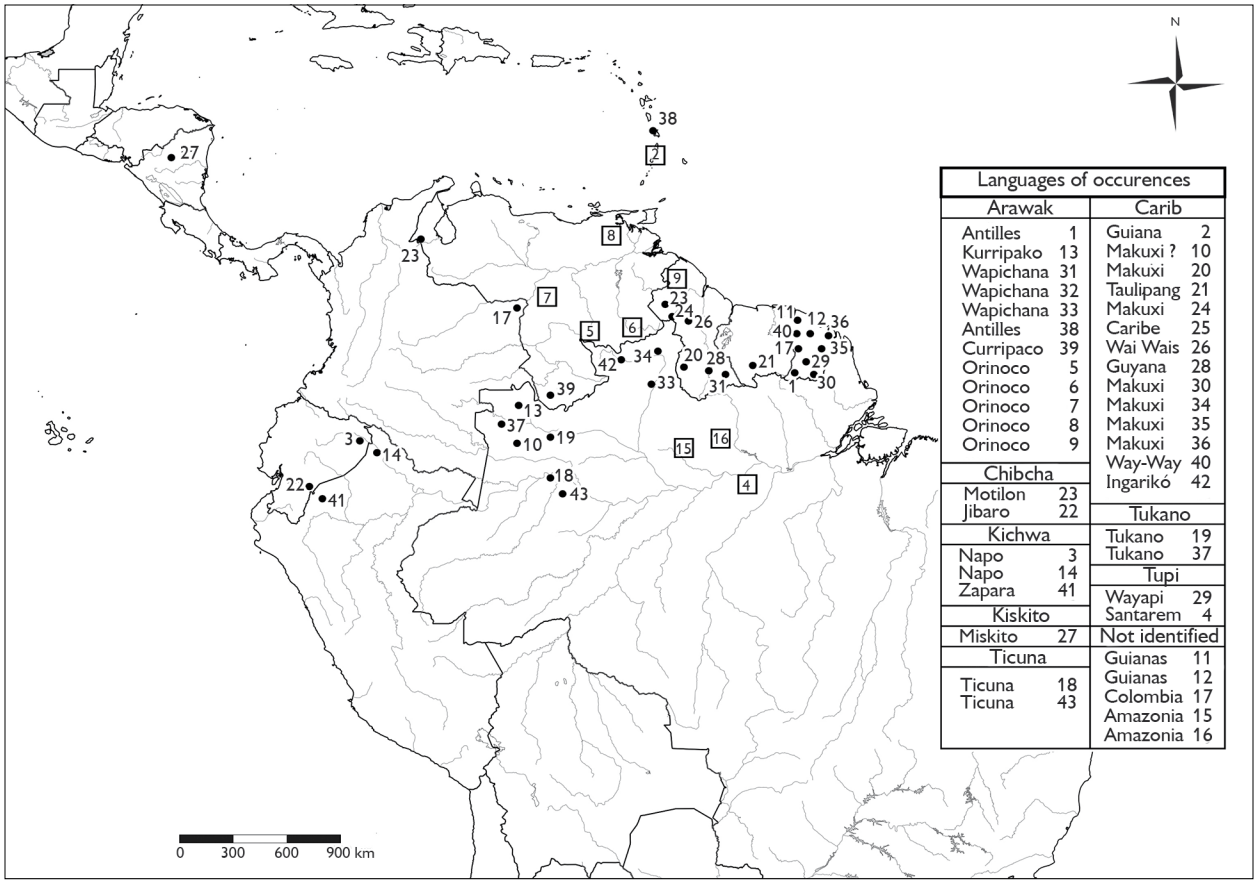

Figure 4. Amylolytic fermentation in Amazonia.

The first nine descriptions of amylolytic fermentations come from six Jesuit missionaries between 1667 and 1780 and cover practically the entire Amazon basin, from the Rio Napo to the Guianas and the Orinoco and extend to the Caribbean islands. With their long permanent residence among the indigenous populations of Central and South America, missionaries had a deep understanding of their traditional way of life. Despite their strong ethnocentric bias, many Jesuit narratives are accurate and empathic. However, the details between their descriptions of different fermentations are not uniform. While descriptions by Maroni (1889 [1738]) and Gilij (1780-1784) are especially detailed and specify that the manioc was inoculated with a mold that forms spontaneously on the piles exposed to the elements, in other cases the information provided is limited. In the case of Daniel (2004 [1750]), the only indication of amylolytic fermentation is that the loaves cassava bread were "set to rot on the roofs of the huts." (Daniel, 2004 [1750], pp. 285-286). It should be stressed that the practice of drying cassava loaves on the roof of the huts was a traditional practice, but Daniel writes:

> They put these loaves in the quantity they want on the palm or straw of their huts, as to ferment, we'd better tell them to rot in the sun and rain already, day and night, until they create mold and hair, rot, and well sour. (Daniel, 2004 [1750], pp. 285-286)[1].

[1] Translated from the original Portuguese.

Except for Father Maroni, all Jesuit authors described a process performed with cassava loaves placed on different species of leaves: manioc, banana, and palm. All reporters stated that this process resulted in a highly intoxicating beverage different from the usual ones. Only in eight cases is the color of the mold indicated: red or purple.

Rochefort's (1667, p. 496) report, original in French, about a Carib tradition in the Lesser Antilles, is the first to mention a process that could be identified, and the report clearly describes amylolytic fermentation. Roth's (1924, p. 260) transcription of the report in English is almost literal:

> The Carib Islanders apparently had two sorts of *ouïcou* made with and without potatoes, respectively. In the latter case it was manufactured as follows: After taking the cassava off the grid, they put it somewhere in the house and cover it with manioc leaves and some heavy stones to "heat" it, which it [230] does in three or four days. They next cut it into several pieces, which they lay on banana leaves, sprinkle lightly over with water, and let them remain uncovered. After one night, this becomes quite red, when it is ready to make *ouïcou* with. It is next boiled without potatoes. (Roth, 1924, pp. 229-230).

Although almost literal, Roth's (1924, pp. 229-230) translation has two shortcomings: the sentence "Quand la Cassave a demeuré une nuit ainsi, elle devient toute rouge: Et c'est alors qu'elle cet bonne à faire le *Oüicou*, & qu'elle fait bouillir son eau sans racines de Patates. On la nomme Cassave pourrie" - "qu'elle fait bouillir". Rochefort's (1667, p. 496) has been translated as "It is next boiled without potatoes," Roth (1924, p. 230) while the original meaning is that 'it [molded cassava] makes the liquid boil, without potatoes [sweet potatoes]'. The process of fermentation is frequently described as boiling. The second point is that Roth (1924) did not translate the last sentence 'On la nomme Cassave pourrie,' that is, 'They call it rotten Cassava.' The process of mold fermentation is frequently described as rotting. Du Tertre (1654, p. 184) likely reported the same process in the Caribbean, when, writing about beverages, he wrote: "il y en a qui font pourrir la Cassave pour faire le Oüycou plus fort, les Sauvages le pratiquent mais je crois que cela n'est pas sain," or, in English 'in order to make *Oüycou* stronger, some [of the Cariben] let cassava putrefy; the Savages use this process, but I believe that is not healthy.' Although Du Tertre does not describe the process, we can suppose that he was describing an amylolytic fermentation.

The second report comes from Grillet and Bechamel (1698, p. 28), two Jesuits who made a voyage to Guiana in 1674. The author could not find the original text in French, and the old original English translation was used instead:

> they make 3 or 4 different sorts of Drink, some of which became very strong by fermentation, as that which they call *Palinot*, which they make with Cassave that is bak'd more than ordinary: The pieces of which they pile one upon another when they are very hot, and keep 'em thus till they begin to mouldy, after which they mix them with Patatoes [sweet potatoes], which they cut in small pieces as well as the Cassave, and put them in great Earthen Jarrs, then they pour a proportionate quantity of Water upon 'em, and so leave all to ferment and work together till this Liquor is as strong as they desire; which is after about 5 or 6 days fermentation. They strain it before they use it, and then 'tis of Colour and Consistence of Beer, of much better tast, but much more headly and intoxicating.' (Grillet & Bechamel, 1698, p. 28).

Maroni's (1889 [1738], pp. 135-136) text is a collection of several reports, including Father Samuel Fritz's voyage along Amazon river. The original text in Spanish describes mainly the habits of Indigenous communities in the western Amazon region, including the Omaguas, the Yurimaguas, the Aisuare, the Ibanomas, and the Ticunas. The description of the fermentation process is from the Napo ethnic group, Kichwa speaking, a dialect of the Andean Quechua. His description of the amylolytic fermentation is doubtless the most detailed report of this process:

> [the beverage] they all have for the most noble events and use it in the most solemn feasts is the *Chaburaza*, which the Napos, to ennoble it, call the soup of wine. It is made in this way: the manioc is peeled and is cooked in a large pot with a little water (the Napos and others toast them in a smokehouse without removing the peel). Then they put manioc roots on the floor or barbecue on clean banana leaves. On the second day, they are sprinkled with a colored powder, which is the mold that grows on the sticks of the farm or on roots of the same manioc,

> half burned, and covered with other banana leaves. [They are left] for four days, in which time they are covered by that powder and breed something like a bloom of the same color, and this is what gives the *Chaburaza* a sweet and flavorful taste, so without that powder it is usually tasteless. After this process, the manioc is crumbled, or better, part of it is chewed, and put in a pitcher or jar and let stay another two days. In this time the liquid is maturing and the sweet taste gains a little shade of sour, styling a kind of broth that in taste resembles wine. This is the *Lacrima Xti* [Christi] of the Napos and Archidonas, with which they finish off their drunkenness, or rather, they have just finished, for the great strength that it has. The *Chaburaza* is considered healthy, and when used sparingly supports the stomach and helps digestion. It does not fade nor is it damaged like other drinks because it stays sweet and tasty for three to four weeks. (Maroni, 1889 [1738], pp. 135-136).[2]

In Maroni's (1889 [1738]) report, we have all the elements of amylolytic fermentation in the initial processing of manioc. Different from the Guianas tradition, manioc is not formed into loaves but is boiled or smoked, and it is inoculated with the 'mold that grows on the sticks of the farm or on roots of the same manioc, half burned, and covered with other leaves of banana.' Then, part of the mash may be chewed and is then fermented in a liquid state. The resulting product is a strong alcoholic beverage, what he calls 'Lacrima Christi,' a strong sweet Mediterranean wine.

Gilij (1780-1784), an Italian Jesuit, wrote describing different ethnic groups in central Orinoco, classified as Venezuelan Caribe. The account is not detailed as Maroni's, (1889 [1738]) but it describes four different processes. The first one was based on corn:

> The *paratì* [is made from] some loaves of corn, boiled, and then left on trellises to mold for a long time. They become almost reddish, and then the women prepare first a large copy of polenta. . . . in large jugs called *Ciamàcu*, or in the Canoes of Seiva, made for this purpose, and crumble them in, almost as if by yeast. To give it strength, and to make it more agreeable, one or two days before drinking they add wild honey or cooked and crushed sweet potatoes. (Gilij, 1780-1784, pp. 298-299).

The other three processes were based on manioc and were similar to the corn process:

> *Paja* is a drink made from cassava bread, piled, well wrapped with leaves, and sprinkled from time to time with water, until it molds and ferments. This drink is strong, but not as strong as the *parati*.
>
> The *Pajàuaru* is stronger, but less pleasant; the only difference from the previous drink is that the cassava bread is more toasted. This drink is blackish.
>
> The *Jaràchi*, the unique drink of the Maipùri, the Guipunàva, and of the other Indians of the Upper Orinoco, is very strong, stronger than all other *chicha*. It too is made of cassava bread, but burnt to such an extent that it looks like charcoal. (Gilij, 1780-1784, pp. 298-299).[3]

The interesting feature in Gilij's (1780-1784) description is that the first drink he mentions was made with corn, and the report clearly indicates that the mold was reddish. He also mentions three distinct preparations with cassava, and the only difference among them is the degree of toasting of the loaves. He does not specify the color of the cassava mold, but since he states that the processes involved in making the cassava drinks are similar to the first, we may suppose that mold was red, though this is not explicitly stated.

Father Joseph Gumilla was a Spanish Jesuit that spent most of his missionary life among the Warau, an ethnic group that live in the Orinoco Delta, speaking an isolated language. Gumilla's description (2001 [1791], pp. 242-243) is synthetic, it is possible to understand that the process is an amylolytic fermentation, but there are not many details. His description of the process is probably originating from his experience in the middle Orinoco.

Father João Daniel was a Portuguese Jesuit that spent most of his missionary life on the Tapajós river, near the city of Santarem among Tupi native. Daniel's (2004 [1750], pp. 285-286) description of the process, is synthetic, but it is possible to understand that an amylolytic

[2] English translation from Spanish.

[3] English translation from Italian.

fermentation was involved, although there are no details concerning the process.

Next evidences are from botanists or researchers. Although they were scientists, the descriptions are not detailed; however, are clear enough to point at a fermentation with an amylolytic mold. The first document is by Alexandre Rodrigues Ferreira, a scientist who undertook an extensive journey between 1783 and 1792 that crossed the interior of the Amazon Basin, the upper Rio Negro, and Mato Grosso. Ferreira (1888 [ca.1792]), writing in Portuguese from the 'campos do Rio Branco' (Roraima) he just described different uses of manioc, without specifying the ethnic group that developed the different processes. *Pajauru* was, for Ferreira (1888 [ca.1792]) a process used in Rio Branco, and he stresseed that such a process was not used in the region of Parà and Solimões, indirectly stating that was not practiced among the ethnic groups of the right side of Amazon River. His description is synthetic:

> (the wines are of different qualities). The ones made from manioc, and the most common among all, is the so-called *pajauarú*. Cassava, taken from the oven when hot, and a few of them soaked in water, are placed on the floor between two layers of *embauba* [*Cecropia* s.p] leaf, where they let them stay for four to five days until they get moldy. Having acquired a sweet taste, they strain them and gather them into great vessels, where they let them sour if they want it strong, or drink it soon if they want it sweet. In order to accelerate fermentation, some Indians usually mix a few portions of *beiju* - cassava bread - chewed by the old ones, whose saliva promotes fermentation. (Ferreira, 1888 [ca.1792], p. 91).[4]

Mello Moraes (1858-1863), quoting Ferreira (1888 [ca.1792]), atribue the process to the Capitania do Pará and to Rio Solimões.

A more detailed description was made by Fusée-Aublet (1775), a French botanist who published a four-volume treatise on the flora of Guiana, containing several pages devoted to fermentations in a short monograph on manioc. Fusée-Aublet lived in a colonial context in which the indigenous people of South America were under a strong Western influence and sugar production was hugely important. He suggested the use of sugar as a means to avoid chewing to encourage fermentation. He mentions four fermented beverages, the first two—the *Vicou* and the *Caxiri*—obtained through the traditional chewing method, and the last two—the *Paya* and the *Kouapaya-vouarau*—obtained through double fermentation.

> *Du Paya.*
>
> We take freshly cooked cassava loaves, which are arranged on top of each other, in order to get them moldy. Every three cassava loaves, three or four potatoes are grated and kneaded with the cassava, and then the mash is put in a vase into which about four pots of water are poured. After mixing and stirring the dough, let the mixture ferment for 48 hours. The resultant liquor is then drinkable, and is filtered before drinking. In its taste, it is similar to a white wine. A large amount of *Paya* intoxicates.
>
> *Kouapaya-vouarou*
>
> To make this drink, the cassava loaf is prepared thicker than usual, and when it is half-cooked, clumps of this cassava are formed, placed one on top of each other, and left like this until they acquire purpurine-colored mold.
>
> One takes three of these moldy cassava clumps and seven to eight grated potatoes, the whole thing is kneaded together, then the dough is mixed with six pots of water, and the mixture is fermented for twenty-four hours. The Natives of Guiana agitate and mix the liquid to make use of it, and they take pleasure in drinking and eating it; the Europeans pass this mixture through a sieve. (Fusée-Aublet, 1775, pp. 74-76).[5]

The botanist Karl Friedrich Philipp von Martius wrote a synthetic description of *pajauarü* process among the Kurripako, an Arawak speaking ethnic group living between Brazil, Venezuela and Colombia. The recipe is original: manioc mash wrapped in leaves was buried in the ground or in the moist sands of a riverbank. Martius (1868 [1820]) did not specify if mold was added to the mash.

[4] English translation from Portuguese.

[5] English translation from French.

> The *Pajauarü* is prepared with thick loaves of cassava bread by soaking them in water when they came from the warm oven, wrapping them tightly in banana leaves or embauva leaves (poquequa) [*Cecropia* sp.], and burying them in the ground or in the moist sands of a riverbank. The vinous fermentation takes place here in three to five days, depending on the place of storage and the weather, and is speeded up if one adds *beijüs* (cassava bread) that had previously been chewed by older people. This mass, mixed with water and probably preserved in a continuous fermentation, sometimes mixed with other ingredients, makes the main drink served at festivities. (Martius, 1868 [1820], p. 520).[6]

In 1846, the Italian explorer Osculati (1854) gave a detailed description of the process, including a recipe for the production of the inoculum: "a red powder or flowering, which they artificially obtain by cutting into small pieces the stem of a *yuca-brava* [bitter manioc] shrub that they toast and leave to the dew for eight days" (Osculati, 1854, p. 111). Osculati's (1854) description was based on a roasted plantain, but the author stated that the same process was used with manioc.

> The *chicha* called *palanda-ayu* is prepared by roasting the mature plantain (banana), peeled and squashed, and placing it on very large leaves called *ayapanga*. [Aya panga, *Ceonoma triglochin* Burret, Cfr: Balslev, 1997, pp. 6-7] During this process, they mix the dough with a red powder or flour, which they artificially obtain by cutting into small pieces the stem of a *yuca-brava* [bitter manioc] shrub that they toast and leave to the dew for eight days. At the end of this period, a mold of a beautiful scarlet color appears on the stem, which has a good smell and comes off at the slightest puff of air. This powder has the property of fermenting and souring the banana dough that is left wrapped in those large leaves for a certain time, after which the preparation is completed. When they want to serve, they take some of this substance, dilute it in cold water, and gulp it down. The beverage is such a nutritious and substantial drink that many Indians spend whole weeks without taking in other nourishment. (Osculati, 1854, pp. 111-112).[7]

Peckolt (1878), a German naturalist living in Rio de Janeiro, translated Jean Baptiste Christian Fusée-Aublet's text into Portuguese, stating that such beverages, common in Guiana, was probably widespread throughout the Rio Negro and all over Amazonia. Although Peckolt (1878) did not write from direct experience, Souza (1875) confirmed his opinions. In charge of the ethnographic report of the Rio Madeira Commission, Souza (1875) provided a good description of the process in use among the Ticuna (speaking an isolated language that may be related to the extinct Yuri language) that lived on the left size of the shores of the Solimões between Tabatinga and São Paulo de Olivença. It is important to stress that in his description of the process there are two different phases. In the first phase, there was the production of a limited quantity of fermented liquid of "a glass of half pint" (Souza, 1875, p. 112). In the second phase, the solid fermented manioc was dissolved in water and formed a thick, cream-like broth with a pleasant flavor, which was very cooling and diuretic. The first phase was similar to the original recipe for sake and produced a wine. In the second phase, the result seems like a food or refreshing drink rather than an inebriating one.

> As for the *pajauaru* or *caixiri*, prepare it as follows: grate the manioc, squeeze it in the *tipiti*, discard the broth, and from the mass make big *beijus* [cassava bread], which are toasted in the oven to make cassava flour.
>
> When it is cooked, they prepare it on planks or *tabocas*, a bed of banana leaves one inch thick, on which they put the *beijus*. They sprinkle with water and then spread on chopped manioc leaves, which they call *maniçoba*, and cover them with another layer of banana leaves of the same thickness as the lower one. On the top and sides, they place boards of sufficient strength so as not to crush the pile.
>
> After three or four days, they uncover it and deposit the *beijus*, already covered with mold, into large pots, which they hermetically seal with leaves overlapping one another and tied with vine.
>
> Two days later they uncover the mash and find that the wet *beijus* have let run a liquid of yellowish and crystalline color with the taste of white wine. Each large pot produces a half pint of this liquid.

[6] English translation from German.

[7] English translation from Italian.

> These beijus, after dissolved in water, become, according to the quality of the manioc, egg yolk or brownish color and form a thick, cream-like broth with a pleasant flavor that is very cooling and diuretic. (Souza, 1875, pp. 111-112).[8]

20th century records contain the descriptions of different processes, which are usually not detailed.

Koch-Grünberg (1921 [1905], pp. 39-40) described the preparation of the *kashiri* among the Tukanos of the upper Rio Negro, and reported several indigenous beverages (Koch-Grünberg, 1923 [1911], pp. 53-55): *kaschiri*, *payuá*, and *parákali* as amylolytic fermentations among the Taulipang and the Makushi, in Roraima.

De Booy (1918), an archeologist, not an ethnologist, explored Sierra de Perija Mountains of Venezuela, close to the border with Colombia, which were previously unexplored before his expedition. He spent six weeks investigating the ethnology of the Macao Indians, a Motilone tribe. The process described (De Booy, 1918, p. 202) is interesting because it report a process made with corn. The corn mash, after becoming moldy, was stored for a long time before being mixed with other ingredients and water in order to ferment (*cf*. also Métraux & Kirchhoff, 1948, p. 366).

Karsten's (1923, 1935) description of *sangúcha shiki*'s processing is rather complex and devoted mainly on ritual aspects, and for this reason it takes up 24 pages. *Sangúcha shiki* was a wine used only in the ritual of shrinking the head of a dead enemy. He described in detail the behavior of the shaman and the participation required in making the drink. The killer of the dead enemy and his family members, with their hands tied, used different types of leaves and a powder extracted from the stem of manioc plants to treat previously roasted manioc (not boiled, as for the preparation of the *nihamánchi*, the ordinary manioc drink). Based on Karsten's (1923) explicit declaration about wet fermentation, the inoculated product was left hanging in baskets in the shade for three days, and was more alcoholic than the traditional product. (Karsten, 1923, pp. 56-80).

Conzemius' (1932) report is related to the Misquito ethnic group, living in Central America, therefore outside South America's area. It deserves to be mentioned because it is similar to the process described by Martius (1868 [1820]), and because it suggests that the amylolytic fermentation process had a greater diffusion than is shown by this study. The process described used corn, which, once ground and wrapped in leaves, was left for a long time to mold before being fermented in a liquid base. This fermentation took place in a hole dug in the ground, a procedure similar to Martius's report.

> Dry maize is ground on the *metate*, wrapped in large leaves after the manner of the "tamales" of the Ladinos, and thus cooked in boiling water. It is then kept for weeks or months over the smoke of the fire, whereby it becomes covered with a grayish mold, which accounts for its name (*puput* "gray"). A few days previous to the celebration of the feast, the mass is taken out of the leaves, crumbled and cooked with a small quantity of water; it is then poured in a hole made in the ground over which a provisional shed has been erected. A thick layer of *bijagua* leaves [*bijagua* leaves *Calathea insignis*, Conzemius, 1928, p. 197] or of balsa bark prevents the beverage from coming in contact with the ground. In two or three days fermentation will be completed and then the drink is ready for the palate. (Conzemius, 1932, p. 100).

The work of Grenand (1972), about the Wayapi, in French Guiana, is a special case. In fact, more interesting than the description of the process is the fact that the author stated that the moldy cassava was also used by children almost like candy: "the pieces of cassava that the Indian children suck without eating, a little like our children with their pieces of candy" (Grenand, 1972, p. 104)[9]. Henkel (2005, p. 5) also observed that "A large portion of the sweet cake may be consumed at this time, particularly by children". This usage is confirmed by Wapichana (2013). In a more recent study (Grenand, 2004), listing the three

[8] English translation from Portuguese.

[9] Translated from French.

different processes to produce *kasili*, states: 'made from moldy cassava, now in disuse (*payawalu*)'.

Differing from other texts, Farabee (1918, 1924) provided a good description of the process. He stated that the beverage, with a similar name and similar process, was common to the Arawak and Caribe groups in the Guianas.

> The most important as well as the most intoxicating drink made by the Indians is *parikari*. It is the same drink that is known among the Carib tribes as *paiwari* and is used in the same way. It is principally used at certain dances which take on the character of drinking bouts, but it may be used at other times as well. It is not always kept on hand, because it requires time and pains to make it. (Farabee, 1918, p. 43).

Elias et al. (2000) mentioned *parakari* several times, but only included a synthetic description of the process. The process of production is described in the following steps: white or cream-colored roots (manic) were scraped, grated, squeezed, baked, and burnt (in thick cakes); then soaked in water, wrapped in banana leaves with powder from manic leaves infected by fungi from a previous preparation of the product, and left for 2 nights.

Farabee's (1924) detailed description of the process motivated Henkel (2004, 2005) to study the manufacturing aspects of this style of fermentation, which for the first time was analyzed by scientific standards. Henkel (2004, 2005) measured the physical and biological variables of the process, and identified the mold as *Rhizopus* sp. Henkel (2004, 2005) published his first article on the subject in 2004, and a second article in 2005. The two articles represent the best introduction to amylolytic fermentation in Amazonia and showed the effects on the nutritional content of the beverage. Comparing this process with similar ones in Africa and Asia, Hankel reconstructed a possible evolutionary origin of it.

After this initial scientific analysis of the process, several documents, not published in peer reviewed journals, described the same process, but from different points of view. Although they may not be considered ethnobiological reports, they are interesting because they confirm that the process is still in use among different ethnic groups in the Guianas Shield and in the upper Rio Negro. They also testify to two different visions of the indigenous processes.

Wapichana (2013) is the report of a native South American who proudly reaffirms the customs and traditions of his people in his blog. L. Ramos (2013), though with the same spirit, observes the same process with detachment because it produces an intoxicating drink. Finally, Rigo (2013) and Villas-Bôas (2016) are examples of the worldwide tendency to catalog and describe gastronomic processes with a desire to return to traditional processes.

In three studies, Rival and Mckey (2008). Rival (2016, 2015) described in detail the *parakari* production processes among the Makuxi, Patamona, and Wapishana. She stressed that the analyses of the different processing sequences ("*Chaîne opératoire*") and the comparison of different fermentation processes "allow for a better understanding of native thinking and what has changed over the course of history" (Rival, 2016, p. 647).

Erikson's (2004) anthology on beer brewing in South America provided 6 new citations of probable amylolytic fermentation that deserve to be included in the article, and it was also possible to identify a new study of amylolytic fermentation among the Ingariko.

In the six quotations encountered in Erikson (2004), three serve only to confirm processes already known. Grenand (2004) only stated that the process carried out with the moldy cassava, that existed in the past (Grenand, 1972), is no longer practiced. Journet (2004) described the process without new information between the Arawak-speaking Curripaco or Kurripako, on the border of Colombia, Brazil and Venezuela, (already described by Martius (1868 [1820]). Guppy (2004) and Camargo (2004) described the process executed by the Carib-speaking Wai-Wai in French Guiana without new data.

Bilhaut's report (2004) is important because it described a process of amylolytic fermentation among the Zapara, or Sapara, an isolated ethnic group of the *Montaña* region on the border between Ecuador and

Peru. The woman that executed the operation stated that she had learned the process from the kichwa neighbors, the Napo (already met twice in Maroni (1889 [1738]) and Osculati (1854), and followed the advice of her husband, of kichwa and achuar ancestry (therefore of the Jibarro group) already met in Karsten's report (1923). It is interesting to note that the use of the leaves to cover the fermentation also followed the tradition of more than 150 years before, when Osculati specifically mentioned *ayapanga* [*Aya panga*, *Ceonoma triglochin* Burret, Cfr: Balslev, 1997, pp. 6-7] and the Zapara called *alu panga*.

The Carib-French dictionary of Breton (1999 [1665], p. 151) offers an ancient recipe from the Antilles:

> The Savages make cassava [= cassava cakes] of unpressed flour, which are half a foot thick, which they pull out half cooked, put them on banana leaves placed on a board, sprinkle them with sea water. And having wrapped them in the same leaves, they find them after eight days all red, knead them, wrap them, and keep them for two months, at the end of which they make *ouicou* so strong, that having once drunk the amount of two glasses, I remained inebriated all day long as strong as if I had had a debauchery of the best wine of Beaune.[10]

Note three fundamental differences in relation to the procedures of the continent. The manioc loaves were undercooked, while on the continent in some cases they were almost burnt. They were bathed with sea water and there is no mention of inoculation. They were ready in a week, while on the continent generally in three or four days and they were put to rest, before being used, for two months.

Ramos Amaral (2019) in a doctoral thesis on the religion of the Ingarikó, briefly described the production process of the *parakari*. The important point of the thesis is that it stressed the large number of fermented drinks produced and shared with neighboring ethnic groups, a thesis confirmed by the name *parakari*, which is shared with neighbors Wapishana and Macuxi.

DISCUSSION

The list of occurrences of amylolytic fermentation in Table 1 and identified in Figure 4 should be enough to confirm that this process was widely used throughout the Amazon basin. From the descriptions, it is possible to verify that amylolytic fermentation was obtained not only with a white mold, *Rhizopus* sp., but also with other molds, one of which the chroniclers indicate as being red or purple, and others that are described as grey, yellowish, green, or an egg yolk color. Although the sources of this study are written texts, without field or laboratory research, it is possible to suggest that the red mold used was *Monascus* sp. In fact, *Monascus* sp., like *Rhizopus*, easily colonizes carbohydrates and is also used in China, Japan, and other Southeast Asian countries for the preparation of food and drink (Park et al., 2016; Takeshita et al., 2016). In particular, *Monascus purpureus* is used in the amylolytic fermentation of rice for the production of red rice, used both for the preparation of beverages and traditional medicines (Arunachalam & Narmadhapriya, 2011). A third mold defined as grey or yellowish green may have been *Aspergillus* sp., used in Japan for the production of *Amazaké* (sweet rice) and *Koji* (a basic fermentation mold used in different recipes) (Sandor, 2012).

The wide diffusion of the process would suggest a common origin; however, the techniques used are quite different. As for the *tipiti*, which Métraux (1928) believed had only one origin, but Carneiro (2000) shows was unlikely, it is possible to hypothesize that the different preparations were developed independently.

Within the records, it is possible to recognize two separate traditions, the first in the region of the *Montaña* (Steward, 1948-1959): the Rio Napo, and the Pastaza, and a second in the Guianas, with an extension into the upper Rio Negro and to the Caribbean islands. The other records are isolated traditions.

[10] Translated from French.

Four records represent the tradition in the region of the *Montaña*: Maroni (1889 [1738]), Osculati (1854), Karsten (1923) and Bilhaut (2004). The common basis is the use of macaxeira (sweet manioc) and by the use of a specific inoculum: "a red or purple mold that forms on the branches of the burnt manioc plant" (Osculati, 1854, p. 11). In all the other records, only Rochefort (1667) in Guiana, Gilij (1780-1784) in the Orinoco and Bilhaut (2004) in the Antilles, indicated a red mold, but they did not specify the origin of the inoculum. In the region of the *Montaña*, the preparation of the raw material is not uniform: since was used sweet manioc (*macaxeira*) the root could be boiled, toasted, or smoked. In the case of Osculati (1854), the process was to be carried out either with *macaxeira* or with *platano* (plantain), or even with pumpkins. This tradition has one original point: fermentation is carried out only with amylolytic mold, producing a high-grade liquor. Different from the Guianas tradition, there is no second liquid-base fermentation. The moist manioc paste produces a high-grade liquid directly through the mold, which is different from the *chicha* produced with the traditional chewing system, also present in the region. The tradition of the region of the *Montaña*, therefore, is closer to the fermentations practiced in Asia, such as Japanese sake and Chinese red wine. In fact, in these examples the fermentation is processed only with amylolytic molds that are not inhibited by the concentration of alcohol, and therefore the liquid can exceed an alcohol content of 20% and is diluted with water, in the case of Sake, to reach a concentration of 15% (NRIB, 2017). Outside the region of the *Montaña*, the fermentations using only molds are those recorded by Souza (1875) and Martius (1868 [1820]).

The concentration of processes between Kichwa ethnic groups, dialect of Andean origin defined as Northern Quechua, could suggest an Andean origin of the process. It may have originated from the *yamur aca*, (Guaman Poma De Ayala, 2005 [1615], p. 243) the special drink intended only for the Inka, which took a month to manufacture, and had a high alcohol concentration.

The second characteristic of the region of the *Montaña* tradition is disclosed in two records that clearly suggest that the fermented mass was also used as a food, diluted with water. Osculati (1854) and Karsten (1935) describe in detail how, in the case of voyages, even of long duration, the fermented mass was wrapped in leaves and used as provision. The process is not unique and was also in use in the eastern region, from Guiana to the upper Rio Negro. Explorers, such as Schomburgk (1931) and Koch-Grünberg (1921 [1905], 1923 [1911]) always mention that during expeditions large quantities of the fermented mash were stored as a provision. However, in these cases the traditional fermented mash used, was obtained through chewing and fermentation with wild yeasts.

The Guianas tradition of amylolytic fermentation extends to the upper Rio Negro and the Caribbean Islands. The preparation is quite uniform: the bitter manioc undergoes a first processing. It may be processed through fermentation in the water of the roots (*mandioca puba*) or it is grated in the grater, passed through the vertical press (*tipipi*) and then transformed into bread loaves (cassava) in ceramic ovens. Depending on the process, the loaves could be more or less toasted (*e.g.* Gilij, 1780-1784; Fusée-Aublet, 1775). From the texts, it seems that greater toasting corresponded to stronger drinks. It is likely that during the roasting a dextrinization (*pyrodextrins*) (Taggart & Mitchell, 2009) of the starches was produced, which facilitate the attack of molds and yeasts. Later, the bread loaves were moistened and left to mold between leaves, usually banana leaves. When the loaves were covered with mold, they were broken up and placed in vats with water where they were fermented again with wild yeasts and bacteria. Unlike the tradition of the region of the *Montaña*, a second fermentation actually occurred, as described by Henkel (2004, 2005).

Additionally, unlike the tradition of the region of the *Montaña*, where the inoculum was represented by a unique 'mold that forms on the branches of manioc,' in Guiana's tradition an inoculation was not always specified.

Henkel (2005) wrote that the leaves of a shrub identified as *Trema micrantha* (L.) Blume (Ulmaceae, *bishawad* in Wapishana) were used as a *Rhizopus* inoculum carrier between *parakari* batches, and the *Heliconia* leaves were used to enclose the cassava layers during the primary fermentation. Farabee (1924) mentioned a certain shrub he misspelled as *bicawid*, instead of *bishawad* in Wapishana, and L. Ramos (2013) called it *curumim*. For Ferreira (1888 [ca.1792]) and Martius (1868 [1820]), the leaves added to the fermentation where *embauba* (*Cecropia* sp.). Of course, the leaves were not the inoculum itself, but as Henkel wrote, just an inoculum carrier. It is significant that the *Trema micrantha* (L.) was used in another indigenous Amazonian preparation. *Tarubá*, developed (C. Ramos et al., 2015) by the Saterê-Mawê (Tupi), is a solid-state fermentation of cassava, which is used to prepare a food-drink. The analysis of microbiological and chemical characteristics carried out by C. Ramos et al. (2015) showed no traces of amylolytic molds, and the amylolytic properties of fermentation were attributed to *Lb. plantarum*, *Bacillus subtilis*, *Bacillus amyloliquefaciens*, *Bacillus licheniformis*, *Bacillus* sp., and *Chitinophaga terrae*. Of course, the *T. micrantha* reused after the different fermentations represented just the transport vector of the molds, bacteria, and yeasts present in the previous fermentations.

In the Guianas tradition, often boiled sweet potatoes (*Ipomoea batata*) were added to the second fermentation. For some authors (Rochefort, 1667; Fusée-Aublet, 1775) the addition of sweet potatoes was used to avoid chewing or the first fermentation. In fact, sweet potatoes contain 4.2 grams of sugar per 100 grams of product (USDA, 2018), and these simple sugars can ease the start of fermentation processes. Breton (1999 [1665]) indirectly confirm the hypothesis stating in the definition: "*ouicou*: "drink"; fermented drink, cassava, by extension: drink party. Today [the term] is replaced in French Guyana by *cachiri*, from an Arawak word designating the sweet potato, ferment used in the production of cassava beer." (Breton, 1999 [1665], p. 263)[11].

The Guianas tradition is uniform, and we can suppose that it has a single origin, probably from the Carib group. It is also shared, by explicit declaration of the witnesses, between the Arawaks and the Macuxis, as confirmed by Farabee (1924). Recent evidence (L. Ramos, 2013; Villas-Bôas, 2016) shows the diffusion of this tradition up to Roraima among the Macuxi and to the upper Rio Negro, among the Ticunas.

In most names of beverages is not possible to find a meaning. Two names occur, with small variations, in different linguistic groups: *Parakari*, in 10 cases and *Pajuaru*, also in 10 cases. The linguistic similarity suggests a cultural transmission, in which, together with the process, the name was also transmitted. In 8 cases *Parakari* is present in Carib language groups, therefore the cultural transmission appears evident. The other two cases of Arawak occur among the Wapishana, today the Wapishana territory is enclosed between the Rio Branco valley in Brazil and the Rupununi valley in Guyana, surrounded by Carib groups. More problematic is the term *Pajauru*, which occurs among the Tukano, Ticuna, Carib and Arawak linguistic groups. The presence of the same term in different linguistic groups is the mirror of a region such as the upper Rio Negro, in which multilingualism (well portrayed by Stradelli, 1929), partly justified by exogamous marriages, results in a diagonal transmission of names and customs.

As for the constancy of the names, it can be assumed that, as some observers have noted (*eg*. Breton, 1999 [1665]; Gilij, 1780-1784; Farabee, 1924), the preparation of the drink, more complex than the traditional one, was linked to a party and a dance, therefore its transmission took place culturally, and specific rites were associated with the preparation technique.

The concentration of amylolytic fermentation on the left side of the Amazon River would suggest that this

[11] Translated from original in French.

process was common only to the region where bitter manioc was in use. Erikson (2004, p. 8), although he did not identified the meaning of the amylolytic fermentation process, seems to support this thesis when he write that, in the region of the bitter manioc, fermentation is obtained with the manioc put to mold in the air or in the water (*mandioca puba*). However, in the region the *Montaña*, the Napo, Jibarro and Zaparo, practiced amylolytic fermentation with sweet manioc.

The records outside these two large traditions are interesting because, although not very detailed, they show different methods of preparation.

In Ferreira (1888 [ca.1792]), the loaves of cassava bread are left to mold among *embauba* (*Cecropia* sp.) leaves for four or five days, after which they are put into large pots. The beverage may be drink immediately, when it is still sweet, or let it ferment further (*azedar*) if they want it to be strong. However, Ferreira (1888 [ca.1792]) does not indicate how much water was added to the cassava loaves.

Souza's (1875) description of the process is detailed, and the fermentation process is clearly limited to amylolytic molds. The process followed the traditional preparation of loaves of cassava bread, moistened and covered with manioc leaves, and then protected with banana leaves. After three or four days, they recovered the cassava loaves and placeed them in large pots hermetically sealed with banana leaves. After two days, the fermentation produced a half *quartilho* (0.35 l) of a transparent liquid with the taste of white wine for each pot; it was a real alcoholic beverage. Later, the product, diluted with water, could be drunk immediately as a refreshing drink, or left to ferment, where it produced an intoxicating beverage. We are faced with a product of pure amylolytic fermentation, which may later be fermented with wild yeast.

Martius' (1868 [1820]) description of the process is synthetic and does not allow us a precise interpretation. It is possible that what was described was an amylolytic fermentation. The interesting feature is that the fermentation took place in a hole dug in the sand. This leads us to a traditional process of food storage for long-term preservation, already mentioned by the first reporters (*eg*. Acuña, 1891 [1641]; Carvajal, 1894 [1546]; Maroni 1889 [1738]) and generally not commented on later. However, Osculati (1854) and Karsten (1935) mention that food buried in the ground was traditionally used during long voyages.

A separate treatment requires a preparation using maize. This was ground, mostly in the *metate*, and turned into loaves steamed in a cornhusk, like the Andean *tamales* and the Brazilian *pamonha*. Once boiled, they were left to mold for a long time (Gilij, 1780-1784), for a fortnight (Crevaux, 1883), or for several months (Conzemius, 1932). When it was necessary to prepare the drink, the maize loaves were melted in water and left to ferment. With this process, it was possible to avoid chewing, traditional in the Andean and lowlands' *chicha*.

Starting from this consideration, it is important to try to understand the origin and the meaning of the process.

Starches are concentrated energy and are sought as a source of nutrition for fungi, bacteria, yeasts, insects, and mammals. In hot and humid environments exposed to the air, both corn and manioc are attacked by molds and bacteria. These fermentation processes are spontaneous and universal (well known by anyone who has spent time in the Amazon rainforest) and lead to the inevitable decomposition of food. Studies from other tropical countries confirm that manioc dough and manioc chips are frequently contaminated by *Rhizopus sp*., *Aspergillus sp*., and *Monascus sp*. (Amoa-Awua et al., 1997; Kaaya & Eboku, 2010). In some cases, molds are also used to enrich traditional foods. For example, in Nigeria *Rhizopus oryzae* is used to enrich manioc flour and *gari* with proteins. In Indonesia, *Rhizopus oryzae* was identified in traditional fermented dried manioc (*gathot*) and was assessed for its antioxidant capacity (Sugiharto et al., 2016).

Indigenous use of amylolytic fermentation is the reasonable discovery of a natural process. In the Amazonian context, indigenous peoples discovered the

process, and we have the records of several occurrences of its use throughout the area for alcoholic fermentation and the accidental production of sweet candies enjoyed by children. Today, the process was discovered simply because a scientist tested a process that had been described several times in detail, but never studied from a biological point of view. Had we the perseverance to scientifically test other processes that were used by indigenous peoples, we would probably discover the deeper nutritional meaning behind practices such as pit storage, storing manioc mash in leaves, or storage in the ground during voyages.

In an ethnohistorical study without experimentation, it is difficult to identify the processes exactly. In fact, all these processes were carried out using wild molds and yeasts coming from the environment, which are difficult to reproduce in the laboratory (Henkel, 2005; Erikson, 2004). Only tests in the field, and therefore in an environment similar to that described in these reports, would allow the identification of the fermentation agents and of the dynamics of the process.

CONCLUSION

The results of this study show the almost universal diffusion of amylolytic fermentation in the Amazon and Orinoco basins. This discovery sheds new light on indigenous food habits, and in part is linked to the problem of the sustainability of populations in an environment once considered poor in resources. In reality, this, like other food production processes, represented an important component to ensuring a balanced diet in an environment that, although rich in resources, is extremely irregular with a strong seasonal distribution of resources and the presence of many toxic species. In this context, the richness of the fermentation processes used was essential for the formation of a balanced and healthy diet.

Faced with the rapid transformation of indigenous populations, it is essential to continue to carry out the study of traditional food production processes, both to understand forms of subsistence in the past and because they may provide valuable information about the value of these processes to modern society.

ACKNOWLEDGMENTS

Robespierre Sentella draw the map of the geographic distribution of amylolytic fermentation. Two anonymous reviewers offered important suggestion that improved the article.

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