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Diversity and use of tropical tuber crops in Latin America

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled Diversity and use of tropical tuber crops in Latin America independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague 17.4.2024

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Abstract

Roots and tuber crops play a vital role in both household and national food security especially in developing countries. In numerous regions across Latin America, impoverished farmers and individuals facing food insecurity rely heavily on roots and tubers for sustenance, nutrition, animal feed, and income generation. Tuber crops are even utilized as alternatives to cereal flours in industrial processes, including the production of starch, distilled spirits, and various minor products. Additionally, they find applications in traditional medicine, contributing to disease risk mitigation and overall wellness. This thesis was done as a literature review of tuber crops cultivated in Latin America. It provided an overview of roots and tuber crops, their definition, modes of propagation, utilization, and prospects for future development. Phytochemical composition including toxicity and medicinal uses were also discussed. The thesis then focused on ecological aspects of tuber crops cultivation such as the impact of climate change and other factors influencing the production of crops. Additionally, the plant species and their variability were presented along with a table summarizing these findings, included as an output of the review.

Key words: tuber crops, Latin America, diversity, plant taxonomy, agrobiodiversity

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List of the abbreviations used in the thesis

CO_2 – Carbon dioxide

GDP – Gross domestic product

LAC – Latin America and the Caribbean

LDL – low-density lipoprotein

WMO – World Meteorological Organization

1. Introduction

1.1. Foreword

Despite the outstanding progress made in improving food production at the global level, approximately half of the population in developing countries does not have access to adequate food supplies. In many parts of Latin America, poorest farmers and food-insecure people are dependent on roots and tubers as a source of food, nutrition, and income (Alexandratos 1995).

Roots and tuber crops play a vital role in regions or countries facing rapid population growth and strained local agri-food systems. This significance becomes particularly pronounced in situations such as droughts or sudden spikes in commodity prices, limiting the capacity for food imports (Scott 2021).

Tropical root and tuber crops are rich sources of carbohydrates globally, able to produce twice as much useful dry matter as cereals. In 2013, global production of tuber crops reached an estimated total of 531 million tons per year. Among these, cassava (*Manihot esculenta*) emerged as the most significant, with a production volume of 273 million tons annually, followed by sweet potato (*Ipomoea batatas*) at 179 million tons per year, yams (*Dioscorea spp.*) at 68 million tons per year, and taro (*Colocasia esculenta*) at 11 million tons per year (FAOSTAT 2014). These are the major crops commonly grown in many developing countries and due to their resilience to climate changes, by the year 2030 they should double their contribution to food security (Nayar 2015).

These crops are generally associated with production for dietary purposes (approximately 45 % of production) with the remainder used as animal feed or for industrial processing for products such as starch, distilled spirits, and a range of minor products (Parvatha Reddy 2015). Fermented cassava starch and starch-based products are traditional in Latin America, especially in Brazil and Colombia. Cassava roots can be processed into beverages such as wine and beer (Ray & Sivakumar 2009). Sweet potato and taro flour also serves as substitute for cereal flours, not containing gluten so it is suited for individuals diagnosed with celiac disease and it is also a major constituent of baby food products due to its easily digestible nature (Aditika et al. 2022). Some edible tubers are also used in traditional medicine, entailing disease risk reduction and wellness (Kamalkumaran et al. 2020).

The potential of these crops is slowly being recognized. Not only are they rightly stated as important for both household and national food security (Onwueme & Charles 1994), but also carry potential for economic growth, such as their significant contribution to total biofuels production (Ray & Ramachandran 2019). Hence, an improved understanding of tuber crops production, utilization and trade might be rather beneficial, especially in developing countries (Scott et al. 2000).

1.2. Study area

1.2.1. Location and Geographical Description of Latin America

Latin America, also known as Hispanic America or Iberoamerica, encompasses South America, Mexico, Central America, and the Caribbean islands whose inhabitants speak Romance languages (Spanish, Portuguese, or French) due Spanish and Portuguese colonization from the late 15th to the 18th century. Despite a sense of common heritage, each nation has distinct differences shaped by factors such as pre-colonial populations, European colonization, and economic resources. These differences are evident in social, cultural, geographical, and climatic aspects, contributing to the diverse tapestry of Latin American nations (Kittleson et al. 2024).

This land includes 19 sovereign nations and one unincorporated territory, Puerto Rico. Its total area covers 20,139,378 km2 (Worldometer 2024). The region is bordered by the Pacific Ocean to the west and the Atlantic Ocean to the east, with the Caribbean Sea lying to the north. While the exact boundaries can vary depending on interpretation, Latin America generally extends from approximately 32° North latitude to 56° South latitude, and from about 35° East longitude to 118° West longitude.

The largest country by both population and land area is Brazil, covering approximately 8.5 million square kilometres and the largest island is Cuba, which spans around 110,860 square kilometres. On the other hand, the Suriname is the smallest and least populated country of Latin America, yet its population is one of the most ethnically diverse in the region (CIA 2024).

The region's location along major tectonic plate boundaries also make it prone to seismic activity, including earthquakes and volcanic eruptions. Despite these natural challenges, Latin America's diverse geography has contributed to its landscape richness. It is home to the Amazon Rainforest, the world's largest tropical rainforest, which covers much of the Amazon Basin in South America. Additionally, the Andes Mountains, the longest mountain range in the world with its peak at 6,960.8 metres above sea level, run along the western coast of South America. In contrast to this, there are located arid landscapes of the Atacama Desert in Chile and the deserts of northern Mexico. The south of Latin America is composed of very fertile pampas, and savannas in the north and central regions (CIA 2024).

Figure 1: Physical Map of Latin America (Encyclopedia Britannica)

1.2.2. Climate of Latin America

Latin America exhibits a diverse range of climates due to its vast size and varied geography. The continent experiences a wide spectrum of climatic conditions, ranging from equatorial and tropical climates near the equator to more temperate and even cold climates in the southern regions (Boudreau et al. 2023).

In the north, countries like Colombia, Venezuela, and Brazil feature tropical rainforests and savannas, characterized by high temperatures and heavy rainfall throughout the year. Moving southward, the climate transitions to a more subtropical or temperate climate in countries like Argentina, Uruguay, and southern Brazil. These areas experience distinct seasons with warmer summers and cooler winters (Boudreau et al. 2023; CIA 2024).

In the Andean region of countries like Ecuador, Peru, Bolivia, and Chile, the climate varies depending on altitude. Higher elevations typically have cooler temperatures, while lower elevations may experience warmer conditions. The Andes also influence precipitation patterns, leading to wetter conditions on windward slopes and drier conditions on leeward slopes (CIA 2024).

According to WMO´s report (2023), the period from 1991 to 2022 showed an average warming trend of about 0.2 °C/decade. High temperatures, low air humidity and severe drought led to periods of record wildfires causing the highest emissions of CO_2 in the last 20 years. Sea levels exhibited a faster rate of increase in the South Atlantic and the subtropical North Atlantic compared to the global average.

1.2.3. Population of Latin America

As of Monday, March 18, 2024, the estimated population of Latin America and the Caribbean stands at 668,541,908 according to the latest United Nations data. This accounts for approximately 8.28% of the global population. Latin America and the Caribbean ranks among the world's most populous regions. The population density in this region is thirty-three people per square kilometre. Urban areas are predominant, with 84% of the population residing in cities, totalling 558,814,380 people as of 2023. The median age in Latin America and the Caribbean is 31.0 years. The vast majority of

Latin Americans are Christians (90%) mostly Roman Catholics belonging to the Latin Church (Worldometer 2024).

1.2.4. Agrobiodiversity and Agriculture of Latin America

Latin America boasts diverse agricultural landscapes, spanning from equatorial zones in the north to sub-Arctic regions in the south, encompassing tropical, temperate, arid, and cold climates.

The continent's tropical regions, with abundant rainfall, foster the growth of cash crops like cashews and Brazil nuts, along with fruits such as avocado, pineapple, papaya, and guava. Coffee and cacao, vital cash crops for the region, flourish here, with Brazil leading global coffee and cacao exports, until a cacao fungus crisis in 2000 shifted cacao production mainly to tropical Africa (Boudreau et al. 2023).

Temperate climates south of the Tropic of Capricorn and in the Andean mid-elevations nurture corn and soybeans, pivotal to the pampa´s agricultural economy. The pampas also support extensive ranching, making Brazil and Argentina significant beef exporters. Arid areas present challenges for agriculture, yet irrigation enables the cultivation of rice and cotton in desert oases. In cold climates, found in the southern reaches of Argentina and Chile, as well as the Andean highlands, native crops like potatoes and quinoa thrive, sustaining local diets (OECD and FAO 2019; Boudreau et al. 2023).

Furthermore, cold climates support grazing animals like sheep, llamas, alpacas, and vicuñas, valued for their meat and wool, which contributes to the region's textile industry. This rich agricultural tapestry underscores Latin America's significance in global food production and trade (Boudreau et al. 2023).

Forestry and fisheries are vital economic pillars in tropical South America. The Amazon River basin, rich in biodiversity, yields sought-after timber species like mahogany and rosewood, fuelling international markets. Meanwhile, lower-grade woods like eucalyptus drive the construction industry, particularly in disadvantaged communities. Along the Pacific coast, marine fisheries thrive, supported by nutrient-rich waters. While Peru and Chile boast abundant anchovy populations, overfishing poses a threat to marine ecosystems. Balancing economic interests with environmental conservation is crucial for safeguarding these invaluable resources (OECD and FAO 2019; Boudreau et al. 2023).

The agricultural sector plays a vital role in the economy of many LAC countries, being a significant contributor to GDP in countries like Argentina, Ecuador, Guatemala, and Guyana (OECD and FAO 2019).

2. Aims of the Thesis

This bachelor's thesis aimed to provide a review of the literature that has been published on crops and plants cultivated and used for their underground organs, particularly tubers. The area chosen for this research was Latin America.

This thesis offered an overview of tropical tuber crops, the significant role they play in both household and national food security, especially in developing countries. It focused on their propagation, utilization, and potential for future development, not only in contribution to food security, but also economic growth. It aimed to discuss their phytochemical composition along with the ecological aspects of tuber crops cultivation.

Additionally, the plant species and their variability were presented with respect to different major ecological regions along with the key products.

3. Methodology

The thesis focused on an overview of tropical tuber crops with a particular emphasis on Latin America. The topics that were analysed included the main use of tuber crops- food security, propagation, utilization, potential for future development, phytochemical composition, and ecological aspects.

Additionally, it focused on presenting various plant species and, in some instances, explored their variability across different major ecological regions. A table summarizing these findings was included as an output of the review.

A systematic literature review was done through electronic research on Web of Science, Scopus, Google Scholar, ScienceDirect, and SpringerLink. A combination of key words such as “Tuber Crops”, “Latin America”, “Diversity”, “Use”, “Utilization”, “Tropical Crops”, “Cultivation”, “Toxicity”, “Phytochemical Composition”, “Production”, “Agrobiodiversity”, “Plant taxonomy”, and so on were used when searching for information. Additionally, printed literature, focusing on tuber crops in Latin America was used as well.

4. Literature Review

4.1. Definition of Tuber Crops

Tuber crops, particularly in Latin America, refer to plants cultivated for their underground storage structures, known as tubers, which serve as important sources of food and nutrition. Apart from their high-water content (70%-80%), these crops are rich in carbohydrates (largely starches that account for 16%-24% of their total weight), vitamins, and minerals, making them essential components of diets across Latin America (Nanbol & Otsanjugu 2019).

Originating from diversified botanical sources, these crops include a variety of species such as cassava, sweet potato, yams, taro, and different types of potatoes. Potatoes and yams belong to the category of tubers, while taro and cocoyams are derived from corms, underground stems, and swollen hypocotyls. Cassava and sweet potatoes, on the other hand, are classified as storage roots, while arrowroots are edible rhizomes (Chandrasekara & Kumar 2016).

They are valued for their ability to grow in diverse environmental conditions and their resilience to various pests and diseases. Tubers play a significant role in food security, livelihoods, and agricultural traditions throughout the region, contributing to the cultural and economic fabric of Latin American societies (Hermann & Heller 1997).

4.2. Tuber crops overview

4.2.1. Taxonomy

Latin America boasts a rich diversity of root and tuber crops, with over twenty-five native species belonging to 16 botanical genera and 15 families, encompassing both mono- and dicotyledons. This represents a greater range of root and tuber crop diversity in terms of taxonomic classification and ecological adaptation than is found anywhere else in the world (Hermann & Heller 1997).

While these plant species belong to distinct botanical families, they are commonly grouped together in scientific research due to their shared characteristics: vegetative propagation, underground food storage, and a bulky, perishable nature (Lebot 2019).

4.2.2. Propagation

Propagation of roots and tuber crops is a crucial aspect of agriculture, ensuring the continuous supply of these valuable food sources. Unlike many other plants, roots and tubers are often propagated vegetatively, meaning new plants are grown from parts of existing plants rather than seeds. Due to their limited ability to produce seeds, influenced by both natural and cultural factors. Natural factors include issues like abnormal seed and seedling development, seed dormancy, and susceptibility to pests and diseases affecting flowers and seeds. Cultural factors also play a role, as plants are typically harvested before flowering, when storage organs have matured, hindering seed production (Léon 1977).

There are several common methods of vegetative propagation used for roots and tubers. One method involves planting sections of the plant's underground structures, such as tubers, rhizomes, or corms. These sections contain buds or eyes from which new shoots can emerge, giving rise to new plants. Another method is through stem cuttings, where a portion of the stem is removed and planted in soil to produce new roots and shoots. In addition to tubers and stem cuttings, some roots and tubers can also be propagated using vine cuttings, side shoots, stolons, or corm heads. Each method has its advantages and is suitable for different types of plants and growing conditions (Onwueme & Charles 1994; Onwueme 1978).

4.2.3. Utilization

Root and tuber crops offer significant agronomic benefits as staple foods due to their remarkable adaptation to various soil types and environmental conditions, as well as their ability to thrive in different farming systems with minimal inputs. Their versatility in growth patterns and suitability for diverse cultural practices makes them particularly well-suited to specific production systems. However, despite these advantages, roots, and tubers present challenges due to their bulky nature and high moisture content. This can result in elevated transportation costs, short shelf life, and limited market margin, particularly in developing countries where these crops are predominantly cultivated (Chandrasekara & Kumar 2016).

During harvesting, root and tuber crops often sustain different types of injuries, which can accelerate respiration and result in the loss of water and carbohydrates, leading to the deterioration of starchy tissues. For instance, cassava roots, when exposed to unfavourable temperatures and humidity, may exhibit symptoms such as blue to black vascular streaking, rotting, and tissue breakdown, significantly impacting the economic value of the crops (More et al. 2019).

Most textbooks suggest that root and tuber crops store well, but this is often not the case. Researchers have noted significant weight loss during prolonged storage, primarily due to water loss from transpiration and degradation of dry matter through natural metabolic processes. Tubers, being more perishable than grains, exhibit higher metabolic activity post-harvest. Under ambient conditions, cassava, sweet potato, and yams can be stored for 2 to 3 days, 2 to 4 weeks, and 16 to 18 weeks, respectively. Tubers are living storage organs, and their storage behaviour can be affected by physiological stress. Adequate ventilation to provide plenty of oxygen is necessary to maintain the ideal metabolic state of tubers. Extreme heat increases respiration rates, while extreme cold lowers them, both negatively impacting tuber quality (More et al. 2019).

Another issue occurring, is browning of surfaces exposed by cutting and peeling. Heat treatment serves as a chemical-free approach to prevent plant browning post-harvest. It involves treating plants with hot water, vapor heat, or hot dry air. Among these methods, hot water treatments are more cost-effective and suitable for large-scale commercial applications. Additionally, heat treatments can enhance fruit quality by prolonging shelf life and marketability through the inhibition of ripening processes (Chang & Kim 2015).

Postharvest management is essential to maximize the benefits of crop production by reducing losses and maintaining product quality and nutritional value (More et al. 2019).

4.2.4. Potential for future development

Root and tuber products are marketed across diverse segments, each with unique demands. In food markets, distinctions arise between low- and high-income consumers regarding consumption preferences and product expectations. While high-income consumers prioritize convenience, quality, and extended shelf life, price often takes precedence for low-income consumers (Wheatley 1995; Sadik 1988).

Roots and tubers present significant potential as low-cost, locally sourced materials for various processed goods, provided they can rival cereals in terms of price, quality, and availability. In developing countries, there is a notable uptick in the consumption of animal products and their derivatives, alongside the utilization of root and tuber crops as affordable carbohydrate sources for livestock (Wheatley 1995).

Industries reliant on starches and flours offer further avenues for the integration of locally produced root and tuber products, potentially replacing imported cereals. Moreover, it also helps alleviate poverty by providing employment opportunities in production, processing and marketings, especially income earning opportunities for women (Scott et al. 2000).

Additionally, roots and tubers offer potential solutions to environmental challenges. For instance, sweet potatoes can function as rapid cover crops, effectively mitigating soil erosion, so utilization of roots and tuber crops can prove highly advantageous (Scott et al. 2000).

4.3. Phytochemical constitution of tuber crops

4.3.1. Toxic substances and antinutritional factors

Tuber crops, while rich in essential nutrients, also contain toxic substances and antinutritional factors that can pose health risks if consumed in large quantities. Except for cassava, known for its cyanogenic glycosides, most cultivated varieties of edible tubers and roots do not contain any serious toxins. However, wild species may comprise lethal levels of toxic compounds and require proper processing before consumption. Despite their potential risks, these wild species serve as vital reserves during periods of food shortage. Local communities are aware of the dangers associated with these species and have devised appropriate methods to detoxify the roots and tubers prior to consumption (Oke 1990).

When it comes to toxicity of cassava, a cyanogenic glycoside called linamarin is the primary toxic principle present across all parts of the plant, especially in leaves and tubers. Linamarin becomes toxic upon contact with an enzyme released during the breakage of cassava root cells. Interestingly, the concentration of cyanogenic glycosides tends to increase from the centre of the tuber outward, with the cassava peel generally containing higher levels. Bitterness, however, does not reliably indicate cyanide content. Traditional post-harvest techniques for cassava can effectively reduce cyanide levels to non-toxic thresholds if executed efficiently (Philbrick et al. 1977; Oke 1990).

Various diseases have been linked to the toxic effects of cassava. It has been implicated in acute cyanide poisoning and goitre, which can eventually be reduced by iodine supplements intake. Remarkably, despite consuming substantial quantities of cassava, up to one kilogram per person per day, tribal communities in the Amazon jungle have not reported cases of goitre or neurological disorders. These tribes also have high levels of iodine in their diet due to the significant consumption of animal and fish protein (Oke 1990).

Sweet potato contains raffinose, a sugar known to contribute to flatulence. This sugar remains undigested in the upper digestive tract and is fermented by bacteria in the colon, resulting in the production of flatus gases such as hydrogen and carbon dioxide. The amount of raffinose varies depending on the cultivar of sweet potato. Additionally, fresh sweet potato exhibits trypsin inhibitor activity, which is associated with enteritis. However, sweet potato is typically consumed cooked, and the heat destroys the activity of the trypsin inhibitor present (Lin & Chen 1985; Oke 1990).

Taro corms contain calcium oxalate, an irritant compound that makes them unsuitable for consumption when raw or inadequately cooked. Oxalate can also interfere with calcium absorption in the body. However, through proper processing techniques such as peeling, grating, soaking, and fermenting, the oxalate content can be reduced (Chakraborty et al. 2015).

Potatoes contain glycoalkaloids, primarily found in the flowers and sprouts. In healthy potatoes, peeling can usually reduce the concentration of glycoalkaloids. However, at higher concentrations, these compounds can cause a burning sensation similar to that of hot pepper and become toxic. Solanine, one of the main glycoalkaloids in potatoes, is not eliminated during regular cooking as its decomposition temperature is around 243°C. While solanine poisoning can lead to severe illness, fatalities are rare (Bushway et al. 1983; Oke 1990).

Wild yam varieties, known as bitter yams, may contain bitter principles, making them unsuitable for consumption unless processed. Bitter yams are traditionally detoxified through methods such as soaking in salt water, fresh water, or streams, especially during times of food scarcity. These bitter principles in wild yams are attributed to alkaloids present in certain species, such as dioscorine and dihydrodioscorine. Both substances are considered nerve poisons and can induce paralysis. As a result, yam species containing these alkaloids are utilized for their toxic properties in activities like hunting, fishing, and for certain pharmaceutical purposes (Onwueme 1978; Oke 1990).

To mitigate these risks, proper processing methods such as peeling, soaking, and cooking are essential to reduce the levels of toxic substances and antinutritional factors in tuber crops. Additionally, consuming a varied diet and practicing moderation can help minimize potential health hazards associated with the consumption of tuber crops (Oke 1990).

4.3.2. Medicinal uses

Apart from all the uses mentioned, some edible tubers hold promise for applications in both traditional and conventional medicine. Many starchy tuber crops, except the common potatoes, sweet potatoes, and cassava, are not yet fully explored for their health benefits. However, tubers have an immense potential in disease risk reduction and wellness, containing bioactive constituents such as phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and many others (Chandrasekara & Kumar 2016).

The phenolics present in tubers render several health benefits, namely, antibacterial, antiviral, anti-inflammatory, anticarcinogenic activities, and vasodilatory actions. Potato tubers with red and purple flesh are rich source of phenolic compounds in the diet, along with their high dietary fibre and antioxidant properties (Bradshaw 2010).

Antioxidant activities were also reported in recent study (Omar et al. 2012), showing that the antioxidant properties were higher in organically grown cassava tubers in comparison to cassava grown with inorganic, mineral-base fertilizers.

Yam exhibits potential in reducing the risk of cancer and cardiovascular diseases among postmenopausal women. Additionally, the rhizome has been traditionally utilized in China and other Asian countries to address conditions such as breast lumps, sore throat, and tumours (Parida & Sarangi 2021).

Apart from that, tubers from certain wild species are commercially exploited due to their content of steroidal sapogenins. These compounds are used in the production of contraceptives, sex hormones, and cortisone (Flach & Rumawas 1996).

Taro contains both dietary and non-dietary fibre, which offer various functional benefits. These include aiding digestion, reducing intestinal transit time, lowering total LDL cholesterol levels, neutralizing excessive stomach acid, preventing constipation, and enhancing the water-holding capacity of food (Temesgen & Retta 2015).

4.4. Ecological aspects of tuber crops cultivation

4.4.1. Vulnerability to Climate Change and Soil Degradation

Rising temperatures due to global changes pose a threat to food security in smallholder mountain communities, affecting the suitability of cultivation areas for various crops. In the Andean region, farmers traditionally cultivate crops at different elevations, but warming climates have forced a shift in cultivation patterns towards higher altitudes. However, this adaptation strategy is not always viable. Research by Visscher et al. (2024), indicates that warmer climates have adverse effects on crop production, but organic fertilization methods can mitigate these impacts by maintaining crop yield and biomass production compared to synthetic nutrient inputs. These findings underscore the urgent need to address climate warming's detrimental effects on small-scale crop production in the Peruvian Andes, which could lead to significant declines in the production of locally important crops. However, the continued use of traditional crops with organic inputs rather than synthetic fertilizers may help bolster agricultural productivity and resilience in the face of climate change.

Moisture stress and salinity are significant environmental challenges that hinder crop production. While cassava demonstrates a greater ability to adapt to drought conditions compared to salt accumulation, it can thrive in low rainfall regions and endure extended dry spells. The plant's response to moisture stress involves reducing transpiration, with extreme conditions plants shed their leaves and remain biologically active (Palaniswami & Peter 2008). Similarly, sweet potatoes exhibit resilience by thriving in infertile soil with minimal inputs and enduring periods of irregular rainfall and drought (Horton 1988).

Typically, the ideal pH range for most tuber crops falls between 5.5 and 6.5. Cassava and sweet potatoes tolerate pH levels up to around eight, with some variations among varieties. Irish potatoes have a broader tolerance range, spanning from 4.5 to 7.5. Meanwhile, the lower pH limit for cassava can be as low as four. Data regarding the pH tolerance limits for aroid crops and yams are incomplete (Flach & Rumawas 1996).

4.4.2. Adaptation strategies

Climate change challenges tropical root and tuber crops, additionally, extreme weather events such as droughts and floods can disrupt cultivation practices and affect overall food security in developing countries, but effective adaptation strategies exist. Promoting climate-resilient varieties, efficient water management, agronomic practices, crop diversification and agroecological methods are vital (Saravanan & Gutam 2023).

Developing climate-resilient crop varieties, especially root and tuber crops, is critical for adapting to climate change. Small-scale producers in low and middle-income countries with significant tuber consumption must prioritize climate-resilient food security. Breeding programs play a leading role in this effort, focusing on traits like robust root systems and drought tolerance. Selecting for resilient traits is essential in creating crops that can withstand drought, heat, diseases, while optimizing nutrient use efficiency (Bakala et al. 2020; Acevedo et al. 2020).

Effective water management is essential for ensuring sustainable agriculture, especially in the face of climate change. Precise irrigation methods, such as drip and micro-sprinklers, play a crucial role in optimizing water use efficiency. Drip irrigation targets water directly to plant roots, minimizing evaporation, while micro-sprinklers ensure uniform coverage, reducing wastage due to evaporation or wind drift. Real-time soil moisture sensors further enhance water management by allowing farmers to irrigate only when needed, thus preventing over-irrigation (Brar 2022).

4.5. Traditional farming practices

Andean farmers developed sophisticated practices to overcome challenges in planting terrain, environmental conditions, and diseases, ensuring successful plots of Andean root and tuber crops each year. They constructed terraces across steep slopes to combat soil erosion and create suitable growing plots. The highlands of Peru, with extreme and varied conditions, host terraced farmland where tubers like oca, potato, ulluco, and mashua are still grown today. Vertical farming practices allowed for different crop varieties at varying elevations, serving as insurance against crop failure and extending cultivation periods. Instead of chemical treatments, Andean farmers rely on intercropping to control diseases and pests. They plant numerous potato varieties in the same field and intercrop mashua with oca, potatoes, and ulluco to manage pests and diseases. Research confirms mashua's resistance to various pathogens and pests, validating its importance as an intercropping species in Andean farming traditions (National Research Council 1989; Flores et al. 2003).

4.6. Regional diversity

4.6.1. Andean region

The Andes stand as one of the Earth's longest mountain ranges, extending over 8,900 km along South America's western coastline. Spanning seven countries- Argentina, Bolivia, Chile, Colombia, Ecuador, Peru, and Venezuela- the Andes showcase diverse climates. The northern region experiences warm, rainy weather, while the western and central parts, encompassing the Atacama Desert in northern Chile, are notably arid in contrast to the humid conditions found in the east (Velásquez et al. 2024). Today, the Andean region stands as a pivotal hub for crop origin and diversity worldwide, marking it as the largest known concentration of underground crops (National Research Council 1989).

One of them is Oca (*Oxalis tuberosa*), cultivated for edible tubers, leaves, and young shoots. Following the potato, oca ranks as the second most prevalent tuber crop in the Andean region. Oca is characterized by its low-growing herbaceous nature, typically reaching heights of 20-30 cm. Its stems, ranging from green to red, are compact and succulent. The tubers exhibit a variety of shapes, from cylindrical to ovoid, and are found in an array of colours including white, yellow, pink, red, purple, or black (Palaniswami & Peter 2008). Thriving in moderately cool temperatures as low as 5 °C and in poor soil conditions, oca was introduced to Europe in the last century (Flores et al. 2003). Despite being introduced as a novel vegetable, it failed to establish itself as a permanent crop. Oca is often planted alongside ulluco, mashua, and native potatoes, making it challenging to determine its cultivated area and production. Wild species of the *Oxalis* genus are found along the low ridges of the Peruvian coast or coexist with cultivated oca in the Andes and forest edges (Hernández Bermejo & León 1994).

Mashua (*Tropaeolum tuberosum*), exhibits a prostrate or climbing habit, reaching over 1 m in diameter and 0.5 m in height, with slender leaves. Its tubers come in varying colours and shapes, with white, yellow, or occasionally purplish or red skins. The region spanning from central Peru to northern Bolivia exhibits the most diverse array of tuber colours and shapes. Propagation is possible through vegetative means or viable seeds (Hernández Bermejo & León 1994), though tuber formation primarily occurs during short daylight periods, hence why is cultivated once a year. Mashua serves as both food and medicinal crop for Andean highlanders, with all parts of the plant, including tubers, leaves, and blossoms, being consumable. However, tubers are most commonly consumed due to their flavour and high nutritional value, boasting relatively elevated levels of protein and fibre compared to other Andean root and tuber crops (National Research Council 1989; Flores et al. 2003).

The Tropaeolaceae family is relatively small and uniform, genus *Tropaeolum*, boasts 86 species found from southern Mexico to South America (Sparre & Andersson 1991). *Tropaeolum patagonicum* produces edible white tubers consumed by Patagonian tribes, while *T. leptophyllum* serves as a food source for Chilean indigenous communities during times of scarcity. Another widely cultivated species within *Tropaeolum* is *T. majus*, known as the garden nasturtium, favoured for its ornamental value in temperate regions. Several wild species closely related to *T. tuberosum* are recognized, with notable examples including *T. longiflorum, T. crenatiflorum,* and *T. purpureum,* which are endemic to Peru, these species tend to have limited geographical distributions (Sparre 1973; Grau et al. 2003).

Ullucu (*Ullucus tuberosus*), is an underutilized tuber crop from the Andes and an important staple of the Inca civilization. It is a low-growing, compact, succulent herb with a mucilaginous surface. Its stem is bare and can display green, red, or purplish hues, supporting alternate heart-shaped leaves that reach heights of 30-60 cm (Malice & Baudoin 2009). This annual crop produces underground stolons that eventually develop into starchy tubers. These tubers, characterized by a waxy skin, are smooth, and can be round or curved, ranging from 2 to 15 cm in length and 2 to 10 cm in diameter. Their colours span from white, through orange, red, and dark purple, to green (Busch et al. 2000). Cultivated ulluco is typically propagated vegetatively through its tubers, although viable seeds have been obtained under greenhouse conditions. In contrast, wild ulluco (*U. aborigineus* Brücher), considered a separate species, is a prostrate plant with long, branched stems that can reach lengths of up to 2 meters. These stems often display reddish or magenta hues and have long internodes. Notably, the tubers of wild ulluco are bitter in taste (Parra Quijano et al. 2021).

Maca (*Lepidium meyenii*), a member of the radish family, is the only species cultivated as a starch crop in the genus *Lepidium*. Maca occupies a very restricted area in central Peru, thriving at elevations ranging from 3,500 to 4,500 meters above sea level. It is considered one of the few crops globally capable of flourishing in such extreme conditions, including barren, rocky terrain, intense sunlight, strong winds, and freezing temperatures. The maca plant is a low-growing herbaceous perennial, typically not surpassing heights of 12 to 20 cm. Its roots are succulent, while its stems are short and decumbent. The hypocotyls, which are the edible portion of the plant, come in various sizes, ranging from 2 to 5 cm, and exhibit a spectrum of colours, including white, yellow, grey, purple, and red. Maca possesses a distinctive and robust flavour profile that may not appeal to everyone, often necessitating the use of other ingredients to mask its taste in juices and other preparations (Hermann & Heller 1997; Hernández Bermejo & León 1994; Flores et al. 2003).

Arracacha (*Arracacia xanthorrhiza*), a perennial herb standing at approximately one meter in height, is characterized by its glabrous nature and hollow stem (Flach & Rumawas 1996). The leaves, resembling those of parsley, range from dark green to purple. The roots, resemble fat short carrots, feature a lustrous off-white skin, with interiors that may vary in colour from white, yellow, to purple. The starchy root, which is the most significant component, although inedible when raw, transforms when cooked into a distinct blend of flavours and aromas reminiscent of celery, cabbage, and roast chestnuts (Palaniswami & Peter 2008). Roots are typically harvested starting from the fourth month, varying slightly based on the cultivar and region. They are commonly consumed boiled, added to soups and stews, mashed into a purée, or sliced and roasted or fried. Similarly, the leaves can be utilized in raw or cooked salads, prepared similar to celery. Additionally, the stump or crown of the roots serves as animal feed (Hernández Bermejo & León 1994). It demonstrates adaptability across a broad spectrum of mesothermic and tropical highland environments. *Arracacia xanthorrhiza* belongs to the *Arracacia* Bancroft genus (Hermann & Heller 1997). The congeners closest to the cultivated species are *Arracacia. equatorialis, Arracacia andina, Arracacia elata* and *Arracacia moschata* (Hernández Bermejo & León 1994).

Another Andean root crop is Mauka. Mauka (*Mirabilis expansa*) is a petite, herbaceous plant, rarely surpassing 1 meter in height, known for its resilience against diseases. Thriving in high elevations, mauka prefers temperatures ranging from 4° to 29 °C. Its stems, cylindrical in shape, bear ovoid leaves with reddish edges. Below the surface, its storage roots come in shades of white, salmon, or yellow, with younger tubers appearing yellow and maturing ones turning white. Fully grown mauka roots can reach the size of a human forearm and boast high protein and carbohydrate content (Hernández Bermejo & León 1994; Flores et al. 2003). The most common use of Mauka is as a food source for both people and animals. It can be used in soups and stews, leaves in salads and chili sauce, in Bolivia, the water from cooking is even served as a soft drink (Hernández Bermejo & León 1994). *Mirabilis expansa* belongs to family Nyctaginaceae, together with another perennial plant with tuberous roots, *Mirabilis jalapa*. However, *Mirabilis jalapa* is cultivated primarily for ornamental and medicinal purposes (Palaniswami & Peter 2008; Liya et al. 2021).

Ahipa (*Pachyrhizus ahipa*) is a leguminous plant primarily grown as a monocrop, although sometimes it is cultivated alongside maize. Despite being perennial by nature, it is typically cultivated as an annual crop. Ahipa can be propagated vegetatively through cuttings or, in the case of multi-tuberous genotypes, from tubers. However, unlike most tropical root crops, the majority of species in the genus are primarily reproduced generatively. Therefore, all cultivated species, including *P. ahipa*, are replanted annually from seeds. It is important to note that seeds and leaves of ahipa are poisonous. The tubers are sweet, easily peelable, and contain anthocyanin pigments, giving them a violet hue. They are rich in vitamins K and C. Ahipa starch is highly digestible, and its protein content, on a dry matter basis, is one of the highest among tuber crops (Bradshaw 2010; Hermann & Heller 1997). Genus *Pachyrhizus* contains also *Pachyrhizus erosus* and *Pachyrhizus tuberosus* species, having lower dry matter content in comparison with *Pachyrhizus ahipa* (Hermann & Heller 1997).

Yacon (*Smallanthus sonchifolius)* is a perennial herbaceous plant that can grow to heights of 1.5-3 m. It produces starchy, fruit-like roots of varying shapes and sizes, which can extend up to 25 cm in length, typically enjoyed raw for their sweet taste. The crunchy texture of yacon roots resembles that of apples. The tuberous root's skin is thin and can exhibit hues of brown, pink, purple, cream, or creamy white. Within this skin are resin ducts filled with yellow crystals. Flower colours range from yellow to vivid orange (Grau & Rea 1997; Caetano et al. 2016). Although yacon has been appreciated for its juiciness and sweet flavour, it has historically been acknowledged as a food with relatively low energy value. Typically, only a few yacon plants are cultivated for family consumption, with less frequent instances of cultivation for commercial purposes at the local level. Yacon cultivation has gradually declined across the Andes due to significant cultural shifts over the past century. However, the increasing interest in yacon beyond the Andean region has sparked renewed attention and research within Andean countries (Grau & Rea 1997).

Potato (*Solanum tuberosum*), the most globally significant starchy tuber, originates from the Andes. Among the numerous tuberous species of the *Solanum* L. genus, only this species holds worldwide importance. Potatoes have risen to become the fourth most crucial food crop following rice, wheat, and maize. They are now a staple in breakfast, lunch, and dinner for many large populations, and are cultivated in over one hundred countries worldwide (Nanbol & Otsanjugu Aku 2019). In highland agricultural systems, potatoes are typically cultivated by small-scale farmers who manage no more than 1 to 2 hectares spread across several plots of land. This crop is usually reliant on rainfall and faces various risks such as droughts, heavy rain, frost, depending on the region. Farmers in highland areas commonly set aside a significant portion of their harvest for use as seed in the next planting season. In regions where potatoes command a higher price, farmers often sell most of their produce and opt to purchase less expensive food items instead of consuming their own potatoes (Horton 1988).

Sweet potato, scientifically known as *Ipomoea batatas,* is a dicotyledonous plant classified under the family Convolvulaceae. This family comprises around forty-five genera and one thousand species, but only *Ipomoea batatas* holds economic significance as a food source. Sweet potato cultivars exhibit variations in tuber skin colour (commonly white, brown, yellow, or reddish-purple), tuber flesh colour (typically white or yellow), tuber shape, leaf shape, root depth, maturity period, disease resistance, and various other vegetative traits. While sweet potato thrives primarily in warm climates and is cultivated across tropical, subtropical, and warm-temperate regions worldwide. The cultivation can be completely mechanized. Harvested tubers can be stored for several weeks. Under controlled conditions, even several months. However, tubers spontaneously sprout during prolonged storage (Onwueme & Charles 1994).

4.6.2. Amazonian region

The Amazon and Orinoco regions boast diverse landscapes, primarily characterized by various types of forests, particularly rainforests, interspersed with fields along their southern and northwestern boundaries. This expansive area, encompassing half of South America, particularly when including the tropical forests of Guayanas, is often referred to as ecological Amazonia. Recognized for its significance in conservation, both culturally and biotically, Amazonia holds a crucial place in ecological preservation (Hernández Bermejo & León 1994).

Considered Amazonia’s greatest contribution to world agriculture, cassava (Manihot esculenta) is a solitary botanical species that does not exist in wild forms. Cassava is a dicotyledonous plant within the botanical family Euphorbiaceae. Much like most of its family counterparts, it possesses laticifers and yields latex (Onwueme & Charles 1994). It is a perennial shrub up to four meters high with a woody stem bearing prominent scars from fallen leaves. Cassava exhibits variability in leaf shape, tuber size, form, and colour, as well as in its linamarin content. Cassava serves as a crucial food-security crop being the sixth most important in the world, particularly in times of social and political instability. It has emerged as an indispensable source of sustenance for many households. Additionally, cassava is increasingly becoming a significant source of income for smallholder farmers and a key supplier of raw materials for local industries (Nanbol & Otsanjugu Aku 2019).

The Araceae family, encompasses several species cultivated for food, edible aroids, across various tropical regions. Among them are *Colocasia esculenta, Xanthosoma* spp., with *X. sagittifolium* being particularly significant, and *Alocasia* spp., notably *Alocasia macrorrhizos*. *Colocasia* and *Xanthosoma* are commonly referred to as cocoyams globally, but “taro” specifically denotes *Colocasia*, while “tannia” denotes *Xanthosoma* when differentiation is needed (Onwueme 1978).

Taro is a tall, herbaceous plant that can reach heights of over one meter. While it is technically a perennial, it is typically cultivated as an annual. The root system consists of fibrous, shallow, adventitious roots. Its storage stem, known as a corm, can be massive, weighing up to 4 kg and measuring up to 30 cm in length and 15 cm in diameter. Taro is characterized by its large, heart-shaped leaves, which can grow 20-50 cm in length (Flach & Rumawas1996). Taro originated in south central Asia, but its cultivation spread to many other countries including tropical regions of America (Onwueme 1978). It is common to cultivate it alongside tree crops, particularly cocoa. While many farmers prefer to rotate crops, edible aroids are occasionally grown continuously for up to 6 years (Horton 1988). When consumed raw or inadequately cooked, every part of the plant induces an acrid sensation, linked to clusters of needle-shaped calcium oxalate crystals, causing irritation in the mouth and throat. However, cooking or fermenting the plant reduces or removes this acridity (Flach & Rumawas1996; Ferdaus et al. 2023).

Tannia closely resembles taro in its general botanical features, with both plants having shoots, roots, corms, and cormels. However, there are significant differences between them. Tannia is typically sturdier and taller than taro, reaching heights of up to two meters or more (Onwueme 1978). *Xanthosoma* is a perennial herb that continuously sheds old leaves as new ones emerge. The fruit is a berry although, actual fruits and seeds are extremely rare (Flach & Rumawas1996). *Xanthosoma* species are native to tropical rainforests, where they usually grow under the forest canopy. However, when cultivated, they are often planted in full sunlight. Cultivated varieties are classified into four species: *X. atrovirens, X. caracu, X. nigrum* (*X. violaceum*), and *X. sagittifolium,* but certain characteristics such as leaf shape, vein patterns, and petiole colour may not be clearly distinguishable (Hernández Bermejo & León 1994).

Yams are cultivated in tropical and subtropical regions worldwide, having hundreds of species, with only one, *Dioscorea trifida*, originating in northern South America. The purple yam was domesticated by Amerindians, likely in the border areas of Brazil and Guyana. This species thrives in forest environments, particularly in the highland tropical rainforests of the Amazon (Teixeira et al. 2013). The plant features vines that twine to the left and yields numerous small tubers per plant. Its leaves are simple, yet deeply divided into 3-5 lobes. The tuber flesh comes in various colours- white, yellow, pink, or purple, and is exceptionally tasty (Onwueme 1978). Despite its high nutritional value and popularity in Brazilian cuisine, commercial cultivation of *Dioscorea trifida* is limited, with most farming done by traditional farmers for personal consumption rather than commercial purposes (Nascimento et al. 2015).

Table 1. List of root and tuber crop species cultivated in Latin America

Scientific name	Use	Common name	Distribution	References
Apiaceae				
Arracacia andina	Culinary dishes, dietary fibre	Andean arracacha	Bolivia, Peru, Ecuador	6
Arracacia elata	Food source, traditional medicine- digestive issues	Tall arracacha	Colombia, Peru, Ecuador, Venezuela	6
Arracacia equatorialis	Food source	Equatorial arracacha	Ecuador, Peru	6
Arracacia moschata	Food source, ornamental use	Musk- scented arracacha	Ecuador, peru, Colombia	6
Arracacia xanthorrhiza Bancroft	Food source- cooked, young stems in salads, animal feed (dairy animals)	Arracacha, white carrot, pilakachu, Peruvian parsnip	Venezuela, Peru, Ecuador, Colombia, Bolivia, Brazil	7
Araceae				
Alocasia macrorrhizos (L.) G. Don	Easily digested starch or flour; laxative; used against coughs	Giant taro, giant alocasia, elephant ear	Asia, Oceania, with subtropical extensions	4
Colocasia esculenta (L.) Schott	Dietary fiber, nutritional source, as plant-based milk alternatives	Taro, old cocoyam, dasheen, eddoe	Southeast Asia,	3, 4
Xanthosoma atrovirens	Puddings, stews, pastry, animal feed, medicinal use, ornamental value	-	tropical America, Asia	4

Table 1. (Continued)

Scientific name	Use	Common name	Distribution	References
Xanthosoma caracu	Food source, medicinal use, animal feed, ornamental value	-	tropical America, Asia	4
Xanthosoma nigrum (Veil.)	Food source, animal feed, as blankets for patients with fever, antidote for insect bites and stings	Alas belitung, kimpul, kong kong taro	tropical America, South-East Asia	4
Xanthosoma sagittifolium (L.) Schott	Culinary use, nutritional value, decorative foliage	Tannia, new cocoyam, yautía, macal, malanga	Tropical America	7
Asteraceae				
Smallanthus sonchifolius	Folk medicine, dietary supplements	Yacon, jicama, chicama, aricoma, aricuma	Worldwide (even in Czech Republic)	1
Basellaceae				
Ullucus aborigineus Brücher	Very rarely food source	-	Argentina, Peru, Bolivia	10
Ullucus tuberosus Loz.	Food source- cooked or green parts as vegetable	Ulloco, ullocu, melloco, olloco, papalisa, ruba	Peru, Bolivia, Ecuador, Colombia, Venezuela, Chile	7
Brassicaeae				
Lepidium meyenii Walp.	Medicinal use, nutritional value	Maca, pepper grass, pepper weed	Central Peru	7

Table 1. *(Continued)*

Scientific name	Use	Common name	Distribution	References
Convolvulaceae				
Ipomoea batatas (L.) Lam.	Food source, animal feed, industrial uses (starch, alcohol)	Sweet potato, batatas	tropical America, Africa, Asia, Europe	9
Dioscoreaceae				
Dioscorea trifida L.	Food source, traditional medicine	Purple yam, cush-cush yam, couche-couche, yampi, mapuey, aja	Norther part of South America	9, 12
Euphorbiaceae				
Manihot esculenta Crantz	Food source, animal feed, industrial uses (starch, biofuel), traditional medicine	Cassava, tapioca, manioc, Brazilian arrowroot	Mexico, Central America, Brazil, Asia, Africa	4, 12
Fabaceae				
Pachyrhizus ahipa (Wedd.) Parodi	Food source- cooked, eaten raw; treating of dermatological problems	Andean yam bean, ahipa, jicama	Peru, Bolivia, Argentina	12, 13
Pachyrhizus erosus (L.) Urb.	Culinary dishes, snack food, pickling, juices	Mexican turnip, jicama, Mexican yam bean	Worldwide, mainly Asia	11, 12
Pachyrhizus tuberosus (Lam.) Spreng	Food source- cooked, eaten raw; drastic laxative	Amazonian yam bean, nupe, jicama	Venezuela, Ecuador	12, 13

Table 1. *(Continued)*

Scientific name	Use	Common name	Distribution	References
Nyctaginaceae				
Mirabilis expansa Ruíz & Pavón	Food source- cooked, leaves in salads, chili sauces	Mauka, chago, arricón, yuca, inca, miso, taso	Peru, Ecuador, Bolivia	7
Mirabilis jalapa Linn.	Medicine, ornamental plant	Four-o-clock flower	Tropical and temperate areas	8
Oxalidaceae				
Oxalis tuberosa Molina	Food source, ornamental plant	Oca, oxalis, oqa, apilla, ruba, timbo, quiba	Bolivia, Ecuador, Venezuela, Peru, Chile, Colombia, Argentina	7
Solanaceae				
Solanum tuberosum L.	Food source, culinary products (chips, fries), industrial uses (alcohol beverages), animal feed	Irish potato, potato, white potato,	worldwide	4
Tropaeolaceae				
Tropaeolum crenatiflorum	Food source (no economic use)	Nasturtium	Peru	5
Tropaeolum leptophyllum	Food source in times of scarcity	-	Chile, Argentina	5
Tropaeolum longiflorum	Food source (no economic use)	-	Peru	5
Tropaeolum majus L.	Medicine, ornamental use	Garden nasturtium, Indian cress, capuchina	Temperate areas	2

Table 1. *(Continued)*

Scientific name	Use	Common name	Distribution	References
Tropaeolum patagonicum	Food source for Patagonian tribe	Patagonian Nasturtium	Patagonia	5
Tropaeolum purpureum	Food source (no economic use)	Purple Nasturtium	Peru	5
Tropaeolum tuberosum Ruíz & Pavón	Culinary use, traditional medicine (digestive issues), animal feed, ornamenat use	Mashwa, mashua, mazuko, añu, isaño, maswallo	Peru, Argentina, Bolivia, Venezuela, Ecuador, + New Zealand	5

1 (Caetano et al. 2016), 2 (Duenas-Lopez 2022), 3 (Ferdaus et al. 2023), 4 (Flach & Rumawas F. 1996), 5 (Grau et al. 2003), 6 (Hermann & Heller 1997), 7 (Hernández Bermejo & León 1994), 8 (Liya et al. 2021), 9 (Onwueme 1978), 10 (Parra Quijano et al. 2021), 11 (Parvatha Reddy 2015), 12 (Rehm & Espig 1991), 13 (Valíček et al. 2002).

5. Conclusions

This review has provided a general overview of tuber crops cultivated in Latin America. The findings indicate that the diverse array of tuber crops in Latin America serves as a vital resource for food security, nutrition, and economic sustenance across the region. Through the exploration of their cultivation, utilization, and ecological significance, this thesis underscores the indispensable role of tuber crops in both household and national contexts. Additionally, by delving into their phytochemical composition and ecological aspects, it sheds light on the potential avenues for further research and development in enhancing the resilience and productivity of tuber crops. Overall, the findings underscore the importance of safeguarding and promoting the cultivation of tuber crops to ensure the well-being and prosperity of communities throughout Latin America.

Available literature documents, that root and tubers are important diet components for humans and add variety to it. In addition to the main role as an energy contributor, they provide several desirable nutritional benefits. As scientific research continues to uncover the therapeutic properties of tuber crops such as antioxidative, antimicrobial, anti-inflammatory, anticarcinogenic activities etc. Their role in modern medicine and holistic health practices is expected to expand, offering new avenues for exploration and innovation in healthcare.

These crops play a crucial role in ensuring food security for farmers and their families, while also generating income through local market sales. Moreover, the value chain associated with these crops creates employment opportunities in processing, transportation, and marketing, thereby bolstering rural economies and contributing to poverty reduction efforts. Therefore, gaining a better understanding of tuber crop production, utilization, and trade could prove highly advantageous, particularly in developing countries.

Several species were involved in this thesis according to their regional distribution. Arracacha stands out as the most promising crop among underutilised Andean root and tuber species, offering a wide range of culinary uses without the undesirable substances found in other crops like oca, ulluco, mashua, and mauka. With its appealing texture and flavour, arracacha is more universally accepted compared to other Andean tubers. While processing of arracacha is currently limited, its potential for various processed products is recognized for their quality. Unlike high-altitude species, arracacha adapts well to diverse environments and daylength regimes. However, diseases and pests pose challenges, although majority of them can be managed through long rotations and integrated practices (Hermann & Heller 1997).

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