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Biocultural Elements and Multifunctionality of Cassava Flour Production in Agrarian Reform Settlements in the Extreme South of Bahia, Brazil

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Abstract
Artisanal manufacture of cassava flour in Brazil has a cultural and biological framework developed over generations of traditional rural workers. We conducted a broad study of flour production in the Extreme South of Bahia in 2019 across 30 rural settlements in 11 municipalities, where we evaluated 107 flour producers. Our results present the socioeconomic profiles of local farmers, cassava varieties, types of flour, particularities of production, and characteristics of commercialization. We highlight the multiple functions of artisanal production of cassava flour, especially as related to social and economic maintenance of households, the promotion of food security, and sovereignty within and around the communities, and the conservation of agrobiodiversity in the rural landscape.

Keywords Agrobiodiversity · Family Farming · Agrarian Reform · Multifunctionality of Agriculture · Bahia · Brazil

Introduction

Developed as a traditional activity by indigenous people in Brazil, the artisanal manufacture of cassava flour performs multiple functions within a regionalized agri-food system (Denardin & Komarcheski, 2015; Roman & Westengen, 2022). Unlike other studies on the multifunctionality of agriculture in rural establishments (Carneiro & Maluf, 2003), we focused on how the artisanal production of cassava flour has multiple functions in the context of agrarian reform. As Maluf (2003) notes in a study of the functions of family farming in different regions of Brazil, it contributes to: "a) socioeconomic maintenance of rural families; b) promotion of food security for rural families and society; c) maintenance of the social and cultural fabric; d) preservation of natural resources and the rural landscape."

Using family farming multifunctionality as an analytical tool allows us to examine different social realities. The United Nations Conference on Environment and Development (Eco-92) associated family farming not only with the idea of sustainability, but also with the reorientation of public agricultural and rural development policies previously based on industrial agriculture and productivity (Sabourin, 2005). This concept of family farming was notably mobilized in France, with the purpose of highlighting the political will to value actions in favor of the multiple functions of agriculture. Additionally, agricultural products were supplied to support farmers willing to engage in sustainable production that can provide collective services without market value, but are linked to the environment, territorial planning, and the social sphere (Roux & Boinon, 2010).

The diffusion of the notion of agricultural multifunctionality in Brazil is associated with its heuristic potential for deeper knowledge of family farming, despite objections regarding the import of international terms from developed countries for the analysis of regionalized agriculture (Sacco

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dos Anjos & Velleda, 2009). Carneiro and Maluf (2003) highlight the functions of agricultural activity performed by family farmers, especially the socioeconomic and cultural reproduction of agricultural households in rural and peri-urban territories, as well as the conservation of biodiversity, natural resources, and mosaics of rural landscapes, offering legitimacy to the development of public policies that strengthen family farming while considering its social, environmental, and cultural plurality.

The artisanal manufacture of cassava flour mobilizes a cultural and biological structure developed over the course of many generations. Historically, producers of cassava flour have been supported by biocultural elements grounded in traditional indigenous knowledge passed down over generations (Toledo & Barrera-Bassols, 2015). As a crop typically cultivated in agri-food culture in the Extreme South of Bahia, in Brazil daily consumption of cassava flour is common in both rural and urban contexts (Marchetti et al., 2020a). However, the socioeconomic and cultural importance of cassava flour for family-scale farming is widely recognized in different regions of Brazil (e.g., Emperaire et al. (2012) in the State of Acre; Sena (2019) in the State of Amazonas; Center for Studies and Promotion of Group Agriculture (CEPAGRO, 2019) in the State of Santa Catarina; see also Denardin & Komarcheski, 2015). Northeastern Brazil, despite low productivity and the reduction in area planted in recent years, has historically produced one of the highest amounts of cassava and cassava derivatives in the country, especially flour, which is principally generated by family-scale farming in the state of Bahia (Coêlho & Ximenes, 2020).

Cassava (*Manihot esculenta* Crantz) is a key species in Brazilian process of agrarian reform. As it is a traditional crop intended for household consumption and income generation, cassava is one of the first crops cultivated by farmers, especially in the early stages of settlement development. In the Extreme South of Bahia, there are dozens of cassava varieties adapted to the specific ecological and cultural context to the region, which is known for the high ethnobotanical, genetic, and traditional knowledge associated with this native species from the family Euphorbiaceae (Marchetti et al., 2020a).

Brazilian agriculture is historically dominated by intense land concentration and social-rural conflicts (Wilkinson et al., 2012). Agrarian reform settlements are territories occupied by landless rural workers who have organized social movements calling for the democratization of access to land, the reduction of poverty, more contextualized education, food sovereignty, and an end to profound socioeconomic inequalities (Carter, 2011). The Landless Rural Workers Movement (MST) is the largest social movement in Brazil and one of the most important in Latin America (De Conti & Villen, 2023; Stedile & Fernandes, 2012).

The process of agrarian reform introduced by MST requires a series of stages prior to the consolidation of the rural settlement. The first phase is the occupation of a rural property whose social function does not conform to Article 186 of the current Brazilian Federal Constitution, or presents legal irregularities regarding its ownership, followed by the establishment of a camp for landless families until the National Institute of Colonization and Agrarian Reform (INCRA) completes the legal procedures for land transfer. If all is in accordance to national land regularization laws, the settlement is recognized and each household has a designated plot of land and integrated into public policies for agrarian reform and family farming.

We use a biocultural and multifunctional approach (Gavin et al., 2015; Carneiro & Maluf, 2003), to identify and describe some of the socioeconomic and biocultural elements of the manufacture of cassava flour in areas of agrarian reform in the Extreme South of Bahia, Brazil. We also discuss the relationship of family farming of cassava to agricultural multifunctionality, especially regarding the role of cassava cultivation in the socioeconomic and cultural maintenance of households resettled by agrarian reform, as well as for the conservation of agrobiodiversity in the rural landscape. Our results are part of the Agroecological Settlements Project conducted by a multidisciplinary team of agricultural technicians and researchers from the Egídio Brunetto School of Agroecology and Agroforestry (EPAAEB) in collaboration with the Support Center for Culture and Extension in Education and Environmental Conservation of the Luiz de Queiroz College of Agriculture at the University of São Paulo (NACE-PTECA/ESALQ/USP) (MST, 2019).

Materials and Methods

Study Area

The Extreme South of Bahia is one of the administrative regions in the state of Bahia, located in the northeast of Brazil. In the colonial period (1500–1889), the regional economy was based on the extractive exploitation of the dense Atlantic Forest, which had little impact on the local ecosystems. Subsequent cycles of cocoa harvesting, logging, and extensive livestock production were responsible for frontier divisions and conflicts with indigenous people. In the 1970s, the construction of Federal Highway BR 101 intensely integrated the region into the national economy, allowing for the expansion and flow of coffee, timber, and livestock products. This process of occupation on a large

scale is representative of the pattern of rural development in Brazil driven by land grabbing (Wilkinson et al., 2012). This pattern is responsible for the land-ownership concentration, rural exodus, and reduced small-scale rural activities in the region (Almeida et al., 2008).

Despite this exclusionary rural development, traditional and local communities are resistant and still inhabit the region, living on Pataxó Indigenous Lands (about 14,000 people) (ISA, 2013), quilombola communities (social groups composed of the descendants of formerly enslaved Africans) (Brasil, 2017a), as well as rural settlements registered by INCRA (Brasil, 2017b), with approximately 4,000 settled households. The first rural settlements were established in the 1980s and, even today, organized social movements promote land occupations to pressure the Brazilian government to expand the democratization of access to land through agrarian reform (Carter, 2011). Due to these social movements, there are dozens of encampments and pre-settlements of landless workers in different stages of development and consolidation.

Our research was carried out in rural settlements and pre-settlements under the political domain of the MST, around the EPAAEB in the Extreme South of Bahia, located in the municipalities of Mucuri, Teixeira de Freitas, Alcobaça, Prado, Itamaraju, Jucuruçu, Itabela, Guaratinga, Eunápolis, Santa Cruz Cabrália, and Porto Seguro (Fig. 1).

Data Collection and Analysis

Data collection was based on participatory approaches with techniques commonly used in ethnobiology and ethnoecology, including the use of a semi-structured interview script and participant observation of agricultural workers and cassava flour manufacturing (Bernard, 1988; Albuquerque et al., 2014; Amorozo & Viertler, 2010). The interviews were carried out with those responsible for the flour production to identify challenges of available infrastructure, machinery and utensils used, production capacity, quantity produced, workers involved, established work relationships, the origin of cassava roots, main varieties used, types of flour and other products derived from cassava, trade relations, methods of selling flour, prices charged, and means of commercialization.

Intentional sampling was collaborative among researchers from university of São Paulo, technicians, and regional leaders from MST and EPAAEB to include all communities in the region with active flour production, regardless of quantity. We previously identified 35 settlements, 16 pre-settlements and 177 flour-houses (places where cassava flour is made). From these production locations, we visited 19 settlements, 11 pre-settlements and 107 flour-houses, interviewing a total of 133 people, of which 84 were men and 49 women. At the household level, those responsible for the flour activity were interviewed. At the collective houses,

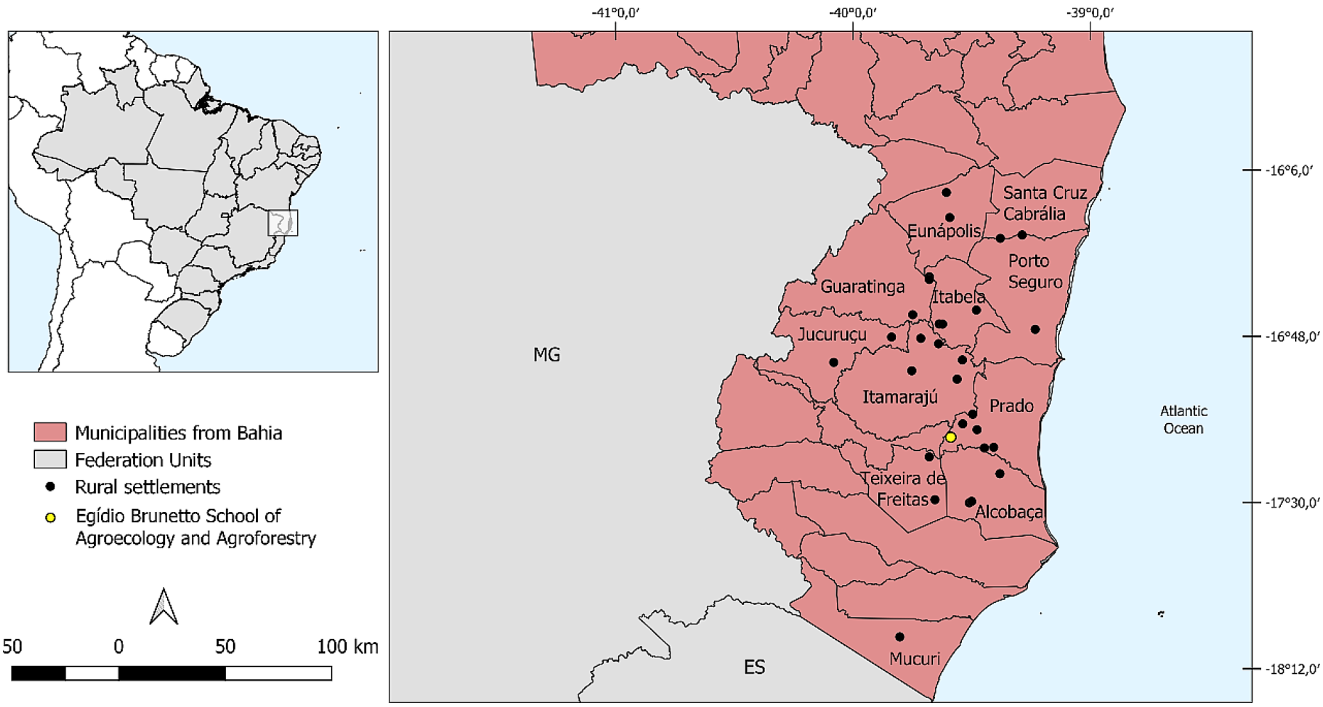

Fig. 1 Visited rural settlements around the Egídio Brunetto School of Agroecology and Agroforestry (EPAAEB) and respective municipalities in the state of Bahia, Brazil

interviews were carried out with the farmer or the group responsible for the production.

All the varieties of cassava grown in five settlements were inventoried in a previous study (Marchetti et al., 2020a), and information about the name, year of acquisition, origin, agronomic characteristics, and uses of each variety were collected *in loco* by semi-structured interviews with farmers locally indicated as specialists in cassava cultivation. Homonyms were registered in the field and later identified by researchers as different varieties. Each variety was identified by cross-checking the information provided by farmers and the detailed photographic record of each variety with morphological descriptors of high heritability (Fukuda & Guevara 1998). Morphological descriptors included plant architecture (pattern of branches), leaf bud color, shape and color of mature leaves and petioles, color pattern of the roots and details of mature branches.

We analyzed data using the biocultural and multifunctional approach following by Maluf (2003) and Gavin et al. (2015). We used descriptive statistics to assess installed production capacity and effective production, as well as calculate estimates and assess production. Qualitative data were analyzed by means of comparison and contrast (Amorozo & Viertler, 2010) in production systems, allowing the triangulation of data and the categorization of flour types. Finally, a conference was held at EPAAEB to socialize and discuss the research results among researchers, technicians, rural producers, and local leaders.

Results and Discussion

Elements of Socioeconomic Cohesion

Production of cassava flour in the region aggregates workers of different ages, with a greater proportion concentrated among middle-aged adults, who represent the group of active workers engaged in the activity and responsible for the consolidation of the settlements. The age of most flour producers was between 40 and 60 years old. Elderly people, over 60 years old, represented 25% of respondents, and adults between 20 and 39 years old accounted for about 15%.

It is worth noting the role of agrarian reform and the valorization of traditional agricultural activities in the Extreme South of Bahia for the maintenance of families in the countryside. In the visited settlements, the production of flour can be considered one of the main economic activities, as was shown by the engagement of both young and old workers, in addition to middle-aged individuals (Fig. 2).

On the other hand, the region is characterized by low socioeconomic development rates (Marchetti et al., 2020a), and the inclination to undertake traditional agricultural activities, such as the production of cassava flour, could represent an adaptation to limited opportunities for income generation based on the available social, cultural, and ecological resources, as widely observed in Brazilian traditional communities in economically marginalized areas (Adams, 2000; Diegues & Arruda, 2001). In this case, it is a great

Fig. 2 Peeling of cassava roots at the Antônio Araújo settlement, municipality of Itamarajú, state of Bahia, Brazil

asset that such activities are economically valued through the strengthening of local social organizations, as well as the development and improvement of public policies favorable to household farming products. These policies include the Food Acquisition Program and the National School Feeding Program, both important federal public policies that have supported family farming since the early 2000s and that have been undermined in the last decade (Marchetti et al., 2020b).

When traditional activities are not valued and they compete with more profitable non-traditional activities, there is a tendency for young people to not engage in agricultural work, as noted by Amorozo (2012) among traditional producers of cassava flour in Baixada Cuiabana, Brazil. The predominance of elderly farmers and the low engagement of young people in rural activities have led to a significant decrease in cultivated area and in cassava flour production. Considering the different contexts and regional dynamics, the maintenance of agricultural work depends directly on the involvement of the younger generations, for which the agrarian reform settlements in the Extreme South of Bahia seem to offer hope.

More than 85% of the interviewees come from municipalities in the region, and less than 15% from bordering states. When asked how they learned about cassava flour production, approximately 75% of interviewees reported having learned it as children by helping their family in artisanal flour production without motorized machines. A minority of 13% learned about cassava flour production in adulthood, usually in the last five years, from neighbors in the settlements. This pattern supports the role of agrarian reform in the social transmission of knowledge among farmers, which can occur culturally at different levels, or categories of transmission: vertical – from parents to children; horizontal – between individuals of the same generation; and oblique – between different generations, usually when a more experienced farmer transmits his knowledge to younger ones, without a direct relationship of kinship (Cavalli-Sforza & Feldman, 1981*apud* Soldati, 2013).

The prevalence of vertical transmission of knowledge suggests a more conservative cultural framework, which therefore justifies considering this a traditional activity. However, the fact that horizontal and oblique transmissions knowledge occur with a certain frequency allows innovations to be constantly incorporated and experienced by farmers. We observed the use of innovative equipment and techniques in the field when recording different levels of industrialization of the materials and equipment, ranging from manual and handcrafted to those powered by an electric motor and with industrial finishes.

Another important element of socioeconomic cohesion observed in the field was a collective effort system, known as a "mutirão," in which work is carried out collectively with the objective of community production or in terms of exchange relationships between settlers, without monetary mediation. This collective effort system was more frequently mentioned when a new land settlement occurs and farmers from neighboring settlements help in the establishment of new crop fields and construction of "shacks" and flour-houses. In these collective interactions, knowledge and experiences are exchanged and the circulation of agricultural species varieties is facilitated, especially those of cassava, which are usually presented by farmers who live near the newcomers. This type of reciprocity and no-market relationship between family farmers was also observed by Sebourin (2010) in a study on the multifunctionality of *Fundo de Pasto* communities in the semi-arid region of Brazil, who argued that these values are not cultural or social data entirely inserted into symbolic structures or representations, as Polanyi or Lévi-Strauss point out, but are constructed and reproduced by human relationships of reciprocity (Sebourin, 2010).

The manufacture of flour is also commonly carried out collectively mainly in pre-settlements with collective flour-houses, as well as in private flour-houses where neighbors and acquaintances gather to work on the processing of cassava. Frequently, payment for these services can be in flour or even as an exchange of services, that is, when the current "helpers" will become future "producers" in a new flour activity and vice versa. Working in *mutirão* systems strengthens social bonds within and between settlements, through ties of proximity, kindness, and generosity.

Elements of Biocultural Cohesion

According to the Code of Ethics of the International Society of Ethnobiology (ISE, 2006), biocultural heritage:

> is the cultural heritage (both the tangible and intangible including customary law, folklore, spiritual values, knowledge, innovations and practices) and biological heritage (diversity of genes, varieties, species and ecosystem provisioning, regulating, and cultural services) of Indigenous peoples, traditional societies and local communities, which often are inextricably linked through the interaction between peoples and nature over time and shaped by their socio-ecological and economic context. This heritage includes the landscape as the spatial dimension in which the evolution of Indigenous biocultural heritage takes place. This heritage is passed on from generation to generation, developed, owned and administered collectively by stakeholder communities according to customary law.

An analysis of the artisanal production of cassava flour in the Extreme South of Bahia reveals several elements of the cultural and biological heritage involved in this activity. Among the main elements, the regional collection of cassava varieties and local knowledge about this food plant stand out. There are varieties that are more suitable for table consumption, which are generally softer and cook faster, while others are indicated for flour production due to their higher starch content and better yields in the root/flour ratio. Thirty-seven cassava varieties were recorded in the region, with two of them preferentially indicated for flour production, locally known as Cachoeirinha and Caravela (Fig. 3). These are the varieties most distributed among farmers, occupying the largest areas of cultivation in the fields. Cachoerinha and Caravela supply 75% and 56%, respectively, of the flour-houses in the region, followed by Unha (30%), Manteguinha (20%), Pretinha (18%) and Buticuda (11%) varieties. Others were indicated in fewer than 10% of the flour-houses.

Cachoeirinha, also called Calipe, Calipinha, Eucalipto, or Malvinha, is a variety with multiple uses and is considered to be sweet cassava, used both to produce flour and for table consumption (cooked). Among its main characteristics, the following advantages were emphasized: early production, production of roots between six to eight months after planting, sweet taste, and white color. These are attributes that, regionally, give superior quality to the flour, described as "very white and tasty". Additional attributes include high productivity, easy harvesting due to root development on the soil surface, suitability for the electric peeler due to the ease with which the light inner bark of the root comes off, and disease resistance. Disadvantageous characteristics were also mentioned, especially a rapid post-harvest deterioration, which requires swift processing due to the risk of browning the flour ("blueing the dough") that results in a bitter taste, in addition to rapid deterioration of the roots in gardens, usually twelve months after planting.

Caravela is a bitter cassava variety exclusively used to produce flour and starch and is widely recognized for high yields both in the production of roots and in the conversion into flour. Also preferred for the quality of the white color of the flour and starch and the low fibrous dough, Caravela starch is the most suitable one for "beijus," a kind of biscuit. Harvesting is easy, due to the low number of branches, but the roots can grow deep, which makes them more difficult to remove from the ground. Another remarkable advantage is the plant's duration in the fields, which, according to reports, can last up to three years without the roots rotting. Included among the disadvantages is the delay in the root production, usually up to 12 months, and the possible susceptibility to diseases in some locations, such as root rot caused by fungi of the genus *Phytophtora*.

The varieties categorized as "aipim" are those commonly used for table consumption, such as Manteiguinha, Cacau, and Macaxeira. These varieties were also mentioned, in some cases, for the manufacture of flour, usually because they "age" in the fields and become no longer suitable for table consumption, or because they may be the only varieties available and the household needs to produce flour in small quantities for their own consumption.

Other varieties exclusively used for flour, such as Unha, Pretinha and Sutinga, were mainly cited as common in the past but recently less cultivated due to susceptibility to diseases and low yields. As a result, these have been replaced by the varieties that are better adapted to current growing conditions and preferred by farmers.

The local varieties of cassava in the Extreme South of Bahia represent a genetic potential empirically recognized by farmers, which makes it possible to identify and select varieties adapted to the different types of soil in the territory.

Fig. 3 Local varieties of cassava. *Cachoeirinha* on the left, and *Caravela* on the right. Details of plant architecture, leaf bud color, shape and color of mature leaves and petioles, color pattern of the roots and details of mature branches are shown

Some varieties are more resistant to periods of prolonged drought or to pests and diseases; some show early production of branches or roots, or late aging of the roots in the field; others are obviously the most productive and have the highest yield in flour and starch (Marchetti et al., 2020a). The richness of cassava varieties is an important element that provides resilience to local agroecosystems and helps farmers in the face of climate change. According to Altieri and Nicholls (2017), the "resilience to climate disasters is closely linked to the level of on-farm biodiversity," which is essential for ecosystem functioning and to support the strategies used by traditional farmers to cope with consequences of global warming.

In addition to the biocultural elements directly associated with the local varieties, other products from cassava were recorded and demonstrate the biocultural diversity present in the region. Fresh starch is produced in almost 90% of flour-houses, and dry starch, also called "polvilho" is produced in 12%. The starch is sold at fairs or to bakeries and serves as raw material for a series of products, especially "beijus," which are also sold at fairs, produced in 40% of the visited flour-houses. "Biscoito de polvilho" is produced in 15% of the flour houses, mainly for family consumption. "Puba," cassava dough obtained from fermented roots, was mentioned in about 10% of the interviews, mainly used as a base for cakes and can be bought to order. Cassava cake, tapioca, tinga, and cassava dough for cake were mentioned in some interviews, mainly as non-marketed products for household consumption.

Different types of flour are also representative of the biocultural cohesion elements associated with cassava in the region. Depending on the micro-region studied, there is a preference for producing white and fine flour (54% of flour-houses), white and medium/round flour (29%), white and coarse flour (8%), "manipuba" flour (5%), yellow and thin flour (3%), and yellow and thick flour (1%). In most cases, the preference is for fine, white flour, the manufacturing process of which fully maintains the starch in the flour and gives it its white color, as well as characteristic flavor and smell.

Types of flour, as well as the culinary breadth provided by cassava, reflect the interrelation between the genetic diversity of cassava and the traditional knowledge and practices of the settled farmers. Traditional producers can make the flour into typical and diversified foods within a specific agri-food system, contributing to an increase in food security and sovereignty, both locally (households installed in the settlements) and regionally (rural and urban areas as a whole). In addition, the biocultural heritage related to cassava promotes the circulation and maintenance of important regional components of agrobiodiversity, among which are the notably dozens of cassava varieties, as well as the different recipes and flours typical of the region.

Flour Production and the Rural Economy

The production cycle of cassava flour is directly linked to the cultivation of the plant. If the cassava field is not well managed, root yield is low and there is no flour production. Both activities are intrinsically linked, but farmers may specialize in either. There are flour producers that pay other farmers to work in the fields. There are those who produce flour in partnership with cassava producers, or who also buy roots from other farmers in the settlements. These different arrangements stimulate the agricultural dynamics and economy of the settlements.

In flour-houses with frequent production, it is common for producers to buy cassava weekly from other local farmers, which encourages agricultural production, jobs, and income generation in the settlements. It is common for flour producers to use multiple strategies to supply the demand for roots. Of the interviewees, 47% use roots exclusively from their fields, 23% use of their own fields and fields in partnership with other farmers, 15% use their own fields plus purchased cassava, and another 15% reported using a combination of their own fields, purchased cassava, and cassava obtained from partners.

Once the supply of roots is guaranteed, flour production is a closed system, with seven processing steps, each with their respective inputs and outputs (Fig. 4). In the first step, the roots are washed and peeled, which can be done with a motorized peeler (7%) or, in most cases, manually with knives and other handmade tools (93%) (Fig. 5). These activities are mainly carried out by women, usually in groups of two to five, who are paid per box of peeled roots (BRL 2 to 2.5 /box, September 2019).

During the second stage, from grating the roots to packing the flour, the work is performed mainly by men, usually with one responsible person assisted by one or two helpers. The grating machine, in step 2, is powered by electricity (64% of cases), gasoline (35%), or increasingly infrequently diesel (3%). The gasoline engine is preferred in places where electrical power is unstable or absent. In the past, according to the interviewees, the grater was manual, which made the activity more physically demanding. No hand grater was found in use during our investigation.

The third step is the pressing of the grated root mass, arranged in raffia sacks, to remove the liquid called "manipueira." There are four different types of presses in the region: the "sari" press, the screw press, the press adapted with a hydraulic bottle jack, and the industrial press. The "sari" press, also called "caboclo" or rod press, is the most rustic and possibly the least efficient due to the long time needed

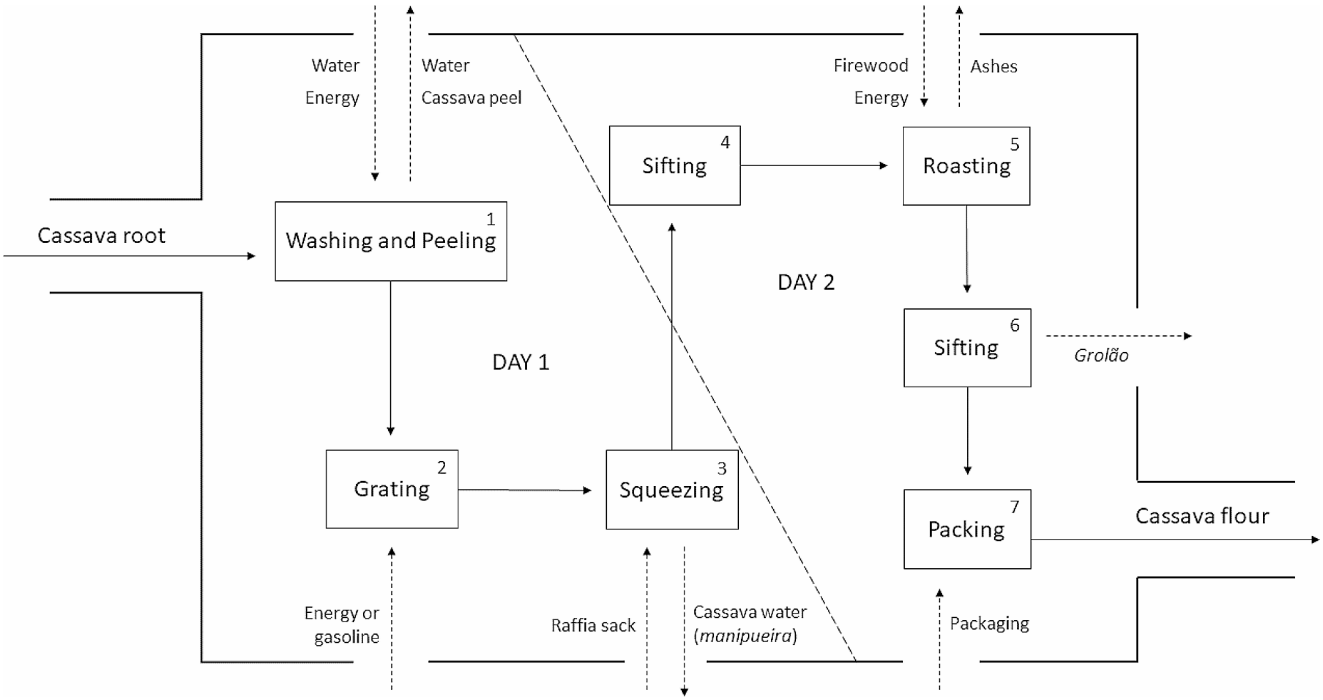

Fig. 4 Diagram depicting the closed system of the cassava flour production comprised of seven processing steps

Fig. 5 Woman peeling cassava roots, knives and other artisanal tools utilized for that activity

Fig. 6 Manual (left) and electric oven (right) used for roasting cassava flour

Fig. 7 Manual ovens used for production of cassava flour and *beiju* (on the left), with artisanal tools displayed in the upper right-hand corner of each photo

to dry the dough, and it was found in only six flour-houses. The screw press was indicated as efficient for drying the dough and the most suitable for small-scale agro-industry but has a higher cost and little availability on the market (36%). The press adapted with a hydraulic bottle jack is the most common (58%) and was identified as presenting the best cost-benefit, despite the risk of accidents due to the high pressure exerted on the jack and the possibility of it escaping the press. Finally, the industrial press, an electric-hydraulic press, was categorized as the most efficient, but it is rarely used due to the high cost of acquisition and difficult maintenance, and it was found in only two collective flour houses, in both cases malfunctioning. Different types of press can be present in the same flour house. Generally, jack and screw presses are found together, and they can be used in conjunction to optimize work, or the jack press can act as a reserve in the case of breakage of the screw press.

The fourth step is the dismantling of the pressed dough, which can be done with a manual sieve or on the grater. The dough is taken to the oven (step 5), which is heated by burning firewood. The ovens use an electric motor to drive the blades that move the flour (35% of cases) or are manual (37%), when the roasting is carried out by a professional with tools such as wooden squeegees and shovels (Fig, 6). In two isolated cases, furnaces with a diesel engine were observed. There are also flour houses with both types of ovens (27%) with the manual oven used in the preparation of "beijus," or when there is an electricity outage (Fig. 7).

As with the replacement of manual graters with those by powered by gasoline or diesel engines, there is a clear desire among producers to replace manual ovens with electric ones

to increase productivity and reduce physical labor. However, it is widely acknowledged that manually produced flour tastes better than that processed in industrial ovens. The manual process requires more attention, care, and dedication to the roasting of the flour, and demands greater experience from the person in charge of the oven. The "rounder" texture is also a characteristic of manual ovens. In general, when the flour is produced in small quantities for household consumption, for example, the manual oven is used. On the other hand, when the production is predominantly for income, the electric motor-powered oven is used to produce flour in greater quantities and less time.

After roasting, the flour is sieved (step 6) to separate the grain ("grolão" - fibrous agglomerates of flour). The *grolão* can be used for animal feed or even crushed and reincorporated into the flour. The last stage (step 7) consists of packing the flour for sale in packaging specific to each flour-house.

The entire flour making process takes one to two days. When small quantities are needed, such as for household consumption only, only one day is needed, starting at dawn and ceasing at nightfall. For larger quantities, production starts at dawn on the first day, followed by steps 1, 2 and 3. The grated cassava is placed in the press (step 3) overnight, and steps 4, 5, 6 and 7 are performed the next day.

Workers' payments are generally made through daily allowances (BRL 50 to 80 /day, September 2019). The highest remuneration is given to the person responsible for the oven, which is the longest stage and requires experience skilled labor to control the oven temperature and reach the desired roasting point. It is common for workers in flour houses to be members of the producer's household, or relatives, neighbors, friends, and other residents of the settlement. In places where the population has less capital for investment, as in pre-settlements, payments can be made in flour or in exchange for services. When the flour is produced only by the family nucleus, its sale becomes a common family good.

The estimated production capacity for flour in the MST in the Extreme South of Bahia (51 settlements and 177 flour-houses) was almost 1,000 tons/month. However, the effective production was only 340 tons/month. This difference is mainly explained by the low price of flour recorded during the period of field research (September 2019), which discouraged producers from investing time and money in flour production. The demand for and price fluctuation of flour in the regional market are the main drivers of fluctuations in effective production of cassava flour in the territory. When demand is high, the price rises and the effective production of flour increases, approaching, or even equaling, production capacity, which leads producers to invest in the activity and purchase more efficient equipment, thus further increasing the production capacity. It is evident that the amount produced varies greatly among the different flour-houses. Collective houses, for example, have greater production capacity and more frequent use, producing approximately 4 tons/month, while family houses with lower production capacity and less frequent use produce approximately 1.5 tons/month. All production is consumed or sold in the region; only two informants mentioned that intermediaries buy local flour to resell in other regions.

Marketing the Flour

When demand for flour is higher than supply, it can be produced to order, and buyers collect it directly at the flour-houses as soon as it is ready. On the other hand, when supply is higher than demand producers commonly adopt multiple marketing strategies, such as offering the product in grocery stores and markets close to the settlements, to other local settlers, or to part-time intermediaries.

Intermediaries play an important role in the flow of production since many producers do not have vehicles in which to transport their bags of flour or direct contact with potential buyers. There are cases in which the intermediary is a close relative and facilitates the outflow by living in the urban area. However, it is common for intermediaries not to be members of the producers' communities, but entrepreneurs who buy flour from the settlements at low prices and reselling it in urban areas or in other regions at higher prices, leaving producers with a reduced profit margin. Only two interviewees mentioned flour delivery to institutional markets, such as the National School Feeding Program (PNAE in Portuguese).

Prices in the Extreme South of Bahia vary according to the type of flour produced, as well as the micro-region, the purchase and sale agreements, as well as the quality and quantity offered. White flour with a slightly sweet flavor and fine texture has the highest demand in the regional marketplace. The average market price for this type of flour was BRL 100 /50 kg bag in September 2019. The lowest value recorded was BRL 60 /50 kg and the highest was BRL 150 /50 kg. According to the interviews, the average price reached BRL 200 /50 kg in 2015.

In the micro-region of Itabela, Guaratinga and Porto Seguro, the settlers produce a type of thick yellow flour with a slightly sour odor and taste, resulting from the fermentation of the roots in water. The *puba* (fermented root) is added to the grater in small quantities, to be incorporated into the mass of unfermented roots, producing flour known locally as *manipuba*. This product is exclusively sold to the indigenous Pataxó people in Barra Velha village, at a price higher than white flour, with an average cost of BRL 150 /50 kg, reaching up to BRL 200 /50 kg.

Fine yellow flour was found in only three flour-houses. It is manufactured in the same way as white and fine flour, but with the addition of turmeric, which gives the yellowish color. According to the interviewees, this type of flour has a better market price, but is little in demand, mostly for small quantities from the restaurants in the micro-region of Teixeira de Freitas.

The price of a bag of flour can also vary according to the agreement between producers and buyers. Credit sales were reported to be the most common, but they involve greater risk and the cost ranged from BRL 100 to 120 /50 kg, with payment terms ranging from 15 to 30 days. Cash sales were mentioned at prices ranging from BRL 70 to 90 /50 kg. When flour was sold in small quantities for household consumption to neighbors or at the fair, the price was around BRL 2 /liter.

The wide fluctuations of the flour market make it difficult to plan production in the medium and long term. Producers' dissatisfaction with the prices charged during the study period was unanimous, which justifies the low estimate of the effective flour production. According to data from "Banco do Nordeste" (Coêlho & Ximenes, 2020), the price of cassava flour in the state of Bahia fell sharply throughout 2019, followed by an increase in 2020, due to the low supply during the Covid-19 pandemic.

The cost of producing 10 bags of cassava flour (equivalent to 500 kg) was around BRL 1,130 in 2019. With the average price of BRL 100 for a bag of flour in this period, the producer absorbed a loss of BRL 130 for every ten bags. Under these conditions, disadvantageous to both producers and workers, the producers cut costs, for example, reducing the workers' daily rates, as well as the amount paid for roots and shipping for roots and firewood. According to the informants, with the reduction of costs, it was possible to obtain a monthly income from cassava flour of around BRL 6,000 in collective flour-houses with greater production capacity, and BRL 1,000 in family flour-houses with lower production capacity.

A possible strategy indicated by the producers to strengthen the production network in the territory and increase household income for economic sustainability, is the certification of cassava flour as an organic and agroecological product, which adds value to the flour produced especially within settlements that are part of the Agroecological Settlements Project.

Other potential certifications for cassava produced in the region are the geographical indication of origin and the seal of family farming products. The first requires a series of studies and surveys at the regional level to apply for the Geographical Indication at the National Institute of Industrial Property (INPI). This Geographical Indication is attributed to products that have a unique quality due to natural resources (soil, vegetation, climate) and "know-how," which can be assigned in two categories: Indication of Origin and Denomination of Origin. Brazilian examples of cassava flour that received this type of certification are the flour produced in Vale do Juruá, in Cruzeiro do Sul (State of Acre), in the region of Uarini (State of Amazonas) and in the region of Bragança (State of Pará), all of which are in the North region of Brazil (Brasil, 2021). On the other hand, the National Seal of Family Agriculture from the Ministry of Agriculture, Livestock and Supply, is less bureaucratic, with seven different modalities, and it can be granted to agro-industries and cooperatives/associations recognized by the national government. Its objective is to identify the origin and characteristics of family farming products, which gives them greater visibility and value.

Conclusion

In Brazil, it is widely documented that family farming is responsible for most jobs in rural areas, as well as the production of the main foods consumed in both rural communities and in urban centers (IBGE, 2006; 2018). It is equally established that family farming plays a fundamental role in the conservation and use of natural resources and biodiversity, giving consistency to conservation actions based on a biocultural approach (Gavin et al., 2015) and sustainable land occupation (UN, 2018).

However, the intense concentration of land ownership in Brazil causes deep socioeconomic inequalities which ultimately renders family farming impractical and prevents its full development (Wilkinson et al., 2012). In the historical context of agrarian reform as an act of resistance, the people's agrarian reform is defended as a credible alternative for the consolidation of sustainable rural development and the settlement of households in the countryside in dignified conditions. Agrarian reform is shown to be capable of reconciling the objectives of environmental conservation and production of healthy food, simultaneously allowing income generation for the rural population. It is thus a means for the recognition and a more advanced fulfilment of the multiple functions of agriculture.

From the analysis of the production of cassava flour in rural settlements in the Extreme South of Bahia, it is possible to conclude that agrarian reform in Brazil, especially on an agroecological basis, as observed in this region, has created conditions to boost the multifunctionality of family farming. The main elements of socioeconomic and biocultural cohesion presented contribute to the recognition and expansion of the multiple functions of agriculture identified by Maluf (2003) in the Brazilian rural environment, especially in the following requirements:

a. **Social and economic maintenance of households** through the evident engagement of different generations of farmers in flour activities, promotes economic dynamics suited to the ecological and sociocultural context of the settlements as well as income distribution among settlers.
b. **Promotion of household food sovereignty and food security within and around the settlements** through the autonomous production of food compatible with regional agri-food systems, which stabilize the supply of flour in the settlements and in the urban environment, making healthy and diversified foods available that are in accordance with cultural traditions.
c. **Strengthening of the social and cultural fabric in the settlements** through social interaction among household members, neighbors, and other settlers, with the exchange of knowledge and experiences of traditional food production practices, promotion of relationships of reciprocity, kindness, and generosity involved in production activities, especially as seen in collective efforts.
d. **Conservation of agrobiodiversity in the rural landscape** through the management and circulation of cassava varieties within and between rural settlements, strengthening the agroecosystems' resilience in the face of climate changes, as well as supporting the reproduction of agricultural knowledge, culinary recipes, typical foods and the diversity of flour and other associated products.

It is evident that such functions are not only inherent in the traditional practices of occupation and the relationships among settlers in the region but are also strengthened by the social and political organization on an agroecological basis promoted by the MST in rural settlements. However, these functions, despite their socioeconomic and environmental relevance at the regional level, are not widely recognized or valued by society.

Thus, it is a great challenge to design actions, programs and public policies that respect the modes of social, political, and local production, while strengthening and promoting the traditional agricultural activities of family farming. The recognition of the multiple functions of agriculture in areas of agrarian reform can provide support to the planning and structuring of these actions. Overall, a holistic perspective that will boost sustainable development and increase society's awareness of the relevance of rural settlements for social inclusion is necessary for the alleviation of socioeconomic inequalities and the promotion of healthy agri-food systems that are in line with the social, cultural, and ecological realities of each region.

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Data Availability Because of restrictions imposed by ethics committee, data have not been publicly deposited. Upon reasonable request, the corresponding author may make available certain data in accordance with the research agreements.

Declarations

Informed Consent This study had the prior informed consent of the farmers included in the research, and the authorization from the National Research Ethics Council (CONEP) (CAAE: n. 26107719.5.0000.5395).

Competing Interests The authors declare no competing interests.

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