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Article

Agricultural Biodiversity in Southern Brazil: Integrating Efforts for Conservation and Use of Neglected and Underutilized Species

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Abstract: Brazil is one of the most biodiversity rich countries in the world, including a wealth of agricultural biodiversity in both wild and cultivated forms. This is particularly noticeable in southern Brazil, home to a wide array of underutilized food species whose genetic diversity is maintained mostly by farmers through on-farm management practices. Farmers' contribution in safeguarding and keeping alive traditional knowledge (TK) essential for recognizing, cultivating, valorising and consuming these resources is critical to their conservation. Part of this diversity, a rich basket of native fruits and landraces of vegetables and grains, is also maintained through *ex situ* collections managed by Brazilian Agricultural Research Corporation (Embrapa) and its partners. This article discusses the integrated efforts for *in situ*/on-farm and *ex situ* conservation and use of agricultural biodiversity in southern Brazil. This diversity represents an important cultural heritage, since its use, cultivation and associated knowledge result from the dynamic history of the Brazilian population, including colonisation and immigration by several different ethnicities. Many of these species are sources of genes that convey tolerance to biotic and abiotic stresses, as a result of the combined action of natural selection and artificial selection by farmers in agricultural systems with low inputs and diverse environmental conditions. Due to their importance for food security, use in breeding programs, high nutritional value, and potential for income generation, Embrapa has taken responsibility for the *ex situ* conservation of these species. The genebanks that safeguard against the loss of these resources do also play an important role in the restoration of this germplasm to farming communities.

Keywords: biocultural diversity; landraces; native fruits; nutrition; family farming; genetic resources; on farm conservation; *ex situ* conservation; farmers' knowledge

1. Introduction

The globalization of our food system has resulted in highly standardized agricultural production and consumption patterns around the world [1]. The fact that only 30 or so plant species feed the world today has been highly stigmatized in recent years: the narrowing of our food security basket makes food systems more vulnerable to shocks of different nature, which is particularly severe for the poor whose livelihood options are dramatically reduced [2,3].

It is highly symptomatic that in almost all countries people are using a mere handful of varieties of apples, potatoes or lettuce, whereas many thousand other varieties are marginalized by markets and eventually lost [1]. There appear to be continually diminishing options for consumers on the market, although additional diversity might be available at higher prices. Agricultural markets are no longer celebrations of crop diversity as in the past, but places where very few, uniform and standardized crops and varieties are commercialized. To make matters worse, supermarkets are taking over local food systems in cities and towns, leading toward the establishment of impersonal relationships between producers and consumers and poor awareness about origin, processes and the rich culture intimately associated with crops and their products [1,4].

Whereas a few select commodity crops are conquering markets at national and international levels, a fairly large number of other plant species (domesticated, semi-domesticated and wild) are still used and appreciated by local populations. This cultural appreciation is linked to livelihood options, since these local resources are at reach of the poor and help them meeting many needs at lesser costs. The traits of many of these species are also critical to face climate change. Part of this portfolio of local agricultural biodiversity consists of neglected and underutilized species (NUS), a broad diversity of agricultural and wild species (including traditional crops), which are rather conspicuous in southern Brazil.

The conservation of NUS plants is mainly secured through *in situ*/on-farm management. This conservation carried out by farmers is also complemented through *ex situ* conservation efforts realized by the Brazilian Agricultural Research Corporation (Embrapa). According to the latest national inventory [5], dated 2009, it is estimated that Embrapa and its partners (other Brazilian research institutions, universities and foundations) hold more than 170,000 accessions in total, representing 212 genera and 668 species. These accessions are held between the base collection (long term conservation) and 383 active genebanks that form part of the national network of plant genetic resources. At least 48% of these active germplasm banks conserve accessions belonging to the NUS category, including traditional crops and plants usually harvested in the wild for direct consumption [5].

The ecological, social, economic, cultural, ethical and aesthetic values of biodiversity have been capturing the attention of different segments of society in the context of debates regarding the deployment of agricultural biodiversity in sustainable development [6,7]. Most recent market strategies for the valorisation of agricultural biodiversity leverage territorial identity, embodiment of traditional food preparation "know-how", local culture and food history. Other interesting entry points for marketing this diversity are those related to organic, eco-friendly, healthy and ethnic products and those linked to solidarity commerce and fair trade.

From a biological point of view, Brazil is one of the 17 most diverse countries in the world [8,9], housing an incredible richness of microorganisms, plant and animal species, as well as ecosystems. It is the fifth largest country in the world both in geographical and population terms. In this immense territory, huge areas fall within different climatic regions (equatorial, subtropical and temperate). This diverse natural setting resulted in the emergence of a great array of species, which have co-evolved with humans, being modified through their continuous actions [10], reflecting the social values and needs in particular locations and points in time. Co-evolution between social and ecological systems, involving dependency and feedback with respect to each other, has generated a level of structural dependence. Knowledge embedded in traditional cultures stimulates and regulates feedback between the social system and the ecosystem. This knowledge, produced every day, is the result of both individual and collective contributions through generations. Its circulation, valorisation and conservation depend directly on collective memory and wisdom. This form of production and circulation of knowledge is a “natural epistemology”, which is endowed with everyday value and is of great importance for the production of scientific knowledge [11].

Knowledge in family farming is highly influenced by social interactions. The dissemination of knowledge depends on direct contact between social actors in a historical and cultural context. Migrations or diasporas, when they occur, can cause drastic shifts and disruptions in local knowledge and its transmission. This is what happened through the process of cultural invasions imposed by the ideology of urban industrial civilization, which was based on two false premises: superiority of technicians and researchers over rural culture (traditional knowledge) and the idea that science is the only form of valid knowledge, which transformed into ideology and a mechanism of domination of some cultures over others [12].

The objective of this article is to discuss the conservation of agricultural biodiversity in southern Brazil, addressing the integrated efforts of *in situ*/on-farm and *ex situ* conservation of its plant genetic resources.

Semi-structured interviews and observations were conducted with hundreds of farmer representatives of different social groups and their respective communities over more than a decade. This information was supported by records from many events related to family farming and agrobiodiversity in southern Brazil (diversity seed fairs, family farming forums, workshops with farmer guardians of landraces, seminars on food security, the Brazilian congress of agroecology, a multi-stakeholder workshop on farmers’ knowledge on agrobiodiversity, and meetings regarding berries and native fruits from Mercosur/Mercosul (common market of South America) in which both authors from Embrapa and farmers participated. Further information presented in this paper was obtained from a selection of cases observed during the authors’ experiences throughout their professional careers. This methodological choice is in accordance with the procedures of participatory research [13] in which reports based on the life history of the actors are considered methodologically adequate.

2. The Southern Region of Brazil

2.1. Characteristics of the Territory

Unlike the rest of the country, the South of Brazil is located in the subtropical region, and is characterized by a humid temperate climate, with occurrence of hot summers in lowland areas. In higher altitude areas, the summer is mild and the winter is harsh (average monthly temperature is below 10 °C), with constant frosts and occasional snowfalls. The climate is classified as humid throughout the region, with total rainfall ranging from 1,200 mm to 2,300 mm per year.

The landscape of southern Brazil is characterized by a wide range of vegetation types, including grasslands, salt marsh vegetation and deciduous forests. Two biomes can be found here, namely the Atlantic Forest and the Pampa [14]. The Atlantic Forest is characterized by the presence of forests; the Pampa by an abundance of herbaceous species in open grassland. Each of these biomes has several associated ecosystems, over mountains and plains. In affiliation with this biodiversity, there is strong socio-cultural diversity that has resulted from the historical process of occupation of this territory. The region has many native and underutilized species, including fruits, fodder, medicinal, and ornamental plants [15,16]. We consider native, or autochthonous, species as those which occur naturally in a region or country and which were not introduced through trans-continental movements of man [17].

Among the underutilized species in southern Brazil there are plenty of non-food crops, such as those used in maintaining quality of life and for healing purposes: yerba mate (*Ilex paraguayensis*), espinheira-santa (*Maytenus ilicifolia*), guaco (*Mikania laevigata*), marcela (*Achirocline satureioides*) and carqueja (*Baccharis trimera*); those used for the production of utilitarian objects, such as gourd (*Lagenaria siceraria*) which is used for *cuia* (a container to drink mate or *chimarrão*, an infusion of dried leaves of *llex paraguariensis* in hot water), and loofah (*Luffa aegyptica*) used as sponges for bathing and washing dishes; and ornamental plants used in landscaping and gardens, such as native orchids, bromeliads and cacti, that contribute to the maintenance of well-being, quality of life, and aesthetics. It is interesting to note that 20 years ago, a much larger number of native tree species was used in rural areas for purposes such as constructing houses, sheds, pig pens and chicken coops. For example, wood was used for the frame and walls, while capim-santa-fé (*Panicum prionitis*) and palm leaves were used as roofing material. Other tree species were used in the production of instruments for rural labour (such as handles for hoes, axes and sickles), energy (coal and wood) and transport (trucks and carts). Unfortunately, the availability of such plants and the associated knowledge for their use has declined dramatically in recent decades, as reported by the farmers and observed by the authors.

Some underutilized plants in Brazil have multiple uses, such as butiá palm or jelly palm (*Butia odorata, Butia catarinensis, Butia lallemantii* and *Butia yatay*), whose fruits are used as food and leaves are used to produce crafts (hats, baskets, decorative and utilitarian objects). The plant is grown in home gardens both in rural areas and in cities. Another example is aroeira-mansa (*Schinus therebintifolius*), which is used in agroforestry systems for hedges, for restoration of degraded areas, in landscaping and floral art, as well as for its edible fruits that are used for flavouring foods (this is the famous pink pepper, now popular in many cuisines worldwide).

As a result of the historical colonization of southern Brazil by people of different origin, a wide diversity of crops are grown in this region that were originally domesticated in other parts of the world, such as pepper, corn, bean, sweet potato, carrot, onion, pumpkin, melon, watermelon, cucumber, gourd and loofah. Local landraces of these crops were developed that are well-adapted to local environmental conditions and which have unique features. Landraces (*variedades crioulas*, in Portuguese) are dynamic populations of a cultivated plant which have not undergone formal crop improvement. They have historical origin, distinct identity, and are often genetically diverse, locally adapted and associated with traditional farming systems [18]. Farmers' communities are open systems, receiving continuous inflows and outflows of local and improved varieties. Landraces are thereby not necessarily arising from traditional material, as they might have well originated from modern varieties which have then been maintained under dynamic farmer management conditions [19]. Although beans and corn are not considered underutilized species, their landraces under cultivation in southern Brazil can be considered underutilized varieties; they are not being commercialized but they are important in local production and consumption systems, being an integral component of local culture through their use in traditional cuisine. These landraces, which consist of specific ecotypes highly adapted to local agroecological niches, have advantages compared to commercial varieties selected for high yield in that they can be cultivated under more stressful and marginal conditions using limited inputs.

Native plants are less utilized in the south of Brazil as compared to the north of the country. In northern Brazil, a large portion of the population is of indigenous descent and has maintained a strong tradition of consuming native plants. Indigenous groups in the south also maintain their link with nature but this area has also received a large inflow of immigrants of different ethnicities and cultures from the Old World in the last two centuries. These people have brought along various aspects of their culture, including their food preferences. As a result, in the south of Brazil, there are now many landraces that have been adapted by old and new residents in a process of cultural syncretism, translating today into a landscape and food culture that reflects a mix of native and introduced species.

2.2. The Occupation of this Territory

To understand the current situation of agricultural biodiversity in southern Brazil, it is necessary to briefly discuss the historical process of occupation of this territory by different ethnic groups over the last five centuries. In the 16th century, Brazil was inhabited by many indigenous populations. Portuguese sailors reached the Brazilian lands in 1500 and this territory became a colony of Portugal. The Portuguese brought slaves from Africa during the 16th century, and in the 19th century, the country finally became independent from Portugal and, shortly after, abolished slavery.

In the 16th century, the main indigenous peoples present in southern Brazil were the Minuanos, Charruas, Tapes, Guaicurus and Guaranís. The Portuguese established extensive livestock farms in this region, which were dependent (in principle) on indigenous labour, and later on the mestizos (future members of the social group called "gaúcho") resulting from the mix between Indians, Europeans and Africans [20]. In the 19th century, following the independence of Brazil, a large number of immigrants arrived in southern Brazil, especially Germans and Italians, who colonized vast areas establishing farms. Later, in the early 20th century, immigrants came from other parts of the world, especially Japan, Poland and Russia. They settled in rural areas and were largely devoted to agriculture. These immigrations were favoured by the Brazilian Government as means to populate large territories, provide labour for developing the nation and contribute to increasing food production.

Each ethnic group brought its own culture, values, cuisine and often seeds of cereals, vegetables, fruits, fodder, spices and medicinal plants to Brazil. Together with these seeds came the knowledge necessary for planting, growing, harvesting, storing and using the plants and their products. The confluence of different ethnicities resulted in the great human diversity that characterizes the Brazilian people today, making them so unique. Different cultures, religions and food preferences appeared in each region of the country, reflecting closely the history of local occupations and the origin of the inhabitants. Many landraces of a large number of species are still grown in Brazil today—including those belonging to native species, such as cassava, and non-native species, such as onion, which came along with Portuguese people.

3. Agricultural Biodiversity of Neglected and Underutilized Species

3.1. The Dynamic Conservation of Agricultural Biodiversity

In spite of the increasing marginalization of local crops and varieties, some farmers still maintain neglected and underutilized varieties of major commodity crops. They practice recurrent selection looking for types that meet their livelihood needs and cultural preferences. A small number of these farmers have a prominent role in the dynamics of *in situ*/on farm conservation, acting as custodians of this agricultural biodiversity, being more active than others in exchanging material with other growers and passing diversity and knowledge on to new generations (Figure 1). Considering that agricultural biodiversity can be reproduced by seeds, seedlings, cuttings and/or bulbs, such a role requires skills for propagating material and conserving it properly during off-season periods. Custodians' efforts are intimately inter-linked with traditional culture, which guides and inspires farmers in many of their interactions with agricultural biodiversity; defining the naming of varieties to the development of specific cultivation practices or food preparation that embed the history of their own region or family. These practices ultimately influence the way genetic diversity is shaped and sustainably maintained by people.

Figure 1. Afrodescendant farmer in southern Brazil showing a landrace of pumpkin (*Cucurbita moschata*) cultivated by her family. Photo: Rosa Lía Barbieri.

The perpetuation of landraces has relied for centuries solely on farmers' efforts, whose determination was motivated by the fact that the origins of the varieties were intrinsically linked with their own families and clans. In such a context, women have always played a fundamental and leading role (Figure 2), which is far from being properly recognized, valorised and supported [21]. Home gardens maintained by women are, for instance, informal experimental laboratories, in which women introduce new material, develop and monitor performance of native species, and test crops throughout their growth cycle, adapting their cultivation to suit specific needs, and thus producing a variety of products [22]. In the Pampa biome, which is occupied predominantly by extensive livestock farms, it was common until some years ago to observe "spaces surrounded by thorns, cultivated with wheat, beans, rice, cassava, corn, pumpkin, vegetables, fruit trees. A domestic industry managed directly by the farmer's wife produced cheeses, sausages, pickles, beef jerky, fabrics, lace, leather, *etc*..." [23]. These Pampa home gardens are less present today and their contribution to the conservation of agricultural biodiversity and TK are gradually being lost.

Figure 2. Farmer descendant of Italian immigrants in southern Brazil showing a landrace of pumpkin (*Cucurbita maxima*) cultivated by her family. Photo: Eugenio Barbieri.

In the last three decades, a massive loss of farmers' varieties has occurred, being replaced by just a few high-yielding and hybrid varieties [24]. Other factors driving genetic erosion are rural exodus (particularly of the youth) and urbanization [5].

Within this scenario, underutilized species seem to still persist, confined in small patches of land and home gardens. They constitute an important cultural and genetic heritage of family farming that, in spite of the overall decline in agricultural biodiversity, still does persist. Many of these species are sources of genes for tolerance to biotic and abiotic stresses due to the combined action of natural selection in different environments and artificial selection carried out by farmers in agricultural systems with low inputs. They thereby may become more attractive in the context of climate changes. Many of these crops can be successfully grown in marginal, degraded or waste lands, due their adaptability, plasticity and resilience to stress under minimal inputs. This genetic diversity could be successfully leveraged in breeding programs to develop improved varieties for drought and heat stresses [25].

Embrapa has been concerned with the *ex situ* conservation of these genetic resources in view of their importance for food and nutritional security, as well as income generation. Investments in the construction and maintenance of genebanks have been amply justified by the strategic role that these genetic resources play in crop improvement programs. Another important role of Embrapa genebanks is the maintenance of varieties for restoration to communities where they have been lost [26].

Ex situ conservation of agricultural biodiversity is highly strategic to society, but its role is also effectively static in nature and needs to be integrated with *in situ*/on-farm conservation efforts for maximum effectiveness [27]. Seeds conserved in genebanks do not face climatic or human selection or adaptation. *In situ* conservation, in contrast, is a dynamic process, where genotypes are constantly under the action of human selection and natural selection. In such a context, Embrapa deploys regular efforts to survey agricultural biodiversity in southern Brazil and collect samples of neglected and underutilized species for securing their diversity in its *ex situ* collections (see Table 1). Embrapa also undertakes initiatives meant to valorise farmers' roles as custodians of agricultural biodiversity, supporting networking among custodians and establishing seed fairs for exchanging samples in different counties of this region [26].

Table 1. Germplasm holdings of underutilized landraces of both major crops and native species from southern Brazil conserved by 29 genebanks of Embrapa (source: State of Brazil's plant genetic resources—second national report [5] and personal information from genebanks' curators provided to the lead author).

Crops		**Species**	**Number of accessions**
Roots and tubers	Potato and wild relatives **	*Solanum tuberosum* and *Solanum* spp. (sec. Tuberarium)	403
	Sweet potato *	*Ipomoea batatas*	80
	Cassava *	*Manihot esculenta*	40
Grains	Oats	*Avena sativa, Avena* spp.	331
	Rye	*Secale cereale, Secale* spp.	106
	Barley	*Hordeum vulgare*	2,467
	Barley and wild relatives **	*Hordeum vulgare, Hordeum stenostachys*	1,375
	Maize (subtropical)	*Zea mays*	80
	Wheat *	*Triticum aestivum*	11,252
	Wild wheat relatives	*Aegilops* spp., *Triticum* spp.	2,212
	Triticale	*Triticosecale* spp.	162
	Peanut *	*Arachis hypogaea*	20
	Beans *	*Phaseolus vulgaris*	773
Forages	Ryegrass *	*Lolium* spp.	2,132

Table 1. *Cont.*

Crops		Species	Number of accessions
Fruits	Native fruits **	*Acca sellowiana, Butia lallemantii, Butia catarinensis, Butia eriospatha, Butia odorata, Butia yatay, Campomanesia xanthocarpa, Eugenia pyriformis, Eugenia uniflora, Inga uruguensis, Myrcianthes pungens, Plinia trunciflora, Psidium cattleianum, Rollinia sylvatica, Rubus* spp.	243
	Strawberry *	*Fragaria* spp.	32
	Prunoideae	*Prunus domestica, Prunus persica, Prunus* spp.	898
	Pear and quince	*Pyrus* spp.	198
	Grape *	*Vitis vinifera, Vitis* spp.	1,345
Vegetables	Onion *	*Allium cepa*	201
	Carrot *	*Daucus carota*	77
	Cucurbits *	*Citrullus lanatus, Cucumis anguria, Cucumis melo, Cucumis metuliferus, Cucumis sativus, Cucurbita argyrosperma, Cucurbita ficifolia, Cucurbita maxima, Cucurbita moschata, Cucurbita pepo, Lagenaria siceraria, Luffa aegyptica, Momordica charantia, Sicana odorifera*	557
	Capsicum peppers *	*Capsicum annuum, Capsicum baccatum, Capsicum chinense, Capsicum frutescens, Capsicum pubescens*	364
Medicinal plants	Espinheira-santa (*Maytenus*) **	*Maytenus ilicifolia, Maytenus aquifolium*	118
Ornamental plants	Ornamental species from Pampa Biome **	*Ruellia angustifolia, Schinus lentiscifolius, Mandevilla coccinea, Baccharis aliena, Dyckia remotiflora, Eriocaulon magnificum, Hypericum connatum, Salvia procurrens, Tibouchina asperior, Brasiliorchis porphyrostele, Oncidium longipes, Cattleya intermedia, Limonium brasiliense, Colletia paradoxa, Calibrachoa excellens, Daphnopsis racemosa, Glandularia selloi*	47
Forest tree species	Eucalypts	*Eucaliptus* spp., *Corymbia* spp.	2,025
	Native and exotic forest trees *	*Acacia melanoxylon, Acrocarpus fraxinifolius, Araucaria angustifolia, Calycophyllum spruceanum, Cryptomeria japonica, Cupressus* spp., *Grevillea robusta, Liquidambar styraciflua, Pinus* spp.	162
Other	Flax	*Linum usitatissimum*	1,100
	Olive	*Olea europaea*	60

* Include landraces. ** Include native species.

3.2. Native Fruits

Considering the overall potential of agricultural biodiversity in this region, native fruits are among the species that offer the highest potential for income generation, especially for small holders and their families. Some of the most noteworthy fruits include pitanga (*Eugenia uniflora*), araçá (*Psidium* *cattleianum*), feijoa (*Acca sellowiana*) and butiá (or jelly palm—various species of *Butia*). In recent years, there has been an increase in research investment in these species, with regard to development of more efficient production systems, and breeding, nutrition and food technology to develop new products. To that end, Embrapa and its partners are conducting research with the aim to conserve, characterize, multiply and evaluate the potential use of these horticultural species [28]. Propagation and cultivation methods have been developed for some species such as pitanga and araçá [5,29,30], along with investigations for developing novel products tapping on emerging markets for more nutritious and pro-health foods. Embrapa maintains numerous germplasm accessions of these native fruits, especially in field collections due to fact they have recalcitrant seeds.

Besides the use of fruits in diets, pitanga (*Eugenia uniflora*) is grown as an ornamental plant due its beautiful trunk and leaves, abundant flowers and the fruit colour, which ranges from light to dark red. In Brazil some products based on pitanga are being commercialized such as juices and toiletries (soaps, shampoos, bath oils, body creams and fragrances). The leaves of this plant contain flavonoids, terpenes, tannins and essential oils and the fruits are rich in carotenoids and anthocyanins [31]. It is thus not surprising that preliminary studies have indicated that pitanga can reduce the proliferation of certain types of cancer, such as colorectal, lung, kidney, breast and ovarian cancer [32].

The araçá (*Psidium cattleianum*) is a shrub that produces white flowers and yellow or dark red fruits. The fruit has great potential for economic exploitation, due to its high productivity and low cost in orchard management. It is an alternative source of income for family farms, being a good option for organic farming, due to its rusticity, the characteristics of its fruit (rich in Vitamin C and antioxidants), and high consumer acceptance. The fruit has high potential for income generation through processed products such as sweetmeats, jellies, juices, chocolates and ice cream. Two cultivars of this crop have been developed insofar by Embrapa, viz. the YaCy with yellow fruits and the Irapuã with red fruits [5,28].

The feijoa (*Acca sellowiana*) is a small tree with showy flowers with white petals and red stamens. Besides the fruits, the petals are also edible. In Brazil, its cultivation occurs in Santa Catarina and Rio Grande do Sul State. These fruits are appreciated for fresh consumption and also for making juices and jellies. Recently, some improved cultivars have been developed through participatory breeding selections by the Agricultural Research Corporation from Santa Catarina State (Epagri) and Universidade Federal de Santa Catarina [33,34].

The jelly palm (*Butia* spp.) starts producing fruit bunches six to eight years after planting and continues producing fruit every year for more than 100 years! The colour of mature fruits (Figure 3) ranges from light yellow to dark red and they have a sweetish acid taste. They are most commonly consumed as fresh fruit, in liqueurs, juices, jellies, ice creams, cakes and chocolates. The leaves and fruit pulp are used to make crafts. The plant is also used in landscaping gardens and yards. In the last five to 10 years, a number of research investigations have shed light on this very useful multi-purpose plant and advanced our understanding on its biology, field management and use in southern Brazil [35–45]. Considering the current loss of natural populations of this palm in the Pampa biome, actions for the sustainable conservation and management of the remaining populations are being carried out, with a view at studying the population dynamics, conserving genetic variability, recording innovative use of germplasm by local populations and providing better characterization and *in situ* conservation, while adopting an integrated plant production and livestock raising approach. A descriptors list for guiding researchers in describing jelly palm has recently been developed in collaboration with Bioversity International that it is currently being validated [46].

Figure 3. Farmer child descendant from German immigrants in southern Brazil picking a bunch of jelly palm (butiá - *Butia odorata*). Photo: Raquel Silviana Neitzke.

3.3. Bioactive Plants

A wide variety of species are being explored by Embrapa that are used as medicinal plants by local communities in southern Brazil. Among the species worth mentioning here are marcela (*Achyrocline satureioides*), bananinha-do-mato (*Bromelia antiacantha*), carqueja (*Baccharis trimera*), espinheira-santa (*Maytenus ilicifolia*), erva-de-bugre (*Casearia sylvestris*), coronilha (*Scutia buxifolia*) and insulina-do-mato (*Sphagneticola trilobata*) [47,48]. Although these are very important species for local communities, it should be noted that only *Maytenus ilicifolia* is currently conserved in the Embrapa genebank [49], making it imperative to bring support to custodian farmers to strengthen their *in situ* conservation efforts that allow conservation of these other species and their associated traditional knowledge.

Another interesting application of these underutilized species from southern Brazil is related to their use as bioactive agents for pest management in ecologically-based production systems. The bioactive aqueous extracts of five species (viz. *Melia azedarach* - Meliaceae, *Tagetes minuta* - Asteraceae, *Pteridium aquilinum* - Dennstaedtiaceae, *Ruta graveolens* - Rutaceae, *Solanum fastigiatum* - Solanaceae and *Urtica dioica* - Urticaceae) are showing good results for the management of aphids in organic horticulture [50]. Such results have been initiated based on farmers' knowledge and are a valuable step toward the development of agro-ecological knowledge systems that blend together the wisdom of both farmers and scientists, which have generally been moving along different pathways of impact.

3.4. Landraces of Commodity Crops

Landraces of sweet potatoes, beans, cassava, corn, rice, pumpkins, cucumbers, watermelons, melons, gourds, peppers, carrots and onions are an integral part of the history of southern Brazil. These crops are in fact extremely popular in the traditional food systems of communities living in this region (Figure 4). For a long time, the propagation and cultivation of these varieties have been carried out directly by farmers with no inputs from national agencies or private companies. Farmers used seeds passed down from generation to generation and exchanged them among neighbours and relatives. This practice has conserved local diversity and associated knowledge, while contributions were also received by different ethnic groups colonizing the region in terms of introducing different genetic material and a wealth of knowledge required for planting, managing, harvesting, storing, and using these crops.

Figure 4. Landrace of cassava cultivated in southern Brazil by descendants of Azorean (Portuguese) farmers. Photo: Walter Fagundes Rodrigues.

More than genetic heritage, the landraces of these crops represent a continuous cultural celebration, which includes everything from the names assigned to them by the farmers (like beans "quero-quero", whose bicolour grain—white and black—have a pattern of colours that resembles a bird typical in southern Brazil called "quero-quero") to their use in preparing a wide range of traditional dishes (like the "little soup" beans, whose consumption as soup is recommended for pregnant women), and many other purposes. Regrettably, much of the genetic diversity that has been used all along for such a cultural celebration has been or is being lost due to urban migrations and changes affecting farming systems, more and more geared towards commercial standardized varieties of few commodity crops.

Concerned with the increasing genetic erosion affecting these genetic resources, Embrapa has been devoting special attention over the past 20 years to the rescue of landraces and their safe keeping in *ex situ* genebanks. The result of these efforts have contributed to safeguard many accessions of landraces of sweet potato, cucurbits, peppers, carrot, onion, cassava, peanut and beans from this area (see Table 1). As a way to promote the use of these accessions, Embrapa genebanks staff has characterized several crops through agro-morphological studies, molecular markers and chemical analyses. In many cases, Embrapa has been also carrying out breeding activities, which have led to the release of several improved varieties to farmers: such as carrot cultivars Brasília and Alvorada, onion cultivars Primavera, Aurora and Cascata; sweet potato cultivars BRS Cuia, BRS Amelia and BRS Rubisol; pumpkin cultivars BRS Tortéi and BRS Linda.

4. Conclusions

A new scenario for conservation and use of agricultural biodiversity of neglected and underutilized plant species can be drawn from changes in consumption patterns, with the aim for higher quality of life, including diets with lower caloric value and the inclusion of organic products and products derived from our biocultural diversity [51]. In our view, consumers today seem to be more aware of the multiple benefits of biodiversity, while showing a greater appreciation of crops and varieties as conduits that link and valorise their own roots and identity. To that end, we observe an emergence of new and targeted markets where there is greater appreciation of family farming and local knowledge, both strategic elements for empowering people in the place where they live. However, for this to become a robust reality, it is necessary to invest more on both the scientific and traditional knowledge associated with agricultural biodiversity. We believe that while this is a major responsibility for Embrapa and its partners from Brazilian universities and research institutions, it would represent a great investment for the livelihood of future generations. We strongly believe that science and technology applied to the sustainable and innovative use of biodiversity in coming years should devote greater attention to cultural dimensions and indigenous plant genetic resources, which provide a huge window of opportunity for differentiated products with higher added value while contributing to build a strategic livelihood buffer against climate change shocks.

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Author Contributions

Rosa Lía Barbieri, Stefano Padulosi and Adriana Alercia conceived and designed the study. The data were collected and analyzed by João Carlos Costa Gomes and Rosa Lía Barbieri.

Conflict of Interest

The authors declare no conflict of interest.

References and Notes

1. Gomes, J.C.C.; Borba, M.F.S. A moderna crise dos alimentos: oportunidade para a Agricultura Familiar. *Agroecologia e Desenvolvimento Rural Sustentável* **2000**, *1*, 52–65, (in Portuguese).
2. Padulosi, S.; Bhag, M.; Ravi, S.B.; Gowda, J.; Gowda, K.T.K.; Shanthakumar, G.; Yenagi, N.; Dutta, M. Food security and climate change: Role of plant genetic resources of minor millets. *Indian J. Plant Genet. Resour.* **2009**, *22*, 1–16.
3. Kahane, R.; Hodgkin T.; Jaenicke, H.; Hoogendoorn, C.; Hermann, M.; Keatinge, J.D.H.; Hughes, d'A.J.; Padulosi, S.; Looney, N. Agrobiodiversity for food security, health and income. *Agron. Sustain. Dev.* **2013**, *33*, 671–693.
4. Padulosi, S.; Thompson, J.; Rudebjer, P. *Fighting Poverty, Hunger and Malnutrition with Neglected and Underutilized Species (NUS): Needs, Challenges and the Way Forward*; Bioversity International: Rome, Italy, 2013.
5. Mariante, A.; Sampaio, M.J.; Inglis, M.C.V., Eds. *The State of Brazil's Plant Genetic Resources: Second National Report*. Embrapa: Brasília, Brazil, 2009.
6. De Boef, W.S.; Thijssen, M. Community biodiversity management and *in situ* conservation of plant genetic resources. In *Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources*; De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., O'Keeffe, E., Eds.; Routledge: Wageningen, The Netherlands, 2013; pp. 51–61.
7. Shi, H.; Singh, A.; Kant, S.; Zhu, Z.; Waller, E. Integrating habitat status, human population pressure, and protection status into biodiversity conservation priority setting. *Conserv. Biol.* **2005**, *19*, 1273–1285.
8. McNeely, J.A.; Miller, K.; Reid, W.; Mittermeier, R.; Werner, T. *Conserving the World's Biological Diversity*; The World Conservation Union, World Resources Institute, Conservation International, World Wildlife Fund-US and World Bank: Washington, DC, USA, 1990.
9. Mittermeier, R.A.; Gil, P.R.; Mittermeier, C.G. *Megadiversity: Earth's Biologically Wealthiest Nations*; Conservation International: Washington, DC, USA, 1997.
10. Norgaard, R.B. *Development Betrayed; the End of Progress and a Coevolutionary Revisioning of the Future*; Routledge: London, UK, 1994.
11. Iturra, R. Letrados y campesinos: el método experimental en la antropología económica. In *Ecología, campesinado e historia* (In Spanish); Sevilla Guzmán, E., González de Molina, M., Eds.; La Piqueta: Madrid, Spain, 1993; pp.131–152.

12. Gomes, J.C.C. Bases epistemológicas da Agroecologia. In *Agroecologia: princípios e técnicas para uma agricultura orgânica sustentável* (In Portuguese); Aquino, A.M., Assis, R.L., Eds.; Embrapa Informação Tecnológica: Brasília, Brazil, 1999.
13. Alonso, L.E. Sujeto y discurso: el lugar de la entrevista abierta en las prácticas de la sociología cualitativa. In *Métodos y técnicas cualitativas de investigación en ciencias socials* (in Spanish); Delgado, J.M., Gutiérrez, J., Eds.; Síntesis: Madrid, Spain, 1994; pp.225–240.
14. Instituto Brasileiro de Geografia e Estatística. Mapa da vegetação do Brasil e mapa de Biomas do Brasil (in Portuguese). Available online: http://www.ibge.gov.br/home/geociencias/default_prod.shtm#USO (accessed on 29 May 2013).
15. Corrêa, M.P. *Dicionário das plantas úteis do Brasil e das exóticas cultivadas* (in Portuguese); Imprensa Nacional: Rio de Janeiro, Brazil, 1926; Volume 1.
16. Stumpf, E.R.T.; Barbieri, R.L.; Heiden, G. *Cores e formas no Bioma Pampa - plantas ornamentais nativas* (in Portuguese); Embrapa Clima Temperado: Pelotas, Brazil, 2009.
17. Heiden, G.; Iganci, J.R.V. Valorizando a flora nativa. In *Cores e formas no Bioma Pampa: plantas ornamentais nativas* (in Portuguese); Stumpf, E.R.T., Barbieri, R.L., Heiden, G., Eds.; Embrapa Clima Temperado: Pelotas, Brazil, 2009; pp.37–41.
18. Villa, T.C.C.; Maxted, N.; Scholten, M.; Ford-Lloyd, B. Defining and identifying crop landraces. *Plant Genetic Resources: Characterization Utilization* **2005**, *3*, 373–384.
19. Shrestha, P.; Shrestha, P.; Subedi, A.; Peroni, N.; de Boef, W.S. Community biodiversity management: Defined and contextualized. In *Community Biodiversity Management, Promoting Resilience and the Conservation of Plant Genetic Resources*; De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., O'Keeffe, E., Eds.; Routledge: Wageningen, The Netherlands, 2013; pp. 19–25.
20. Freitas, D. *O capitalismo pastoril* (in Portuguese); Universidade de Caxias do Sul: Caxias do Sul, Brazil, 1980.
21. Siliprandi, E. Mulheres agricultoras e a construção dos movimentos agroecológicos no Brasil. In *Mulheres camponesas: trabalho produtivo e engajamentos políticos* (in Portuguese); Neves, D.P., Medeiros, L.S., Eds.; Alternativa: Niterói, Brazil, 2013; pp. 329–343.
22. Léon, I.; Senra, L. Las mujeres gestoras de la soberanía alimentaria. In *Las mujeres alimentan al mundo: soberania alimentaria en defensa de la vida y del planeta* (in Spanhish); Herrero, A., Vilella, M., Eds.; Entrepueblos/Entrepobles/Entrepobos/Herriante: Barcelona, Spain, 2009; pp. 16–39.
23. Xavier, P. A estância no Rio Grande. In *Rio Grande do Sul: terra e povo* (In Portuguese); Editora Globo: Porto Alegre, Brazil, 1969; pp. 55.
24. Canci, A.; Guadagnin, C.A.; Henke, J.P.; Lazzari, L. The diversity kit: Restoring farmers' sovereignty over food, seed and genetic resource in Guarciaba, Brazil. In *Community Biodiversity Management: Promoting Resilience and the Conservation of Plant Genetic Resources*; De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M., O'Keeffe, E., Eds.; Routledge: Wageningen, The Netherlands, 2013; pp. 32–36.
25. Sthapit, B.; Padulosi, S. On-farm conservation of neglected and underutilized crops in the face of climate change. In *On-farm Conservation of Neglected and Underutilized Species: Status, Trends and Novel Approaches to Cope With Climate Change*; Padulosi, S., Bergamini, N., Lawrence, T., Eds.; Bioversity International: Frankfurt, Germany, 2011; pp.31–48.

26. Dias, T.A.B.; Ferreira, M.A.J.F.; Barbieri, R.L.; Teixeira, F.F.; Azevedo, S.G. Gene banks that promote on-farm management through the reintroduction of local varieties in Brazil. In *Community Biodiversity Management: Promoting Resilience and the conservation of Plant Genetic Resources*; De Boef, W.S., Subedi, A., Peroni, N., Thijssen, M. O'Keeffe, E., Eds.; Routledge: Wageningen, The Netherlands, 2013; pp. 91–95.
27. Dulloo, M.E.; Hunter, D.; Borelli, T. Ex situ and *in situ* conservation of agricultural biodiversity: Major advances and research needs. *Notulae Botanicae Horti Agrobotanici Cluj* 2010, *38*, 123–135.
28. Franzon, R.C. Caracterização de Mirtáceas nativas do Sul do Brasil (in Portuguese). Master thesis, Universidade Federal de Pelotas, Pelotas, Brazil, 2004.
29. Franzon, R.C. Propagação vegetativa e modo de reprodução da pitangueira (*Eugenia uniflora* L.) (In Portuguese). PhD thesis, Universidade Federal de Pelotas, Pelotas, Brazil, 2008.
30. Franzon, R.C.; Castro, C.M.; Raseira, M.C.B. Variabilidade genética em populações de pitangueira oriundas de autopolinização e polinização livre, acessada por AFLP (in Portuguese). *Revista Brasileira de Fruticultura* **2010**, *32*, 240–250.
31. Bagetti, M.; Facco, E.M.P.; Piccolo, J.; Hirsch, G.E.; Rodriguez-Amaya, D.B.; Vizzotto, M.; Emanuelli, T. Physicochemical characterization and antioxidant capacity of pitanga fruits (*Eugenia uniflora* L.). *Ciência e Tecnologia de Alimentos* **2011**, *31*, 147–154.
32. Vizzotto, M. Embrapa, Pelotas, RS, Brazil. Personal communication, 2013.
33. Nodari, R.O.; Santos, K.L.; Ducroquet, J.P.; Guerra, M.P. Goiaba-serrana: domesticação. In *Origem e evolução de plantas cultivadas* (in Portuguese); Barbieri, R.L., Stumpf, E.R.T., Eds.; Embrapa Informação Tecnológica: Brasília, Brazil, 2008; pp. 415–435.
34. Donazzolo, J. Conservação pelo uso e domesticação da feijoa na Serra Gaúcha–RS (in Portuguese). PhD Thesis, Universidade Federal de Santa Catarina, Florianópolis, Brazil, 2012.
35. Rossato, M. Recursos genéticos de palmeiras nativas do gênero *Butia* no Rio Grande do Sul (in Portuguese). PhD Thesis, Universidade Federal de Pelotas, Pelotas, Brazil, 2007
36. Rossato, M.; Barbieri, R.L. Estudo etnobotânico de palmeiras do Rio Grande do Sul. *Revista Brasileira de Agroecologia* **2007**, *2*, 997–1000, (in Portuguese).
37. Rossato, M.; Barbieri, R.L.; Schäfer, A.; Zacaria, J. Caracterização molecular de populações de palmeiras do gênero *Butia* do Rio Grande do Sul através de marcadores ISSR. *Magistra* **2007**, *19*, 311–318, (in Portuguese).
38. Büttow, M.V.; Barbieri, R.L.; Rossato, M.; Neitzke, R.S.; Heiden, G. Conhecimento tradicional associado ao uso de butiás (*Butia* spp., Arecaceae) no sul do Brasil. *Revista Brasileira de Fruticultura* **2009**, *31*, 1069–1075, (in Portuguese).
39. Tonietto A.; Schlindwein, G.; Tonietto, S.M. *Uso e potencialidades do butiazeiro* (*Circular Técnica 26)* (in Portuguese); Fepagro: Porto Alegre, Brazil, 2009.
40. Büttow, M.V.; Castro, C.M.; Schwartz, E.; Tonietto, A.; Barbieri, R.L. Caracterização molecular de populações de *Butia capitata* (Arecaceae) do Sul do Brasil através de marcadores AFLP. *Revista Brasileira de Fruticultura* **2010**, *32*, 230–239, (in Portuguese).
41. Corrêa, L.B.; Barbieri, R.L.; Rossato, M.; Büttow, M.V.; Heiden, G. Caracterização cariológica de palmeiras do gênero *Butia* (Arecaceae). *Revista Brasileira de Fruticultura* **2009**, *31*, 1111–1116, (in Portuguese).

42. Schwartz, E. Produção, fenologia e qualidade dos frutos de *Butia capitata* em populações de Santa Vitória do Palmar (in Portuguese). PhD thesis, Universidade Federal de Pelotas: Pelotas, Brazil, 2008.
43. Schwartz, E.; Fachinello, J.C.; Barbieri, R.L.; Silva, J.B. Avaliação de populações de *Butia capitata* de Santa Vitória do Palmar. *Revista Brasileira de Fruticultura* **2010**, *32*, 736–745, (In Portuguese).
44. Fior, C. Propagação de *Butia odorata* (Barb. Rodr.) Noblick & Lorenzi (In Portuguese). PhD Thesis, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, 2011.
45. Mistura, C.C.; Barbieri, R.L.; Castro, C.M.; Priori, D.; Villela, J.C.B. Transferibilidade de marcadores microssatélites de coco (*Cocos nucifera*) para butiá (*Butia odorata*). *Magistra* **2012**, *6*, 360–369, (In Portuguese).
46. Mistura, C.C. Caracterização de recursos genéticos de *Butia odorata* no Bioma Pampa (In Portuguesee). PhD Thesis, Universidade Federal de Pelotas, Pelotas, Brazil, 2013.
47. Rodrigues, W.F.; Gomes, G.C.; Medeiros, A.R.M.; Barbieri, R.L. *Espécies arbóreas da serra dos Tapes: um resgate etnobotânico (Documentos 190)* (in Portuguese); Embrapa Clima Temperado: Pelotas, Brazil, 2007.
48. Ceolin, T. Conhecimento sobre plantas medicinais entre agricultores de base ecológica do sul do Brasil (In Portuguese). Master's Thesis, Universidade Federal de Pelotas, Pelotas, Brazil, 2009.
49. Mariot, M.P.; Barbieri, R.L. Divergência genética entre acessos de espinheira-santa (*Maytenus ilicifolia* Mart. ex Reiss. e *M. aquifolium* Mart.) com base em caracteres morfológicos e fisiológicos. *Revista Brasileira de Plantas Medicinais* **2010**, *12*, 243–249, (in Portuguese).
50. Lovatto, P.B. As plantas bioativas como estratégia à transição agroecológica na agricultura familiar: análise sobre a utilização empírica experimental de extratos botânicos no manejo de afídeos em hortaliças (in Portuguese). PhD thesis, Universidade Federal de Pelotas, Pelotas, Brazil, 2012.
51. Toledo, V.M.; Barrera-Bassols, N. *La memoria biocultural: la importancia ecológica de las sabidurías tradicionales* (in Spanish); Icaria: Barcelona, Spain, 2008.