Clecia Simone Gonçalves Rosa Pacheco
Reinaldo Pacheco dos Santos
(Orgs.)

VOL. 3

ESTUDOS AGROECOLÓGICOS

O AVANÇO DA CIÊNCIA NO BRASIL

científica digital

EDITORA CIENTÍFICA DIGITAL LTDA
Guarujá - São Paulo - Brasil
www.editoracientifica.com.br - contato@editoracientifica.com.br

Diagramação e Arte
Equipe Editorial
Imagens da Capa
Adobe Stock - 2024
Revisão
Os Autores

Edição © 2024 Editora Científica Digital
Texto © 2024 Os Autores
1ª Edição - 2024
Acesso Livre - Open Access

Dados Internacionais de Catalogação na Publicação (CIP)

E82

Estudos Agroecológicos: o avanço da ciência no Brasil: volume 3 / Clecia Simone Gonçalves Rosa Pacheco (Organizadora), Reinaldo Pacheco dos Santos (Organizador). – Guarujá-SP: Científica Digital, 2024.

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui Bibliografia
ISBN 978-65-5360-570-1
DOI 10.37885/978-65-5360-570-1

1. Agroecologia. I. Pacheco, Clecia Simone Gonçalves Rosa (Organizadora). II. Santos, Reinaldo Pacheco dos (Organizadora). III. Título.

CDD 631.5

Elaborado por Janaína Ramos – CRB-8/9166

Índice para catálogo sistemático:
I. Agroecologia

E-BOOK
ACESSO LIVRE ON LINE - IMPRESSÃO PROIBIDA
2024

Clecia Simone Gonçalves Rosa Pacheco
Reinaldo Pacheco dos Santos
(Orgs.)

Estudos Agroecológicos: o avanço da ciência no Brasil

Volume 3

1ª EDIÇÃO

científica digital

2024 - GUARUJÁ - SP

Parecer e revisão por pares

Os textos que compõem esta obra foram submetidos para avaliação do Conselho Editorial da Editora Científica Digital, sendo aprovados na revisão por pares e indicados para publicação.

APRESENTAÇÃO

A agroecologia já era utilizada desde a década de 1930, mas foi apenas nos últimos quarenta anos que sua base científica se consolidou, graças ao aprofundamento das discussões teóricas sobre a gestão dos agroecossistemas e às críticas ao modelo tradicional de desenvolvimento agrícola. Destaca-se que a agroecologia não é um modelo de agricultura ou tecnologia novos, nem de um sistema de produção inovador, mas sim, uma abordagem científica que promove a agricultura de base ecológica como um meio de transição para um estilo de agricultura sustentável.

Neste aspecto, a agroecologia busca promover o manejo ecológico da natureza através do engajamento social coletivo e participativo, com uma abordagem holística e sistêmica, objetivando reverter os desequilíbrios socioecológicos causados pelas práticas degradantes das forças produtivas na natureza e na sociedade.

Com base nisto, a obra "Estudos Agroecológicos: o avanço da ciência no Brasil" teve origem em uma colaboração entre pesquisadores, professores e estudantes, principalmente de níveis de graduação e pós-graduação, que enriqueceram e aprofundaram as discussões neste ambiente educacional. Além disso, resulta de iniciativas interinstitucionais e programas de apoio à pesquisa e à extensão que envolvem pesquisadores de diversas áreas do conhecimento e de diversas Universidades públicas e privadas, tanto nacionais quanto internacionais.

O propósito desta obra foi promover a integração entre instituições nacionais e internacionais, juntamente com redes de pesquisa, para apoiar a formação contínua de profissionais e agricultores da área agroecológica e ambiental. Através da partilha de conhecimentos, experiências e práticas, buscou-se orientar estratégias para um desenvolvimento rural mais sustentável e fomentar a transição para modelos agrícolas mais ecológicos. Essa iniciativa buscou contribuir para a melhoria da qualidade de vida das atuais e futuras gerações, em um mundo com recursos limitados e desequilíbrio ecológico.

A obra discutiu temas como de grande relevância para a agroecologia, tais como: a utilização de resíduos de nadadeiras de filetagem de tilápia como fertilizante orgânico para o cultivo de girassol; indicadores fitotécnicos para cultivo de plantas de cobertura e produção de fitomassa; o processo agroecológico de introdução do cultivo da batata yacon na agricultura familiar nas montanhas do Espírito Santo/Brasil e sua história de sucesso; caracterização de substra-

tos artesanais da agricultura familiar em Santa Maria de Jetibá no estado do Espirito Santo e seu potencial para produção de baby leaf; o conhecimento, o uso tradicional e o manejo sustentável de plantas alimentícias não convencionais no Brasil e um diálogo com a Encíclica Laudato Si´ do Papa Francisco; e, adaptando os princípios do SPDP e o cultivo de plantas de cobertura na agricultura familiar do Espírito Santo, traçando um recorte temporal de 2006 – 2016.

Portanto, agradecemos aos autores pelo comprometimento, disponibilidade e dedicação para o desenvolvimento e conclusão dessa obra. Esperamos também que esta obra sirva de instrumento para os diversos níveis transição e para o desenvolvimento da pesquisa extensionista de estudantes, professores, agricultores, comunidades rurais e movimentos socioambientais e, para os demais interessados pela temática aqui abordada.

Os Organizadores

SUMÁRIO

06

AGROECOLOGICAL PROCESS TO INTRODUCE YACON CULTIVATION ON FAMILY FARMING AT THE MOUNTAINS OF ESPIRITO SANTO STATE - BRAZIL

Maria da Penha Angeletti
Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (INCAPER)

Celso Walther
Prefeitura Municipal de Santa Maria de Jetibá (PMSMJ)

Lucas Contarato Pilon
Biodynamic Federation Demeter International (BFDI)

Horacio Vicente Caetano Gonçalves
Escola Família Agrícola de São João do Garrafão (EFASJG)

Helcio Costa
Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (INCAPER)

Jacimar Luis de Souza
Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (INCAPER)

Ernesto de Moraes Muzzi
Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (INCAPER)

Andrea Ferreira da Costa
Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (INCAPER)

Miriam Piassi
Instituto Capixaba de Pesquisa Assistência Técnica e Extensão Rural (INCAPER)

doi 10.37885/240115536

ABSTRACT

There is a growing global interest in consumption of yacon, *Smallanthus sonchifolius* (Poepp. & Endl.) H. Robinson (Asteraceae) roots, due to its medicinal and nutraceutical properties, prevention of metabolic and intestinal tract diseases besides the potencial for alternative sugar industry. There is also a growing interest in the production of yacon roots as a diversification option for family farming. Lack of information on the species' behavior, lack of local technological references and seedling availability are challenges that must be overcome. A pioneering initiative was carried out on 2006 – 2007, to start introducing and adapting commercial cultivation of yacon in the mountain region of Espirito Santo State, Brazil, municipality of Santa Maria de Jetibá, Afonso Cláudio and Domingos Martins, communities São Bento do Garrafão, Mata Fria and Tijuco Preto, respectively. The aim of this paper is to integrate and provide information about various aspects of that process; to demonstrate initial management practices adopted; describe historical process and to arouse interest in this nutraceutical food that can bring benefits to both farmers' families and consumers.

Keywords: Crop Diversification, Safe Agricultural Products, Functional Foods, Yacon Root Consumption.

INTRODUCTION

There is currently a great concern about lifestyle, health and diseases. More conscious consumers with a great demand for healthier, calorie-controlled foods. On the other hand, Family Farming can offer products such as yacon, with multiple benefits, associated with nutritional qualities, flavor and appearance, food safety, medicinal and nutraceutical or functional properties (Angeletti *et al.*, 2007).

Yacon *Smallanthus sonchifolius* (Poepp. & Endl.) H. Robinson (Asteraceae) is part of the food and medicinal biodiversity of the Andean Region, South America, where it is also known as *jícama, llacon, aricoma, llama, lacjon, yakuma, jiquima, arboloco*, etc. Its roots were used by the Inca people in traditional medicine and also as food. In the Inca language, yacon means 'watery' 'juicy', as they "quench" thirst in regions with little water. The first written record about yacon appears in a text attributed to Father Barnabé Cobo, who in 1653 wrote comparing its roots to fruits and talking about the importance of its use in sea travel: "*You eat raw fruits and have a lot of good flavors and much better if you spend time in the sun. This is a wonderful fruit to ship, because it lasts a long time. I saw it arrive by sea and last more than twenty days and despite being so zumosa, it was sweeter and much cooler in hot weather*" (Seminario, 2004).

The species *Smallanthus sonchifolius* Poep. & Endl is distributed throughout the Andean territory as a wild or cultivated plant. The natural habitat is the Andes zone between 800-2800 m altitude, at latitudes 0-24 °S, characterized by temperate and subtropical climates regimes, with temperature ranging from 18 to 25 °C (Manrique *et al.*, 2005; Arnao *et al.*, 2011). In general, the crop is possible under several climatic conditions, thus, it has been grown in several countries, with differences in altitude, even on altitudes as high as 3500m above sea level, suggesting a large adaptive capacity to climate, altitude and different soil types besides the hardiness of the crop and apparent insensitivity to photoperiod, which favors commercial production in different agro-climatic conditions. Yacon has also been growing successfully in hot climate countries like Brazil (Manrique *et al.*, 2005; Cabrera *et al.*, 2006; Ferreira , 2013).

Yacon plant thrives well in moderately deep, well-structured and drained soils, rich in humus and minerals (Maldonado *et al.*, 2008). However, according

ISBN 978-65-5360-570-1 - Vol. 3 - Ano 2024 - www.editoracientifica.com.br

to Grau and Rhea (2002), growth is poor in heavy soils, but the crop responds well to sandy soils, and the plant can tolerate a wide pH range.

The yacon crop was introduced in Brazil in the early 90s, in the Region of Capão Bonito, State of São Paulo, by Japanese immigrants who used its leaves and roots to treat diseases such as diabetes and high blood cholesterol levels (Moscatto *et al.*, 2004; Carneiro, Almeida, 2005).

Popularly known as *diabetic's potato*, *diet potato*.

It is a vegetable that contains active phytochemical components with favorable health properties. In recent decades, yacon popularized in Japan and around the world for its low-calorie content. The fresh roots and processed products such as syrup and leaf tea have been recommended for dieters and people with diabetes and various digestive diseases, due to their low caloric content, nutritional value and prebiotic function. There are reports that ingestion of yacon syrup, which is extracted and concentrated from roots, improved insulin resistance and reduced body weight in obese individuals (Satoh *et al.*, 2013).

Yacon root is known to contain various bioactive componentes such as dietary fiber and polyphenolic compounds. Yacon roots stores its carbohydrates in the form of fructooligosaccharides (FOS). The roots are consumed as dietetic food and are used to prevent and treat metabolic diseases including hypertension and diabetes mellitus. Results suggest that oral intake of yacon root modulates the intestinal environment, thereby inhibiting intestinal inflammation (Higashimura *et al.*, 2021).

The introduction of commercial yacon cultivation in the State of Espírito Santo, Brazil, was carried out in 2006 – 2007 in the mountain region, through a participatory process including a pioneering group of family farmers from the municipalities of Santa Maria de Jetibá, Domingos Martins and Afonso Cláudio; technicians from INCAPER and the Municipality of Santa Maria de Jetibá, as reported in Angeletti *et al.* (2007) and Angeletti *et al.* (2018).

However, a lot of information about the planning and execution of this networking process has not yet been made available.

Considering Yacon as an option for crops diversification on family farming systems, the aim of this paper is to integrate and provide information about various aspects of that process; to demonstrate initial management practices adopted by

family farmers; describe historical process and to arouse interest in this nutraceutical food that can bring benefits to both farmers' families and consumers.

DETAILING THE CASE

As reported in Angeletti *et al.* (2007) and Angeletti *et al.* (2018), a process for participatory introduction of Andean root Yacon was conducted between May 2006 to October 2007 in the Mountainous region of the Espírito Santo, Brazil, in Serrana Central micro-region, a natural zone characterized bycold temperatures, rainy and hilly lands and mild temperatures, rough and rainy (FEITOSA, 2007). The pioneering initiative took place in the municipality of Santa Maria de Jetibá, coordinates 20°S and 40°W in the rural Community of *São Bento do Garrafão* and surrounding municipalities: Domingos Martins, Community *Tijuco Preto* and Afonso Cláudio, *Mata Fria* Community, all in altitudes above 900meters.

The process was developed as partnership between Family farmers; Espírito Santo Research Institute, Technical Assistance and Rural Extension – INCAPER; Municipality of Santa Maria de Jetibá - PMSMJ; Agricultural Family School of São João do Garrafão – EFASJG. With the support of Supermarkets of Santa Maria de Jetibá: *Berguinha; Guilhermes, Super Show and Tressmann;* the rural workers union Sindicato STRSMJ and SICOOB Bank.

Procedures Carried Out

The integrated actions consisted of:

1. Demand from a family farmer at the local INCAPER office.
2. Seek information about the botanical species; agroclimatic requirements; cultivation, harvesting and post-harvest technologies in Brazil; market potential and health benefits of consumption.
3. Participatory rural diagnosis for identify and bring together family farmers interested in this innovation.
4. Quantify farmers' needs for propagating material.
5. Collective purchasing of yacon seedlings and distribution.

ISBN 978-65-5360-570-1 - Vol. 3 - Ano 2024 - www.editoracientifica.com.br

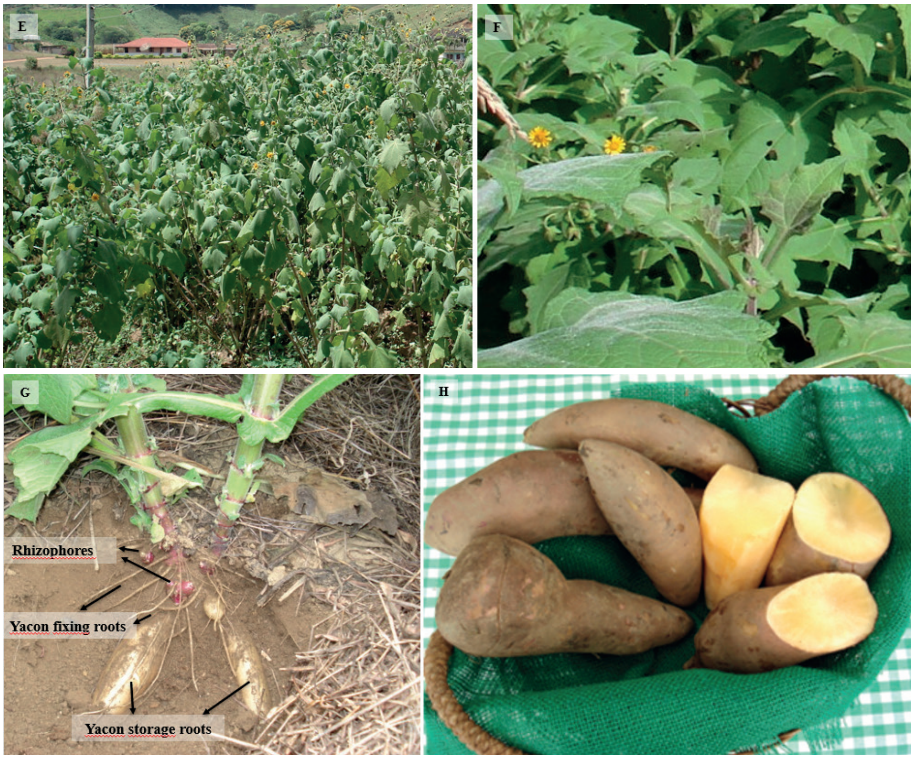
6. Setting up common practices to be adopted in the initial management of the rhizophores; soil preparation; planting and cultivation of yacon.
7. Technical monitoring of areas cultivated with yacon.
8. Organization of staggered harvesting by farmers and PMSMJ technician.
9. Search for market opportunities.
10. Preparation of a manuscript for EFASJG - Escola Família Agrícola de São João do Garrafão to work with students on the initial leveling of information about Yacon, within the didactic activities of the technical course in Agroecology.
11. Encouragement for students to seek new content and create their language about yacon, as a basis for creating a folder.
12. Participatory creation of a folder, together with teachers and students of the EFASJG.
13. Preparing EFASJG students to take the lead in the yacon tasting campaign in supermarkets
14. Carrying out a campaign in local supermarkets of Santa Maria de Jetibá to promote the consumption of yacon and to raise awareness of the benefits of yacon consumption.

Detailing the plant and management practices for cultivation

The introduced species is purple stem morphotype, green leaves, arrow-shaped leaf blade, purple color seedlings, roots in elongated or fusiform shape, with brown cortex, cream/ivory reserve tissue as described by Dostert *et al.* (2009); Galécio and Cordova (2006) (Figura 1). The seedlings used were produced from rhizophores acquired from organic family farmers municipality of São José, Santa Catarina State, Brazil. The number of shoots per rhizophore ranged from 01-03, although, the general pattern are 4 gems (Cordova; Galecio, 2006, Cabrera *et al.* 2006).

To stimulate sprouting the rhizophores were placed on moistened grass straw and were covered with a layer of moistened grass straw and stored in a shaded, cool and dry place for 2 to 03 weeks. After this, the seedlings were planted directly in the field.

Figure 1 - Details of the yacon morphotype introduced in the region. A. Purple color of rhizophores; B. Purple stem; green leaves, arrow-shaped leaf blade; C. Young plants; D. Adult plants at flowering stage; E. Adult plants in full bloom, starting senescence; F. Litle flowers; G. Yacon storage roots, fixing roots and rhizophores; H. Shape of the harvested roots, color of the cortex and cream color of yacon's reserve tissues.



[1]The Authors.

The first plantings were done in winter of 2006 (July to August). The seedlings were planted in ridges or furrows already fertilized with manure. The recommended management practices are shown in Table 1, as reported by Angeletti *et al.* (2018), Figure 2.

Table 1 - Recommended management practices to introduce yacon (*Smallanthus sonchifolius* Poep & Endl.) on family farming's agroecosystems in the Mountainous Region of Espírito Santo State, Brazil[1].

Item	Description
Straw mulch	Mulch available on the farm
Soil preparing	Plowing, disking, rotaryhoe
Planting system	In Ridges with 0,5 m base and 0,3 to 0,4 m high Or On furrows 0,3 m deep (in sandy to silty soils)
Rows Spacing	1,0 m
Spacing between plants	0,5 m
Planting depth	0,05 to 0,07 m placing the buds or shoots up
Fertilization	Poultry manure or composting (20 kg m^{-1} of ridges or furrows)

[1] Adapted from Angeletti *et al.* (2018).

The soils used had medium to high fertility status while the pH was adjusted to 6.0 as standard for planting vegetable crops in this area.

As the family farms in the municipalities produce vegetable crops, yacon plantings were carried out on the margins of vegetable blocks to optimize the use of irrigation and meet the yacon's needs, especially at the beginning of the cycle.

When the rhizophores did not have shoots at the time of planting, they were waited for initial budding and leaves emergence before straw mulching.

Figure 2 - A. Farmer preparing ridges after organic fertilization; B. Yacon young plants developing on ridges, no mulch, with spontaneous vegetation for later use as mulch; C. Yacon flowering 6 months old plants, planted on furrows, without mulch. São Bento do Garrafão Community, Santa Maria de Jetibá, Espirito Santo State, Brazil. [1]

[1] Adapted from Angeletti *et al.* (2018).

Where necessary, weeds around the seedlings were removed and this done before mulching, spreading of straw on the soil surface.

There have been cases in which spontaneous vegetation was allowed to grow between the yacon ridges for mowing and subsequent mulching on the site itself.

It was agreed that pesticides should not be used because of the medicinal aspects of yacon's roots.

Technical monitoring visits of farms as well as periodic technical meetings were held.

DISCUSSION

Historical and technological aspects

This participatory process for introduction of Yacon in Mountainous Region of Espirito Santo State, Brazil, started when the familiar farm Mr. Jaime Bleidorn visited the local office of INCAPER, Espírito Santo Research Institute, Technical Assistance and Rural Extension seeking for information on how to obtain yacon propagating material. He had seen a report on *Globo Rural* about the root and its potential for reducing the sugar content in the blood. Faced with diabetes in his family, he thought about trying to produce a vegetable crop that could be sold and at the same time, take care of your family's health.

According to him, there were other farmers in the communities of *São Bento do Garrafão* (Santa Maria de Jetibá); *Tijuco Preto* (Domingos Martins) and *Mata Fria* (Afonso Cláudio) interested in cultivating yacon, learning about the crop and having the product for their own consumption.

As reported by Angeletti *et al.* (2007) and Angeletti *et al.* (2018):

→ Farmers were organized through meetings where groups presented and discussed information and opinions for decision making.

Therefore, the first step was to hold a meeting with interested farmers and technical professionals from Incaper and Santa Maria de Jetibá City Hall. The meetings were held at night, after daily work, in the Lutheran Church hall and at the school in the São Bento do Garrafão community. The initial quantities of seedlings needed were quantified and Incaper took care of finding places in Brazil to obtain the propagative material.

It was a very little known crop and the supply of seedlings was very restricted.

→ Rhizophores of yacon were purchased from an organic family farmer of São José municipality, Santa Catarina State, Brazil.

Through a collective purchase, an average of 50 seedlings were purchased for each of the 45 participants interested in cultivating Yacon on a commercial level, for the first time in Espírito Santo.

ISBN 978-65-5360-570-1 - Vol. 3 - Ano 2024 - www.editoracientifica.com.br

The pioneer family farms where commercial yacon cultivation was introduced with the number of rhizophores are reported in Table 2.

Table 2 - The pioneer family farms where yacon commercial cultivation was introduced in mountain region of Espírito Santo State, Brazil. Incaper, 2024.

Family Farm	Nº Rhizophores	Family Farm	Nº Rhizophores
Bleidorn Farm, A.	34	Retz Farm, V. S.	14
Bleidorn Farm, J.	56	Schaffel Farm, Da	39
Brandemburg Farm, J.	34	Schaffel Farm, Dn.	56
Brandemburg Farm, L.	22	Schaffelen Farm, L.	56
Haese Farm, I.	56	Schlieve Farm, A.	56
Haese Farm, D.	56	Schliewe Farm, D.	56
Haese Farm, G.	56	Schulz Farm, E.	56
Haese Farm, L.	22	Schulz Farm, M.	158
Herbst Farm, M.	98	Schulz Farm, T.	12
Kutz Farm, A.	34	Schulz Farm, W.	27
Kutz Farm, J.	22	Schultz Farm, D	07
Lauvers Farm, J.	56	Schultz Farm, F.	22
Lietig Farm, H.	56	Schultz Farm, V.	27
Lietig Farm R.	56	Schwanz Farm, A.	56
Littig Farm, V	39	Strey Farm, Da.	56
Littig Farm, Va.	34	Strey Farm, De	66
Littig Farm, Ja.	63	Strey Farm, G.	46
Littig Farm. Jo.	13	Strey Farm, V	34
Littis Farm, N.	108	Ziebell Farm, La	86
Littis Farm, Z.	56	Ziebell Farm, L.	58
Raasch Farm, F.	115	Formentini Farm [1]	5
Reinholz Farm, M.	56	Ewald Farm [1]	9
		Emcapa Farm [1]	16

[1] Cultivation areas by professionals.

Source: Authors.

The initial field trial began with an average number of 50 rhizophores per farmer.

A Shepherd from the Lutheran Church in a neighboring town, Itarana, was later discovered to have yacon among his medicinal plants. It was very good because it already generated confidence in the farmers, all of them of the Lutheran religion.

The initial spacing indicators between rows and between yacon plants and the ridge cultivation system were influenced by the experience of that Shepherd.

The pioneering yacon cultivation practices adopted by the participants are shown in Table 3.

Table 3 - Detailing cultivation and management practices adopted in 2006 – 2007 on family farms to grow yacon in mountain region of Espírito Santo State. Incaper, 2024.

Cultivation and management practices	Percentage of adoption (%)
Spacings adopted	
1.0 x 0.50m	36,1
1,2 x 0,40m	19,4
1,0 x 0,60m	11,1
Others spacings (1.00 x 0.40m; 1.5 x 0.40m; 1.20 x 0.60m; 0.70 x 0.40m; 2.0 x 0.60m; 2.0 x 0.50m; 1 .30 x 0.40m; 0.8 x 0.40m and 1.0 x 0.80m)	33.4
Total	100
Planting systems	
Ridges	84,8
Furrows	15,2
Total	100
The use of mulch	
Have used mulch	55,26
No mulch	44,74
Total	100
Mulch type	
Bean straw mulch	52,38
Molanes grass mulch (*capim gordura mulch*)	23,80
Other types of mulch (corn straw; green corn straw; spontaneous plants; native grass straw; native grass straw + coffee straw)	23,82
Total	100

Source: Authors.

As can be seen in Table 3, the spacing most used on family farms to grow yacon was 1.0 x 0.50m, in 36,1 % of family farms. Followed by 1.20 x 0.40m and 1.0 x 0.60m. Many other different spacings have been adopted by farmers, since 0,70 x 0,40m, for higher population densities to the 2.0 x 0.60m spacing for lower population densities.

Between the planting lines, the spacing varied from 0.70m to 2.0m. The ridges base and the height of the ridges depend on this spacing adopted.

ISBN 978-65-5360-570-1 - Vol. 3 - Ano 2024 - www.editoracientifica.com.br

Within the planting lines, spacings varied from 0.40m; 0.50m and 0.60m.

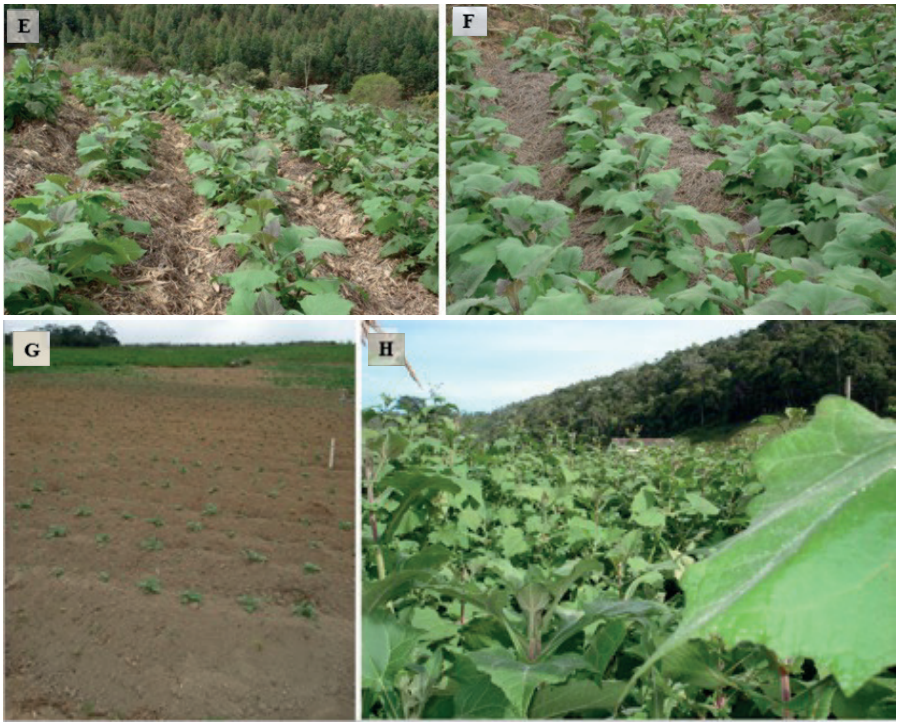
Ridges cultivation was predominant, used on 84.8% of the family farms that pioneered commercial yacon cultivation.

As for the use of mulch, the behavior was more balanced, with 55.6% adoption. The predominant type of mulch was bean straw, followed by molanes grass (*capim gordura*).

Others mulches used were: corn straw; green corn straw; spontaneous plants; native grass straw; native grass straw + coffee straw.

Some aspects of cultivation practices are shown in Figure 3.

Figure 3 - A. Ridges prepared for planting; B. Ridges covered by bean straw mulch; C. Plants on ridges; D. Ridges covered by mulch of spontaneou grass; E. Ridges covered by corn mulch; F. Ridges with native grass mulch; G. Ridges, no mulch; H. High plants population density.



[1] Updated from Angeletti *et al.* (2018).

Crop evolution, plant behavior and harvesting

Irrigation was applied during the first two to three months of growing cycle and was performed once or twice a week, with plots without straw mulching receiving higher irrigations as quoted by Queiroga *et al.* (2002) for chili.

In plantings without straw mulching, it was observed slow growth of plants; quality of roots damaged as by high soil temperatures (according to farmers 'cooked roots', change the flavor) and reduction of roots production per plant were observed. The use of straw mulching reduced the occurrence of weeds in crops, thus reducing the time and cost to control weeds.

There were attacks by ants, forming galleries on the roots. The galleries caused the entry of other soil pathogens leading rotting of roots, and reduced the production potential. This led some farmers to use chemical methods for control as against the initial agreement on zero application of insecticides.

ISBN 978-65-5360-570-1 - Vol. 3 - Ano 2024 - www.editoracientifica.com.br

The first harvests were made 7 months after planting. At this phenological stage, the plants were in full bloom, starting yellowing and leaves falling in the lower third of the plants, as reported by Manrique *et al.* (2005).

The root harvesting point was determined based on the flowering of the plants and signs of plant senescence. The harvest of roots was started before ideal time of plant senescence, aiming to take advantage of market opportunities and extend the harvest period for longer. Ferreira (2013) reported that harvest should begin with 50% of the plants at senescence stage.

The whole plants were harvested to remove roots (Figura 4) and rhizophores.

Figure 4 - Yacon in São Bento do Garrafão, Santa Maria de Jetibá, Espírito Santo State, Brazil. Aspects of harvest and post-harvest of yacon. A. Storage Roots in clayey soil; B. Root harvesting in soil with higher sand content; C. Yacon harvest at *Sítio Bleidorn*, J.; D. Yacon Harvest at *Sítio Schlieve*, A.; E. Yacon roots at field, before washing. F. Yacon Roots washed and packaged for the market - *Sítio Schwanz*, A.

[1] Updated from Angeletti *et al.* (2018).

In the first experiences, average yields of 10.5 kg per plant were obtained, varying from 6 to 15 kg/plant, with an average number of 10 roots per plant. Yields per area were not reported due to differences in harvesting standards, stand losses and root losses.

It was observed more plant vegetative growth and less productivity and root qualities from crops grown in humid, very fertile lowlands. In addition, a higher number of vegetative propagation structures – rhizophores. So, the choice of location could be a factor that may have influenced the production and the quality of the roots.

Some farmers split the largest rhizophores in half to increase the number of seedlings formed. In this case, there was less growth of yacon plants from rhizophores with a smaller amount of reserves. Plants from whole rhizophores were larger and more uniform in their development.

Detais on local Campaign to promote the consumption of yacon roots

→ A local Campaign was carried out in supermarkets of Santa Maria de Jetibá city, to promote yacon roots "*in natura*" consumption, as reported by Angeletti *et al.* (2007). Presenting the roots to consumers, tasting, sharing knowledge and distributing of folders were done by students of Agricultural Family School of São João do Garrafão (EFASJG).

According to Angeletti *et al.* (2007), the idea for the Campaign arose at a meeting of a group of family farmers who pioneered the commercial cultivation

of yacon in ES. They had decided to continue planting yacon, believing in the potential of the product, despite it being still unknown and having little consumption in ES and Brazil.

The local population of Santa Maria de Jetibá - 31,000 inhabitants and the city's largest supermarkets were considered the closest market to be conquered.

The Campaign was planned with the aim of awakening consumers' interest in experiencing the positive effects of yacon, opening up the opportunity to sell the first harvest of yacon in supermarkets and opening up consumer market opportunities for future harvests. Details of the stand preparation and dialogue with consumers by students of EFASJG are shown in Figure 5.

Figure 5 - Campaign to promote the consumption of yacon roots, Santa Maria de Jetibá – ES. A. Student of EFASJG preparing the roots for tasting; B. Students at the stand ready to start; C. Moment of dialog between students and consumers; D; E; F. Special moments when students talk to the consumer community.

[1] Updated from Angeletti *et al.* (2007).

The folder created for the campaign is shown in the Figure 6.

Figure 6 - Folder created especially to promote yacon to the local consumer community.

Source: Angeletti *et al.* (2007).

→ More details of the Campaign:

12 events lasting 5-6 hours per day were held;

Period from June 15th to July 14th, 2007.

The campaign was concentrated on Fridays and Saturdays, when the urban and rural population concentrate their purchases on supermarkets.

On each date and location, a pair of EFASJG students from Agroecology course worked. A total of 23 students took part.

There was someone in each pair who speaks Pomeranian, to help people who don't know how to speak Portuguese.

The participation of 1199 local consumers were recorded.

More than 1500 folders were distributed.

During the tasting campaign in the supermarkets the students of EFASJG were asked by consumers on yacon, a product unknown by the community. The main questions are reported in Table 4.

Table 4 - Most frequently asked questions from consumers about yacon during a tasting campaign in supermarkets, Santa Maria de Jetibá – ES. Incaper, 2024.

Supermarket	Frequently asked questions during the supermarket tasting campaign
Berguinha	When will it hit the market? How is it produced? How do we buy it? Information about the plant Which is better, the younger or older root? How much to consume? Information on recipes
Guilhermes	Where is it found? How do you plant it? What is the price? How to consume it
Super Show	How Much it costs? Is it ok to take with other medicines (for diabetes)? How to preserve it? Where can I get seedlings?
Tressmann	How is it prepared? Where is it produced? How is it dehydrated? Does it help control the thyroid? How to consume it?

Source: Authors.

– Commercialization aspects

As reported by Angeletti *et al.* (2007); Angeletti *et al.* (2018), and updated in this Paper.

Yacon producers sold their entire harvest in local supermarkets and at CEASA-ES (Espirito Santo Central Supply S.A.).

It was observed that the campaign strengthened yacon as an option for vegetable diversification.

The *Tresmann* Supermarket has been sold yacon roots since May 2007, with 1.5 boxes a week. In the middle of the campaign period, sales were 4.5 cases/week and in the last week of the campaign, 8 cases/week, which continued after the campaign ended, according to reports. The *Berguinha*, *Guilhermes* and *Super Show* Supermarkets, which didn't sell yacon, began to receive demand from consumers and sell 01 to 02 boxes a week.

When the local harvest ended, Supermarkets *Berguinha, Guilhermes, Super Show* and *Tressmann* continued to buy the yacon at CEASA-ES, to meet consumer demand.

→ The search for market opportunities was also carried out outside Santa Maria de Jetibá.

Visits were carried out, involving farmers and technicians, to the main distributors of yacon roots at CEASA – ES, on the Metropolitan Region of Vitória (Espirito Santo State capital), like *COMERCIAL NUNES; HORTIFRUTTI; YARA* and others.

Informations to characterize the market for fresh yacon roots in the period 2006-2007 and identify marketing opportunities for Santa Maria de Jetibá's production is presented in Table 5.

Table 5 - Informations on the fresh yacon root market in the metropolitan region of Vitoria - ES, collected on 2006 / 2007. Incaper, 2024.

Place of sale	Quantity of yacon sold (kg)	Origin and purchasing potential
Centrais de Abastecimento do Estado do Espírito Santo (CEASA – ES)		
CEASA - ES	27.968,00 (01-01-2006 to 31-12-2006 period)	*São Paulo*
CEASA - ES	27.036,00 (01-01-2007 to 16-07-2007 period)	*São Paulo*
	2.940,00 (01-01-2007 to 16-07-2007)	*Espírito Santo*
Yacon root distributors in Vitoria Metropolitan Region		
YARA	21. 120,00 kg a year. (They buy 22 boxes of 20 kg a week = 1056 boxes of 20 kg a year)	*São Paulo* They're willing to buy from Santa Maria de Jetibá. They liked root standard.
HORTIFRUTTI	12.000,00 kg a year (They buy 10 boxes of 10 kg every other day; 1200 boxes a year)	*São Paulo* They could start buying from Santa Maria de Jetibá 2 boxes a week They liked the product
COMERCIAL NUNES	24.000,00 kg to 48.000,00 kg a year (They buy 05 to 10 boxes of 20 kg a day; 1.200 to 2.400 boxes a year	*São Paulo* They could buy from SMJ They liked the product

Source: Authors.

Based on the informations on purchasing potential, the marketing of the roots harvested from the cultivated areas was organized, as well as the planting of new areas for the following year.

In 2006, 100% of the yacon sold at CEASA-ES came from São Paulo. Until July 2007, 10% of the yacon in CEASA-ES originated from Santa Maria de Jetibá-ES (Table 5).

According to distributors, yacon is a good product to work with. According to them, consumption remains regular throughout the year. Whoever starts eating and benefiting never stops. Besides the advantages of logistics, the roots from the Espirito Santo State showed higher 'storage time' due to the fact the roots from São Paulo State passed out due to chemical bleaching process, thus weakening the root cortex with consequent reduction on time of commercialization.

In a consultation carried out in January 2024 with the Municipality of Santa Maria of Jetibá, a yacon planting area of 10 ha was estimated, in conventional agriculture, with high productivity (01 box of 20 kg/square meter of area), representing a productivity of 200 tons per hectare.

No information was found on organic yacon production in the municipality.

– Contemplating the process and continuity

→ According to the farmers, the cultivation of yacon crop was relatively easy.

From these initial plantings, were observed that the spacing adopted was inadequate due to the size of roots, which was out of the commercial standard required.

It was also observed that in some crops, planting in ridges brought very dry soil, although the application of straw mulch minimized this phenomenon. Moreover, in this management practice harvesting proved easier, causing less mechanical damage to the roots. The method of planting could be considered for future research.

The farmers also expressed interest in other clones of yacon and there have been demand for technologies for intercropping yacon with other commercial crops.

→ After harvesting, it was necessary to store the rhizophores for subsequent plantings. It was recommended that the rhizophores be placed on a layer of dry, slightly moist straw to maintain their turgidity. They were then covered with a layer of dry grass straw. They were stored in the shade, in a covered, dry and cool place until it was time to stimulate the shoots again for subsequent plantings.

At this storage stage, the occurrence of fungus (*Sclerotium rolfsii*), varying in color from light to dark (Figure 7) was identified and recorded. Another phytosanitary problem identified in yacon cultivation in ES was the occurrence of root-knot nematode (*Meloidogyne* spp.) in Laranja da Terra as shown in Figure 7.

Figure 7 - A. *Sclerotium rolfsii* identified and recorded on yacon rhizophores at storage; B. Occurrence of Meloidogyne spp. in yacon roots.

Source: Authors.

→ Through interaction and conversations between farmers and technicians, new possibilities were identified. For example, cultivation in ratoon (soca): After removing the senescent plants from the soil and harvesting the reserve roots, the shoots on the stem and the anchoring roots are pruned. Only the central structure of the rhizome (trunk or "stump") remains. This trunk is then planted in the holes left open after tilling the soil during the harvest. The planting depth was sufficient to cover the entire structure. In this way, several shoots develop and a new plant is formed, and a second crop and second harvest can be obtained at a lower cost. The use of cultivation in ratoon will depend on the phytosanitary state of the plants.

Spreading for other locations – Organic and Agroecological Systems

Among these family farms that pioneered yacon cultivation, four were organic farms, *Schlieve Farm, A.; Schliewe Farm, D.; Schultz Farm, F. and Formentini Farm, E.*

From these organic farms, yacon seedlings were passed on to organic farmers in other regions of the state of Espírito Santo and it is now a crop that forms part of the organic product portfolio in many municipalities in the state.

Nowadays, the organic farmers currently produce it to sell at street markets, '*feiras livres*".

After Santa Maria de Jetibá (from 2009 to 2011) organic cultivation of yacon also began in Laranja da Terra, in Ullig Farm, *N.; Marcelino Farm, A.; Milke Farm, A.* and *Santa Helena Farm* for local marketing and also for weekly delivery to buyers and distributors of organic products for Metropolitan Region of Vitória, capital of Espirito Santo State.

Also, in Laranja da Terra, at CETEFA - *Centro de Educação Técnica Fé e Alegria* (Faith and Joy Technical Education Center), yacon cultivation was introduced as part of the curricular activities on medicinal plants and as a food grown in the vegetable garden to feed the students and to distribute seedlings to the community.

In the municipality of Afonso Cláudio, from 2010 to 2011, yacon was first introduced at the MAS - *Municipal Agricultural School,* part of the public

ISBN 978-65-5360-570-1 - Vol. 3 - Ano 2024 - www.editoracientifica.com.br

education network. Seedlings were distributed to students, children of family farmers, in order to make the seedlings and this new crop diversification option accessible. At MAS, students followed the field work and participated in the installation of a scientific study on the behavior of yacon in Afonso Cláudio, Empoçado Community, a low-lying region with high temperatures. Practical classes in interaction with the Mathematics discipline were carried out, in moments of evaluating the behavior of plants, demonstrating in practice how to obtain average values of stem diameter, plant height and number of leaves etc.

Aspects of introducing and adapting yacon to diversify family farming in Laranja da Terra and Afonso Cláudio are shown in Figures 8 and 9, at Marcelino Farm, A. and CETEFA - *Centro de Educação Técnica Fé e Alegria do Brasil.* Also, in Afonso Cláudio, MAS - *Municipal Agricultural School*.

Integration between yacon innovation and schools for farmers sons and daughters was created in both places.

Figure 8 - Aspect of yacon cultivation introduction in Laranja da Terra and Afonso Cláudio. A. Incaper technician, Mr. Ernesto M. Muzzi, pioneer in Laranja da Terra; B. Young yacon plants growing in furrows, native grass mulch, Marcelino Farm; C. Mr. Lucas Pilon, teacher of CETEFA, Laranja da Terra, harvesting yacon roots; D; E; F. *Municipal Agricultural School* of Afonso Claudio, respectively, a scientific study; teacher in agricultural techniques class teaching students mulch and weed control; G; H; I. Researcher teaching students to calculate average values in practice.

Source: Authors.

Figure 9 - Aspects of Incaper's partnership work with the Municipal Agricultural School. A. Plants in the furrow cultivation system, mulched with grass; B. Experimental area being harvested; C. Harvesting yacon roots; D. Banner for a campaign to promote yacon consumption in a local supermarket; E; F; G. Dialogue between students and consumers during the event.

Source: Authors.

FINAL CONSIDERATIONS

The initiative of farmers promoted this whole process and has influenced and is influencing the agriculture of an entire state.

The agronomic viability of cultivation of yacon in winter planting was observed in the agro-climatic conditions in the mountainous region of Espírito Santo State;

From the second year of yacon cultivation onwards, most of the farmers/producers began to sell their produce to a buyer, a middleman from Santa Maria de Jetibá.

The initial group dispersed.

Agreements on pesticide-free production did not take place.

The Incaper CPDI Serrano team created safe production standards for yacon roots.

However, there was no consensus among farmers on establishing and adopting safe standards for yacon production. The ant attack led to the use of agrochemical products, accepted by the local buyer. The use of herbicides on yacon crop also started.

Being an innovative product, consumer awareness and formation of local market are needed to strengthen the cultivation of yacon;

It is essential to carry out research for development and production of yacon in monoculture or intercropping and organic production system.

The system of cultivation in ratoon (socas) is a possibility that could be studied as an option for production and conservation of seedlings and reduce cost.

Acknowledgements

All pioneer family Farmers and Partners who joined efforts in this collective effort; INCAPER – Instituto *apixaba de Pesquisa Assistência Técnica e Extensão Rural*; PMSMJ - *Prefeitura Municipal de Santa Maria de Jetibá* – ES; EFASJG - *Escola Família Agrícola de São João do Garrafão*; CETEFA - *Centro de Educação Técnica Fé e Alegria do Brasil;* EMA – *Escola Municipal Agrícola*, Afonso Cláudio; Supermarkets *Berguinha*; *Guilhermes*; *Super Show* and *Tressmann* em Santa Maria de Jetibá; SICOOB; STRSMJ.

REFERENCES

ANGELETTI, M da P. ***et al.*** Estratégia de trabalho participativo para marketing do yacon (*Smallanthus Sonchifolius* Poep. & Endl) no comércio de Santa Maria de Jetibá – ES. **Revista Brasileira de Agroecologia**, v. 2, n. 2, p. 285-289, 2007. Disponível em: <https://revistas.aba-agroecologia.org.br/rbagroecologia/article/view/7205>. Acesso em: set. 2023.

ANGELETTI, M. da P. ***et al.*** Ações integradas para introdução do yacon (S*mallanthus sonchifolius* Poep. & Endl) na Região Serrana do Espírito Santo. **Cadernos de Agroecologia** – **Anais do VI CLAA, X CBA e V SEMDF,** v. 13, n. 1, jul. 2018. Disponível em: <https://cadernos.aba-agroecologia.org.br/cadernos/article/view/1339>. Acesso em: set. 2023.

ARNAO, I. *et al.* Potencial antioxidante de 10 accesiones de yacón, *Smallanthus sonchifolius* (Poepp. & Endl.) H. Robinson, procedentes de Cajamarca – Peru. **An Fac Med**., v. 72, n. 4, p. 239-43, 2011.

CABRERA, M. V.; SAAVEDRA, A.A.; MONTOYA, A. J. D. **Experiência de técnicas de propagación vegetativa para la producción comercial de yacón**. Cajamarca. Instituto Cuencas, MINAG – Agencia Agraria de Cajabamba, 2006. p. 8.

CARNEIRO, R. M. D. G; ALMEIDA, M. R. A. Registro de *Meloidogyne ethiopica* Whitehead em plantas de yacon e tomate no Distrito Federal do Brasil. Brasilia. **Nematologia Brasileira**, v. 29, n. 2, p. 285-287, 2005. Disponível em: <https://www.semanticscholar.org/paper/Registro-de-Meloidogyne-ethiopica-whitehead-em-de-e-Carneiro-Almeida/09c3ef17118d0bd3daeda44e10bc6861f1f5764e>. Acesso em: dez. 2023.

CORDOVA, A.; GALECIO, M. Identificación y evaluación agronómica de los biotipos de Yacón (*Smallanthus sochifolius*) en la microcuenca la Gallega, Provincia de Morropon – Piura. **Universalia**. V. 11, N. 2, pp.14-23. 2006. Disponível em: https://dialnet.unirioja.es/servlet/articulo?codigo=2924549 >. Acesso em: dezembro, 2023.

DOSTERT, N. *et al.* **Hojas botánicas**: yacón – *Smallanthus sonchifolius* (Poep.) H. Rob. Lima. Universidad Nacional Mayor de San Marcos, 2009. p. 15.

FERREIRA, B. M. R. **Relação entre as características físicas das folhas de yacon** (*Smallanthus sonchifolius*) **e os níveis de compostos funcionais.** 2013. 78 Fls. Tese (Doutorado) Engenharia de Alimentos – Universidade Federal do Paraná. Disponível em: <https://acervodigital.ufpr.br/handle/1884/32757?show=full>. Acesso em: dez. 2023.

FEITOZA, H. N. **Integração do sistema de informações geográficas das Unidades Naturais do Espírito Santo** – GISUNES ao GEOBASES. Incaper/Fundagres, 2007. p. 7. Disponível em: <http://biblioteca.incaper.es.gov.br/digital/handle/item/1083>. Acesso em: ago. 2023.

GRAU, J. A.; RHEA, J. Yacon (*Smallanthus sonchifolius* Poepp. & Endl) H. Robinson. In: HERMANN, M.; HELLER, J. (Eds.). **Andean roots and tubers:** Ahipa, arracacha, maca, yacon. Promoting the conservation and use of underutilized and neglected crops. 21. Institute of Plant Genetics and Crop Plant Research. Gatersieben / International Plant Genetic Resources Institute. Rome, Italy, 1997. p. 199-242.

HIGASHIMURA, Y. *et al.* Dietary intake of yacon roots (*Smallanthus sonchifolius*) affects gut microbiota and fecal mucin and prevents intestinal inflammation in mice. **Journal of Clinical Biochemistry and Nutrition,** v. 69, n. 3, p. 272-279, 2021. Disponível em: <https://www.jstage.jst.go.jp/article/jcbn/69/3/69_20-203/_article/-char/ja>. Acesso em: ago. 2023.

MANRIQUE, I.; PÁRRAGA, A.; HERMANN, M. **Jarabe de yacon**: Principios y procesamiento. Serie: Conservacion y uso de La biodiversidad de raíces y tubérculos andinos: Uma década de investigación para El desarollo (1993 – 2003). n. 8 Centro Internacional de La Papa, 2005. p. 31. Disponível em: <https://cipotato.org/wp-content/uploads/2014/06/1919-Jarabe_Yacon.pdf>. Acesso em: nov. 2023.

MOSCATTO, J. A. *et al.* Farinha de yacon e inulina como ingredientes na formulação de bolo de chocolate. **Food Science and Technology**, v. 24, n. 4, p. 634-640, 2004. Disponível em: <https://www.researchgate.net/publication/240770878>. Acesso em: ago. 2023.

QUEIROGA, R. C. F. *et al.* Utilização de diferentes materiais como cobertura morta do solo no cultivo de pimentão. **Horticultura Brasileira**, 20 (3), p. 416-418, 2002.

SATOH, H. *et al.* Yacon diet (*Smallanthus sonchifolius*, Asteraceae) improves hepatic insulin resistance via reducing Trb3 expression in Zucker fa/fa rats. **Nutrition & Diabetes,** v. 3, n. 70, 2013. doi: <10.1038/nutd.2013.11>. Disponível em: <https://www.nature.com/articles/nutd201311>. Acesso em: ago. 2023.

SEMINARIO, J. Origen de las raíces andinas (1). In: SEMINARIO, J. (Ed.). **Raíces andinas**: contribuciones al conocimiento y a La capacitacion. 2004. Serie: Conservación y uso de La biodiversidad de raices y tubérculos andinos: Uma Decada de Investigacion para El desarollo (1993 – 2003) n. 6. Universidad Nacional de Cajamarca, Centro Internacional de La Papa, Agencia Suiza para El Desarollo y La Cooperación. 2004. p. 1-38. Disponível em: <https://books.google.com.br/books?hl=pt-BR&lr=&id=L-sz8Eir9IIC&oi=fnd&pg=PA1&dq=related:R8A3UfmUXwMJ:scholar.google com/&ots=azzGGut7sD&sig=fooH5L3sk3qyuMTGJLodXl8ArWI#v=onepage&q&f=false>. Acesso em: ago. 2023.