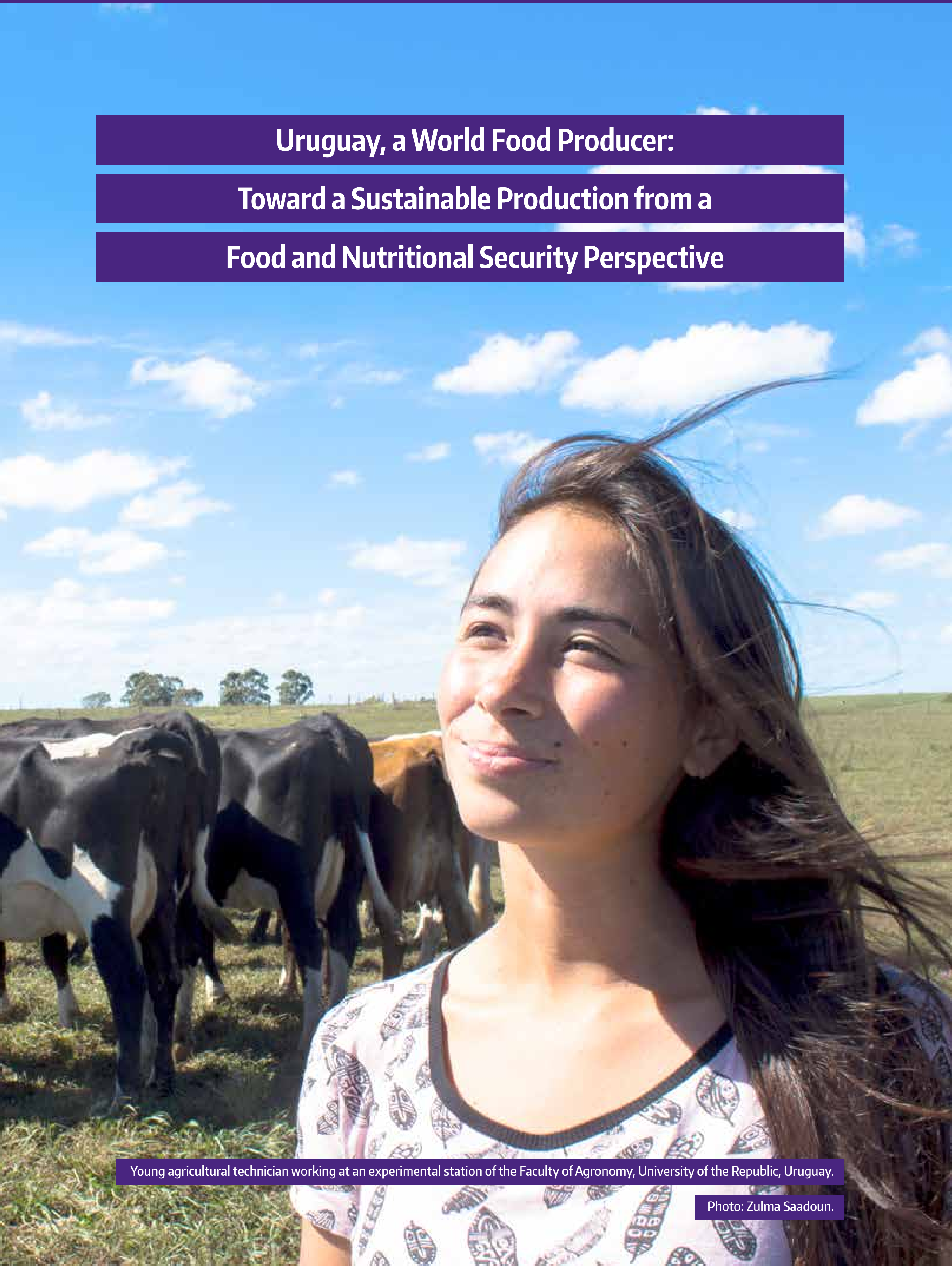
Uruguay, a World Food Producer: Toward a Sustainable Production from a Food and Nutritional Security Perspective



Young agricultural technician working at an experimental station of the Faculty of Agronomy, University of the Republic, Uruguay.

Photo: Zulma Saadoun.

Uruguay

[1] María Cristina Cabrera,
[2] Laura Astigarraga, [3] Omar Borsani,
[4] Gianfranca Camussi, [5] Pablo Caputi,
[6] Miguel Carriquiry, [7] Pablo Chilibroste,
[8] Milka Ferrer, [9] Guillermo Galván,
[10] Fernando García Préchac, [11] Lucía Grille,
[12] Carmen Marino Donangelo, [13] Daniel Panario,
[14] Ali Saadoun, [15] Pablo Soca,
[16] Valentín Picasso, [17] Daniel Vázquez,
[18] Fernanda Zaccari

Uruguay, a country with a high rate of human development and availability of natural resources, has the capacity to produce food for its own population and the rest of the world. This gives it a unique opportunity to address the enormous challenge of improving agriculture, making it less vulnerable to external changes, **adding value to chains through a sustainable, sensitive approach to food and nutritional security,** incorporating quality and safety, and promoting equity in the human and social dimensions.

Summary

Located in the Southern Cone, Uruguay is a country with a total area of 176,216 km², and a population of 3,431,555 inhabitants (World Bank, 2015). Its population, living mostly in urban areas (over 95%), has a literacy rate of nearly 99% and a low replacement rate. Uruguay has been classified as a high-income country by the World Bank, and is in the high human- development category according to the index used by the United Nations Development Program (UNDP, 2015). The country has abundant natural resources, arable soils, and available water and natural meadows, which has contributed to its thriving agricultural and livestock industries. Uruguay is a net exporter of agricultural products, with a capacity to produce food for its own population and the rest of the world. It is the world's seventh largest beef exporter (USDA, 2016), while its rice exports account for 2.1% of the rice sold worldwide. It has no significant risk of food and nutrition insecurity due to the abundance and variety of food, as well as the favorable conditions for producing them. However, micronutrient deficiencies coexist with overweight and obesity in young individuals, posing a major challenge for the years to come.

Low-cost production of *commodities* makes the country competitive. However, this specialization also makes it vulnerable to changes in the international market and climate or health events, impacting the population and decreasing the capacity for entrepreneurship and innovation. Food and nutrition security in Uruguay is vulnerable to these changes, which cause the inequities that affect the sectors of the Uruguayan population with the least resources. In recent years, actions have been launched using an integral point of view, to make agricultural systems more sustainable, environmentally-friendly and innovative. This will entail taking into account the added value, quality and safety of food items produced by the country, the social and human component, as well as the knowledge required to implement these changes. Actions are being taken from the new institutional framework to increase highly qualified human capital. Public and private research, development and innovation programs have begun to focus on training human resources capable of innovating and achieving a major impact on value chains. The interdisciplinary approach to problem solving has been encouraged during this new stage and will have a positive impact in the medium term.

Introduction

Using an interdisciplinary approach, this chapter presents the main aspects that determine the Food and Nutrition Security (FNS) status of Uruguay, an agricultural cattle farming country, from its natural resources to food production, including the human component. The academics and specialists participating in this collective study, invited by the Inter-American Network of Academies of Sciences (IANAS) and the Academy of Sciences of Uruguay, provide a critical view of present and future scenarios. This chapter highlights the advances being made as a result of scientific research, and the evolution toward public policies that impact on FNS.

Study Focus

Food production in an agricultural export country faces the challenges posed by changes in markets, quality and safety demands and the care of natural resources such as soil, water and plant cover, in a changing climatic situation. With regard to its own population, the challenge for the country is to streamline food systems, to provide a sufficient quantity of food with nutritional quality and to contribute to the Uruguayan population's food and nutrition. In each aspect, priority is given to a description of the country's opportunities, the obstacles to be overcome and the challenges to be faced in order to achieve sustainable, high-quality food production, as well as nutrition-sensitive value chains that are inclusive at the human and social level.

1. National characteristics

Miguel Carriquiry[1]

1.1 Country area, arable land inventory, environmental heterogeneity of the landscape

Uruguay comprises an area of 176,216 km², with a variety of natural resources that allow the development of agricultural and forestry activities in over 90% of its territory. Tradition and the availability of natural resources are among the main reasons behind the leadership of the agricultural sector as a determinant of economic growth (UNEP, 2015). Over 80% of the territory is devoted to livestock production, while extensive crops and commercial forestry occupy the majority of the remaining area. The establishments dedicated to livestock raising are responsible for more than 75% of the area dedicated to livestock production.

1. Full Professor, Institute of Economics (IECON), Faculty of Economics and Administration, UdelaR.

1.2 Demographic characteristics and future trends

Uruguay has a relatively stable population of 3,286,314 according to the latest official census (INE, 2012), with some estimates placing it at 3,431,555 in 2015 (World Bank, 2015). The majority of the population (over 95%) is urban, while the literacy rate is nearly 99%. Uruguay has been classified as a high-income country by the World Bank, and is in the high human-development category according to the index used by the United Nations Development Program (UNDP, 2015).

Its low replacement rates, emigration of young adults and a relatively high life expectancy mean that Uruguay's population is ageing rapidly. Recent studies (Calvo, 2016) indicate that trends in the age structure, which modify the demographic dependency ratios, pose challenges on various fronts, from health care and the social security system, to labor markets and education. Projections show that, given the limited natural increase in Uruguay's population, the proportion of children will decline to match that of older adults by 2035, and that the latter will exceed the number of children thereafter. These changes will exacerbate certain socioeconomic challenges, such as increased health care and care costs in the context of today's family structure, and labor-market demands, straining the retirement and pension system (Calvo, 2016).

1.3 Proportion of the population suffering from food and nutrition insecurity and the FNS trajectory

According to data from the Food and Nutrition Security Observatory, the proportion of the population under the poverty line and indigence have declined over time, standing at 9.7% and 0.3%, respectively, in 2014. The same source indicates that the fraction of the population at risk of failing to meet the food demands associated with normal physical activity has also fallen. This fraction dropped from 17.5% in 1990 to approximately 10% in 2004, and has since hovered around 8%. Uruguay achieved the Millennium Development Goal of halving the number of people who were food-insecure ahead of time, in 2014.

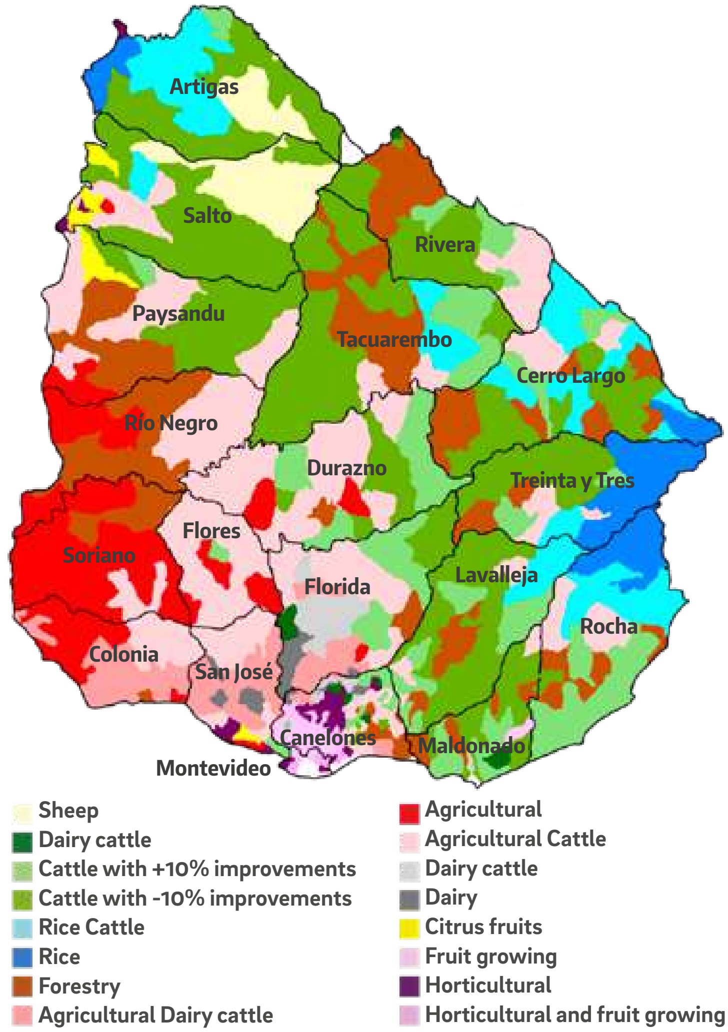
1.4 Agricultural production systems

The Uruguayan agricultural sector is extremely heterogeneous in terms of scale and productive practices, among other dimensions. However, particularly in the extensive agriculture sector, similarities are found with what UNEP (2011) defines as "industrial agriculture", characterized by production practices based on the use of off-farm inputs.

Broadly speaking, most of the agricultural area is used for three activities: extensive agriculture; livestock raising and commercial forestry. The country has seen the rapid transformation of these productive activities. There have also been significant changes in agricultural activity, particularly in terms of the total area dedicated to the mix of different crops and the seasons when these crops are grown. A key aspect of agriculture in Uruguay is the significance of mixed agricultural-livestock production systems in parts of the country where soil is suitable for crop growing. The coexistence of livestock (mainly beef cattle) and crops in crop-pasture rotations is an important aspect of agriculture in Uruguay, whose extension has varied over time. Recent increases in profits from crop production (relative to meat production), and changes in production models and governance have led to a reduction in the inclusion of pastures in rotations and to the displacement of cattle to less productive soils. Some of these changes may be reversing as crop prices decline.

Whereas the area under soybean cultivation was insignificant before 2000, it has become the largest crop in recent years, occupying more than one million hectares. In terms of value, soybean is currently the main export crop, vying with beef for first place in the country's exports. This has also led to a significant change in terms of the seasonality of crop production. In the recent past, the area of winter crops doubled that of summer crops. This ratio has now been reversed due to the rapid expansion of summer crops, particularly soybeans. This reversal has worried a number of observers, since it increases the need for resources, particularly water, during the seasons when droughts or water deficits are more likely. Increases in rainfall variability, as a result of climate change, can increase the risks to the agricultural economy.

Map 1. Map of Uruguay showing political divisions and agricultural production areas



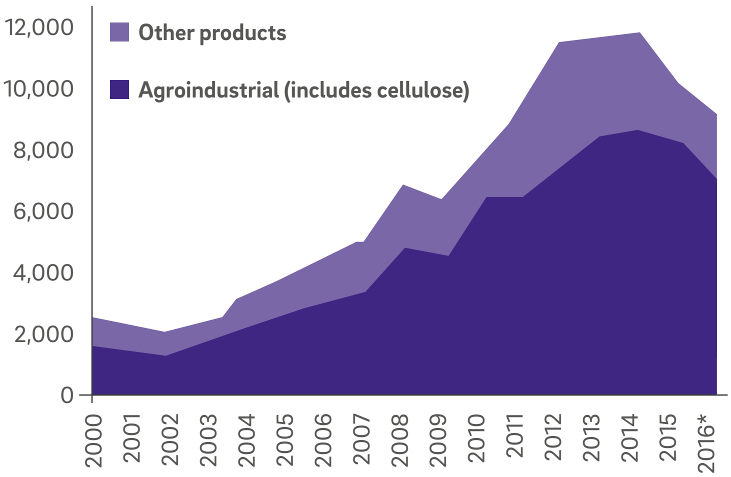
Source: Adapted from MGAP Map.

1.5 Main export/import markets and agricultural products

Agricultural and agroindustrial products account for an increasing share of the country's exports (Paolino and Hill, 2011), currently totaling 80%. Uruguay is mainly an exporter of food products and other agricultural products. The principal export products are beef (chilled and frozen), soybeans, forest products, dairy products (mainly whole milk powder) and rice. **Figure 1** shows the evolution of agricultural exports in recent years.

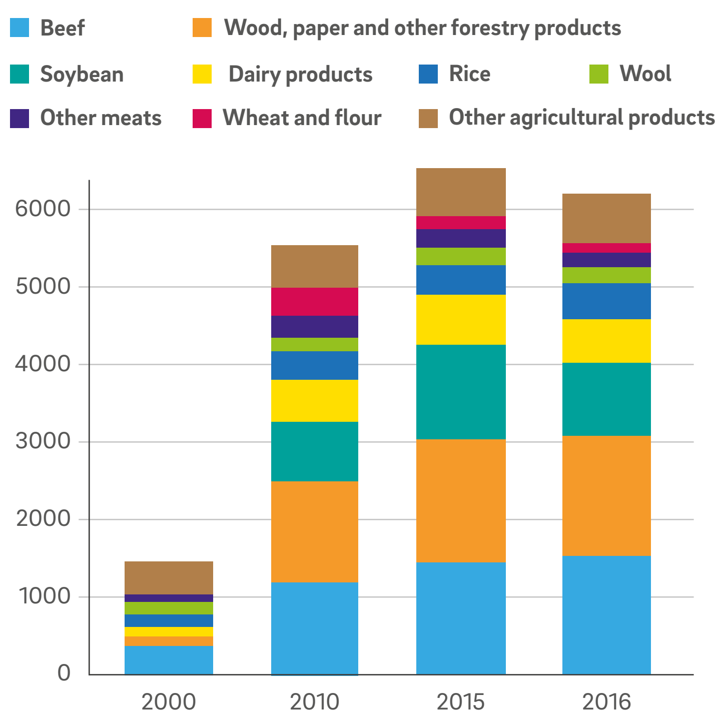
Although soy exports were insignificant or did not exist in 2000, they have become one of the main products sold abroad in recent years (**Figure 2**). Forest-product exports have also expanded, due to strong public incentives to plant commercial forests in the mid-1990s and significant recent investments in pulp-production capacity.

Figure 1. Evolution of exports of goods in millions of dollars



Source: Anuario OPYPA 2016, *Estimated value.

Figure 2. Agricultural and agro-industrial exports in millions of dollars



Source: Prepared by the authors based on data from MGAP and Ministry of Agriculture.

The overseas market is the main destination of several Uruguayan products. To mention just a few, over 90% of rice and soybeans and over 70% of beef production is exported. Although export markets by product, China, NAFTA and the European Union are the main destinations for Uruguayan products in general, and beef in particular. More than 75% of the soybean exported is destined for the Chinese market.

1.6 Potential sources of instability for Food and Nutrition Security

The availability of productive land, climate, agricultural production and low population density are factors that explain why Uruguay faces no significant challenges in terms of FNS. In fact, it is commonly said that Uruguay has the capacity to feed between 27 and 28 million people, a figure that would rise if certain productive practices were improved based on currently available technologies and institutional frameworks (Mondelli and Bervejillo, 2015). As mentioned earlier, Uruguay exports a high proportion of the food and commodities it produces. Despite this abundance in terms of food production at the aggregate level, there are still sectors of the population that face food insecurity, although their numbers have rapidly declined in the recent past.

1.7 Main agricultural challenges

The nature of Uruguay's production systems is a source of both competitiveness and vulnerability. Although its natural resources mean that the country is able to produce crops, particularly livestock products, at low cost, its production systems are vulnerable to climate variability, particularly droughts. Soil erosion and water pollution are among the main environmental challenges facing the agricultural sector and the country as a whole.

Open-air and rainfed production take advantage of the natural availability of land and water. These low-cost production systems expose the sector to risks due to significant rainfall variability both between years and within a single year. This variability is expected to increase in the future as a result of climate change. The changes in crop patterns mentioned previously may be increasing production systems' vulnerability to climate change, which in turn requires different forms of risk management. These include investment in risk and insurance technologies and methods for using the available water (with varying degrees of shortage during the year) more efficiently.

Soil loss, as a result of erosion, has implications for both production and the environment. Erosion and other forms of soil degradation reduce productive potential and increase the need for nutrient aggregation, which results in higher production costs per hectare (ha) and unit-of- output. Moreover, erosion and nutrient runoff result in water pollution, degrading the environment and imposing external costs on society. Loss of water quality is evident in the watersheds and reserves that feed the most populated areas, such as Montevideo, the capital of the country, and the surrounding cities.

2. Institutional framework

María Cristina Cabrera[2]

2.1 National Agricultural Research System

In 2016, the National System of Researchers (SNI) had 1,744 classified researchers, 1,494 of whom were active, 233 associate and 17 emeritus. According to ECLAC (2014), the total number of researchers is only a third of what it should be, in comparison with neighboring countries. Of the total number of active researchers, 9.1% are from the area of humanities, 10.4% from engineering and technology, 11% from agricultural sciences, 12.8% from medical and health sciences, 21% from social sciences and 35.7% from natural and exact sciences. A high percentage of researchers (75%) are attached to the University of the Republic. In the case of agricultural sciences, 25% are drawn from INIA, private universities and other institutions that research agricultural sciences. The total number of classified researchers, as well as those engaged in agricultural sciences, reflects a research capacity that still insufficient for achieving the objectives of a sustainable productive country based on knowledge generation and innovation (ECLAC, 2014).

2.2 Science and Technology Strenghts

The Global Innovation Index, cited by Rubianes (2014) in the ECLAC report and designed by INSEAD and the World Intellectual Property Organization (WIPO), makes it possible to compare countries and their evolution through the use of seven variables: A) Institutional development; B) Human capital and research; C) Infrastructure; D) Market complexity; E) Complexity of businesses; (F) Technology products, and (g) Creative products. According to the 2009 and 2012 annual reports, Uruguay ranks 53rd and 64th worldwide, respectively, and between third and sixth in Latin America. Its greatest strengths are its institutions, infrastructure and creative products. Rubianes (ECLAC, 2014) cites the following aspects as strengths: i) Human capital, which has steadily increased at a reasonable annual rate, mainly as a result of graduate students; ii) infrastructure in nearly all areas, and iii) knowledge production, reflected in the number of Uruguayan publications, also on the rise.

2.3 Universities and research institutes

Science and technology activities related to agriculture are mostly undertaken by the public sector, particularly by higher education and agencies specializing in agriculture, such as the University of the Republic (UdelaR) and the National Institute of Agricultural Research (INIA). Other public organizations, such as the National Seed Institute (INASE), the National Milk Institute (INALE), the National Meat Institute (INAC) and the National Wine Institute (INAVI) contribute to research and human resource training activities in issues related to agriculture, by supporting and participating in them. Private universities, research institutes and other public or private institutions contribute to training and research in various areas of agriculture

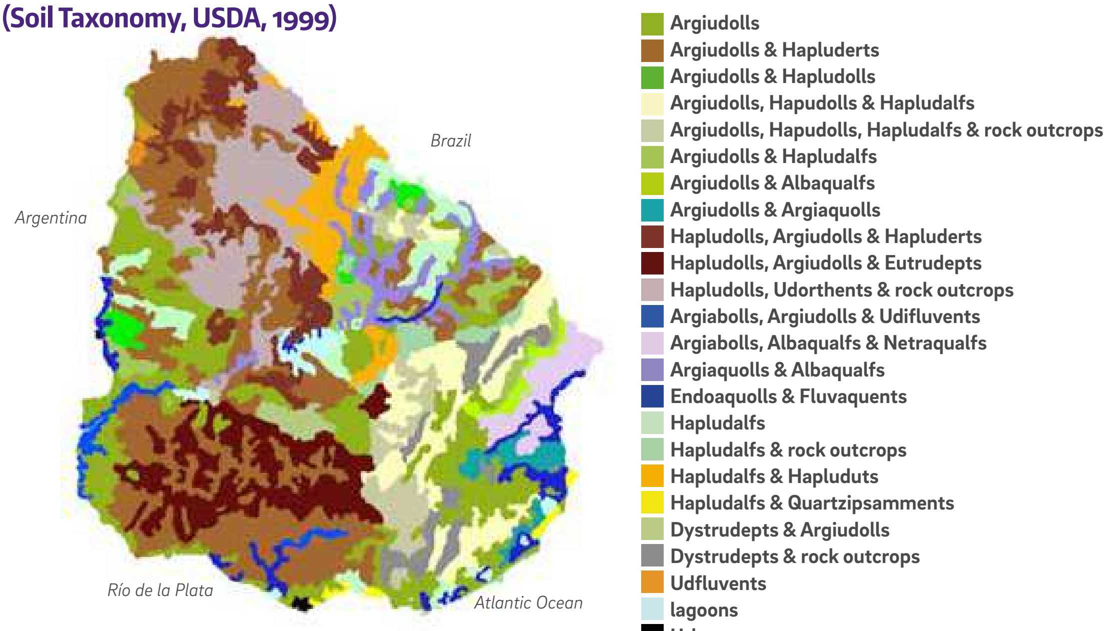
2. Full Professor, GD Nutrition, Faculty of Agronomy. Associate Professor, Physiology & Nutrition, Faculty of Sciences, UdelaR. mcab@fagro.edu.uy

through partnerships with the other actors, primarily in the scientific-university context. This interinstitutionality, in both graduate training and research, has increased in recent years. The relative contribution to investment, research and innovation by the public and private sectors is 70% and 30%, respectively. This proportion is lower than the prevailing rate for the region, meaning that there is a need for the private sector to invest more in research and innovation.

2.4 Scientific collaboration networks inside and outside the country

In 2012, the Uruguayan Agency for International Cooperation (AUCI) announced 114 cooperation initiatives in the Productive Area, 63 of which involve traditional cooperation, 38 regional cooperation and multi-country cooperation, and 12 South-South and triangular cooperation. In traditional cooperation, the largest share of donor funding was used to support science, technology and innovation. In regional and multi-country cooperation, emphasis was placed on partnerships with Mercosur and between Mercosur and Spain and the European Union. The cooperating partners were: Mercosur (FOCEM), Canada (IDRC), UNSG (FAO and IFAD), CIAT, FONTAGRO, IDB, OAS (IICA), CAF and the European Union. In South-South cooperation, Uruguay was a bidder in three, a recipient in one and both in eight initiatives, mostly in the agricultural sector and in science and technology (approximately 65%). The partner countries were Argentina, Brazil, Colombia, Mexico, Nicaragua and Paraguay. In triangular cooperation, only one activity was carried out in the agricultural area, which involved the implementation of a group traceability system for beef in Bolivia. The cooperating partners were Costa Rica, Bolivia and IICA. The main issues were climate change, natural resources and biodiversity, and productive chains and competitiveness. The ANII (National Agency of Research and Innovation) created instruments to promote partnership and coordination between private and public institutes, and concentrating and strengthening research, development and innovation capacities. This was the case of the Sectoral Technology Networks, which synergistically combine the capacities of their members and establish new capacities for the country. Argentinean-Uruguay Scientific Cooperation Programs are implemented in priority areas defined by GMI, the STIC-AmSud Regional Program in the areas

Figure 3. Map of Uruguayan Soils on a scale of 1:10⁶, using Soil Taxonomy (Soil Taxonomy, USDA, 1999)



Source: Durán A., Califra A., Molfino J.M., 2001.

of information technology and Eranet-LAC, a project funded within the Seventh Cooperation Framework Program, which consists of a network of the European Union (EU) and the Community of Latin American and Caribbean States (CELAC), in innovation and joint research, one of the areas being biodiversity and bioeconomy. Other Networks are cited in the chapter items.

2.5 Access to and maintenance of databases for monitoring farming systems

Information and databases for the monitoring of agricultural systems are traditional in the country. According to a 2015 FAO report on Priorities for Uruguay in Agriculture and Food Security, the country has a relatively important institutional system linked to the agricultural sector. The main body is the Ministry of Livestock Agriculture and Fisheries (MGAP), which has eight General Directorates: Secretariat, Water Resources (DINARA); Natural Resources (RENARE); Agricultural Resources (DGSA); Livestock Resources (DGSG); Rural (DGDR); Farm (DIGEGRA) and Forestry (DGF) development. It also has three advisory units from the ministerial authority: The Directorate of Agricultural Statistics (DIEA); the Office of Agricultural Programming and Policy (OPYPA) and the International Affairs Unit (IAU). International cooperation is coordinated by the Secretariat for International Cooperation, which is directly answerable to the Minister. Annual reports are submitted on production, export, consumption and other relevant data, which can then be monitored, analyzed and estimated. In their respective Web pages, this information is freely accessible.

2.6 Development of skilled workforce and state of national education systems

In 2016, Uruguay had a Human Development Index (HDI) of 0.793, a high percentage of literate adults (97%) and a public education system, free of charge and freely accessible at every stage: Elementary; middle and high school, university and vocational technical training (UNDP, 2016). A total of 98.7% of children ages 3 to 5 are enrolled at school. Higher education is mostly supported by the University of the Republic with a smaller but growing share of private universities. A total of 3.8% of adult women and 1.9% of adult men have completed tertiary education. However, in order to comply with the Sustainable Development Objectives (SDO) and the 2030 Agenda for sustainable development (UNDP, 2015), it is necessary to consider the shortcomings at the local level, which will have to be reversed in a sustainable development perspective based on knowledge. These are: a higher-than-expected elementary school drop-out rate, a higher-than-expected pupil-teacher ratio, average educational attainment (measured as the average cumulative years of schooling by 2014), and lower-than-expected gross high school enrollment - defined as the total enrollment corresponding to that educational level, regardless of age, and measured as the percentage of the school-age population attending this level from 2008-2014.

3. Ecosystem and Natural Resources

3.1 The Uruguayan soil resource: its use and conservation

Fernando Garcia Préchac[3]

The Uruguayan ecosystem belongs to the Pampa biome. It consists of natural grasslands that occupy 65% of the territory, 10% of native forest and trees on river banks and small areas of mountainous terrain. The topography consists of gently rolling hills, with slopes of between 3% and 6%, and plains whose area varies according to the zones. The average altitude above sea level is 140 meters, with some mountain areas. The highest point is 513 meters above sea level (masl). According to Soil Taxonomy, Molisols and Vertisols predominate (in green and brown in **Figure 3**, the most commonly used type of soil for crops), with significant areas of Alfisols, Ultisols, Inceptisols, Entisols and Histosols.

As for the presence of arable land, 3.5 thousand ha have approximately 75%, 3.1 thousand ha have 50%, 1.9 thousand ha have 25% and 1.4 thousand ha have between 25% and 75% togeth-

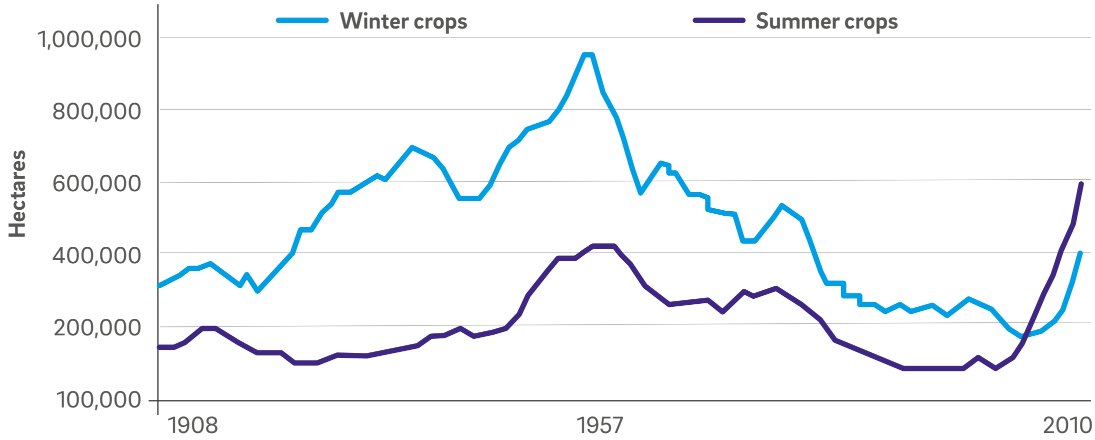
3. Full Professor. Soils and Water Department. Faculty of Agronomy. UdelaR.

er with the topographic conditions that permit rice production (Cayssials and Álvarez, 1983). The rest of the territory consists mainly of fields with less than 25% of cultivable soils (6.9 Mha), mainly dedicated to the production of meat and wool, as well as 0.3 Mha of wetlands and sand dunes.

The cultivated area varied significantly during the 20th and present centuries (**Figure 4**), influenced by market prices and international demand. In the mid-1950s, the size of this area peaked due to wheat production based on a low level of technology and conventional tillage. This led to the first assessment of soil erosion status (Cayssials et al., 1978), indicating that approximately one-third of the country was affected; mainly the area with the best soil. According to more current work (Sganga et al., 2005), this situation has not significantly changed. This stability was due to the reduction of cultivated areas during the second half of the 20th century and the general adoption of crop rotation with pastures planted with grasses and legumes (Crop-Pasture Rotation, CPR). The effect on CPR soil conservation was increased by the widespread adoption of direct sowing in the early 1990s. However, since the beginning of the 21st century, there has been a marked increase in the cultivated area, due to the cultivation of soybean, the grain for which there is the greatest demand on the international market with the highest price per ton (t). Thus, soybean displaced other crops and CPR. Despite the use of direct sowing, the low return of crop residue to the soils, their rapid decomposition due to their low Carbon/Nitrogen ratio, plus the lack of winter cover crops or grain yields in the winters, erosion problems began to be observed that generated a state of general and political alarm, and called for legal regulations governing soil conservation

In 2008, soil management and conservation legislation began to be updated. By 2013, and after a training period for farmers and agronomists, these changes came into full force. Growers must have a plan for responsible soil use and management (PUMR) prepared by a certified agronomist that covers the expected future rotation period. PUMR must demonstrate - using USLE/RUSLE with the EROSION v6.0.20 program (García Préchac et al., 2015) - that the estimated annual erosion rate is below the tolerance value established for the soil used. Each piece of land in the national cadastre has an approximate land survey map at a scale of 1:20,000, whereby the agronomist can obtain soil information for each plan. PUMR is presented "online" and comprises an implementation protocol that can be analyzed and monitored by the official authority (Ministry of Livestock, Agriculture and Fisheries). Those who violate the protocol are fined according to the regulation. At the end of the 2013-2014 agricultural year, nearly 95% (1,438,168 ha) of the farmlands implemented PUMR (**Figure 5**).

Figure 4. Evolution of cultivated areas in Uruguay, with winter and summer crops, from 1908 to 2010 (Saavedra, 2011)



Source: MGAP-DIEA 1. Fortnightly moving averages.

This percentage reached 98% by the end of 2015, which is considered a success in the effort to mitigate soil erosion, as well as its collateral environmental impact.

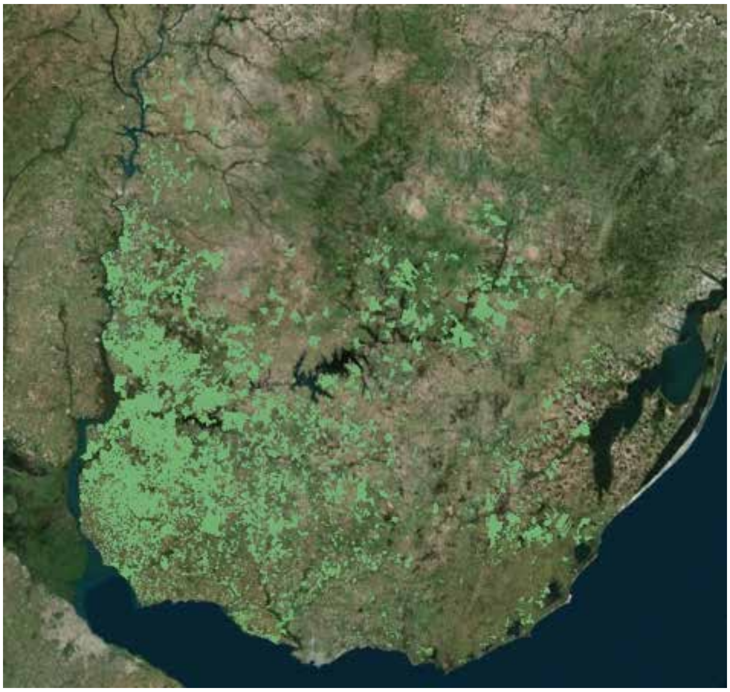
3.2 The water resource. Current status and perspectives

Daniel Panario[4]

Uruguay has more than 10,000 m³ of water per inhabitant per year (Revenga, 2000), both surface and groundwater, which would be more than enough to meet the demands of a larger population. Surface water is uniformly distributed throughout the territory as surface aquifers, most of which are suitable for supplying the scattered rural population.

What happens to water in the various compartments of the environment determines its management. It reaches the rivers from runoff, water tables and, as a universal solvent, in other words, that interaction transforms it when it travels through various settings. This changes life in rivers and reservoirs, determining what remains and what leaves. The three large agro-ecosystems - cattle, agricultural and forestry – behave as follows: **i) Livestock systems.** Although there are intensive livestock systems, such as the dairy industry, most of the territory is occupied by extensive livestock, which usually has a minor impact. However, overgrazing has been observed in most natural pastures. This is the case, in particular, of the concavities of the landscape located in the lowlands, in which the characteristic hard high grasses (scrub) have been eliminated due to fire or animal overload. This has caused these primary channels (concavities) to lodge in the valley, thus producing headwater erosion, significantly accelerating the flow, with the resulting increase in the intensity and frequency of floods and droughts. From the point of view of water quality, total Phosphorus (P) levels in the drainage channels are approximately 25 μg/L (Panario, 2016), since there has been no promotion of a trough system that discourages cattle (12

Figure 5. In light green, farms that submitted the soil use and management plans (SUMP) in 2014



million in 2016) from drinking in the water courses. The phosphorus load of excrement calls for the modification of the legal limit in the current legislation (De León, 2016). These levels are already high enough for dammed waters to be eutrophic, as happens in the Rio Negro dams, to which phosphorus fertilizers and pesticides are added. **ii) Agricultural systems.** Although rainfed agriculture has been a traditional activity since the 19th century, which has gradually damaged the land it occupied, the expansion of soybean cultivation and the technological package that accompanies it have significantly affected water quality in the river courses of agricultural land. Phosphorus is dissolved or bound to the smallest solid particles - those that can only be deposited in reservoirs – meaning that current levels of pollution of the drainage channels cannot be attributed to the agriculture of the past. Irrigation agriculture, mainly deployed in the eastern wetlands of the country, was undertaken through partial drainage, even though they were included in an area protected by the Ramsar Convention. **iii) Forestation.** Afforestation with fast-growing exotic species has

4. Full Professor, Institute of Ecology and Environmental Sciences (IECA), Faculty of Sciences, UdelaR.

expanded significantly since the 1990s as a result of subsidies for these plantations. High forest basins were included in the forest priority areas, despite the fact that forest crops, during years with normal rainfall, reduced watershed yields by approximately 20% (Farley et al., 2005).

In recent years, due to the proliferation of cyanobacteria in the main drinking-water sources, certain preventive measures have been taken. Phosphorus levels have remained unchanged, with an increase in water-treatment costs. Uruguay must draw up a water policy based on the preservation of the ecosystems responsible for the proper functioning of the water cycle, while striking a balance between goods production and the externalities of the productive processes. The greatest challenge for water involves providing sufficient quantity, access and quality to meet society's demands, while allowing ecosystems to maintain the services they provide.

3.3 Environmental sustainability of pastoral meat and milk-production systems: Opportunities for Resilience

Laura Astigarraga[5] y Valentin Picasso[6]

In Uruguay, livestock are reared on natural pasture (Campos Royo Pallarés et al., 2005) and pastures planted with grasses and leguminous mixtures. However, the expansion of soybean production due to direct sowing has reduced the area of pastureland, driving livestock production into marginal land (DIEA, 2011), and providing opportunities for the intensification of livestock systems based on enclosure and grain use. In this context, meat production has increased by over 45% and milk production by over 250% since 1980 (DIEA, 2013), which currently accounts for nearly 77% of the country's GreenHouse Gas (GHG) emissions (MVOTMA, 2015). Uruguay's current and future challenge is to reduce the environmental impact due to agricultural production.

5. Full Professor, Animal Production and Pastures Department, Faculty of Agronomy, UdelaR.

6. Associate Professor, Animal Production and Pastures Department, Faculty of Agronomy, UdelaR; Assistant Professor, University of Wisconsin, USA.

Recent work has studied the environmental impact of Uruguayan beef and dairy systems, based on a case-study analysis of the country's productive systems (Modernel et al., 2013, Lizarralde et al., 2014, Becoña et al., 2014, Picasso et al., 2014). For meat production, Modernel et al. (2013) identified pasture-based systems (natural or planted) and two systems in the finishing phase (pastures or confined plus grains). For milk production, Lizarralde et al. (2014) identified three groups of milk-production establishments – with production processes with low, medium and high efficiency - based on a multivariate analysis of conglomerates. The environmental-impact assessment was undertaken on the basis of a Partial Life Cycle Analysis methodology to study the Carbon Footprint (CF) (IPCC, 2006), the Nitrogen (N) and Phosphorus (P) balance and fossil-energy use, including agricultural activities and agricultural input production.

3.3.1 Environmental impacts of milk production systems

Intensive systems, which produce meat based on confinement and grains, have a lower CF, as borne out by other studies (**Figure 6**). Methane, of enteric origin, was the most important GHG (66%, 58%, and 46% for natural/planted pasture, planted/planted and planted/confined, respectively) together with nitrous oxide due to N excretion and the use of nitrogen fertilizers (30%, 33% and 31%, respectively). However, when analyzing the environmental impact expressed as fossil-energy use or as excess nutrients with respect to what is retained (surplus expressed per kg gained), the systems are arranged in the opposite direction to that presented by the CF analysis. Fossil energy consumption increases with the use of inputs: the planted/confined pasture system requires three times more energy to produce a kilo of live weight gain compared to the natural/planted pasture system. The greater use of energy is due to fuel consumption to produce fodder and grains, owing to fertilizer production and phytosanitary measures. The nutrient surplus (inputs-outputs), expressed in relation to the amount retained (outputs in product) turned out to be double in N and P for pasture planted/confined with respect to natural/planted pasture.

3.3.2 Environmental impacts of meat production systems

Cluster analysis made it possible to identify three groups of farms, with low, medium and high efficiency in the production process, which was reflected in the values of the average CF of each group (**Figure 7**). The low-efficiency group had the highest CF (1.09 kg CO_2 eq/kg MCFP (Milk Corrected by Fat and Protein), explained by low productivity per hectare, low milk production per cow and low rodeo efficiency (VO/stock ratio). Food consumption, of both forage and concentrate, is low (11.0 kg DM/cow), which is explained by reduced forage production and a concentrate supply that does not compensate for the low consumption of forage per cow. The high-efficiency group corresponds to farms with high productivity per hectare (5377 LCGP/ha), high milk production per cow and high rodeo efficiency (VO/stock ratio). These dairy farms are distinguished by high consumption per cow (15.2 kg DM/day) and a high supply of concentrate, presenting a lower contribution of methane (50%) to total emissions when expressed per liter of milk. It was also found that, in mixed pastoral systems, the more efficient the production process, the lower the excess nutrients or fossil-energy use.

In conclusion, in Uruguay the CF varies among production systems, suggesting that there is an enormous potential to reduce GHG emissions. Using forage efficiently by optimizing forage allocation throughout the year is a key mitigation option that can increase beef and dairy productivity and reduce the CF without major investments. At the regional level, for meat-production systems, increased meat productivity and natural resource conservation could be complementary objectives. This approach is being followed in Uruguay and the region, with public policies designed to preserve the natural countryside, achieving a three-fold benefit: the adaptation of pastoral systems to climate variability; the improvement of food security and climate-change mitigation.

Figure 6. Environmental impacts of meat production systems with different feed sources

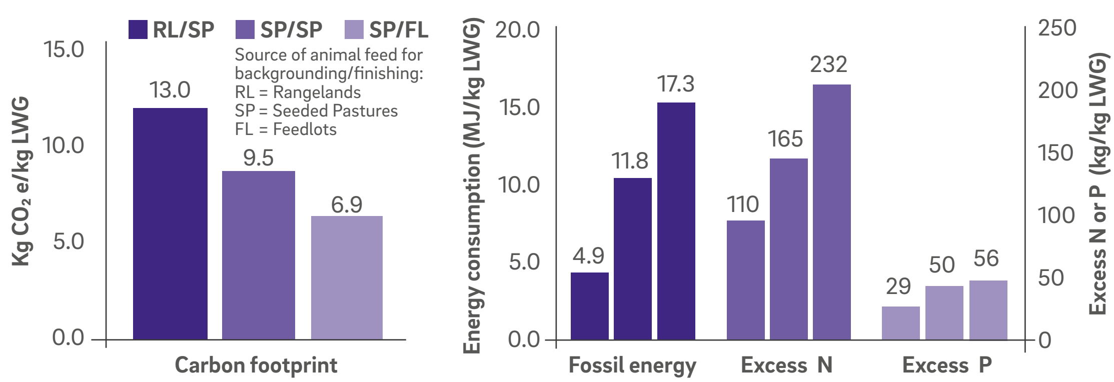
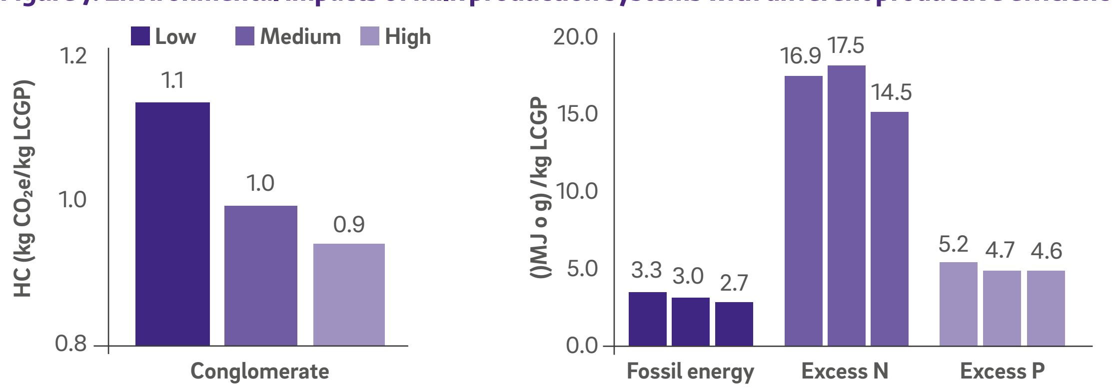


Figure 7. Environmental impacts of milk production systems with different productive efficiency



4. Technology and Innovation in the improvement of agriculture. Opportunities and obstacles

4.1 The Role of biotechnology: The use of biotechnology tools in the development of agricultural products based on local interests

Omar Borsani[7]

It is nearly 15 years since the authorization and subsequent commercial use in Uruguayan agriculture of transgenic maize carrying the *Bacillus turingensis* toxin gene, in a gene construct designed in the laboratory and subsequently incorporated into commercial maize. This marked a watershed in the use of biotechnological tools, especially recombinant DNA technologies for the purpose of improving crop productivity. Since then, new transgenic events have been incorporated into characteristics-of-interest associated with crop management. There are many reasons why this technology has not been adopted to improve characteristics-of-interest in other crops of importance to the country. However, during this period, a number of changes have increased the possibility of developing new improvement strategies through the use of biotechnologies. These include the exponential reduction of the costs of DNA sequencing services over time on the one hand, and the emergence of genetic manipulation technologies that would allow the development of more easily targeted and undeveloped transgenic mutants on the other. This chapter will focus on how these two tools are being used in the country to improve crop quality and productivity and how this will impact the country's agriculture in the near future.

The possibility of sequencing entire genomes of different plant species, at an affordable price by the country's laboratories, means that the genetic information contained in that genome can be accessed, making it possible to identify the characteristics to be improved or transferred. For example, the use of sequencing has made it possible, through associative mapping using SNP (*Single Nucleotide Polymorphisms*), to identify the gene regions associated with grain quality in rice. Thus, on the basis of a mapping population and association with a specific SNP, genes that would be responsible for the starch grain structure among other characteristics, (Bonnecarrere et al., 2014) were identified. Knowing these variants makes it possible to accelerate the improvement processes for these characteristics. At the same time, genome sequencing, as well as the possibility of analyzing complete transcripts of almost any species, has encouraged national researchers to construct genetic maps of fruit species. This is the case of the Uruguayan guava *Acca sellowiana*, a species for which a genetic map is in the process of being constructed (Quezada et al., 2014). On the other hand, genome sequencing and a complete transcriptome of the Tannat berry, an emblematic vine cultivar in the country, is another case where this type of approach significantly increases the appraisal of genetic resource (Da Silva et al., 2013). The information obtained may be used in the medium term for the purpose of improvement or for the identification of new genes with potential biotechnological use. In the same line, breeders working on crops such as barley, wheat and soybeans, among others, are increasingly incorporating the use of genome sequencing tools, both to shorten improvement times and to appraise the germplasm used.

Another tool technology that has begun to be explored in the country is the methodology known as CRIPS/Cas9, which uses the ability of certain proteins to modify DNA in a directed way (Lozano-Juste and Cutler, 2014). This genetic modification will change the way we conceive of the genetic improvement of crops in Uruguay and in the rest of the world. This technology allows specific mutations to be made in a targeted manner, generating mutant individuals in that specific sequence. Some of the country's laboratories are working with this methodology in order to generate specific mutants in proteins-of-interest (National Agricultural Biotechnology Network -Uruguay). In the beginning, the aim was to improve the characteristics associated with tolerance to environmental stress. However, the possibility of improving the quality of certain grains through this type of methodology is presented as a unique opportunity. The future

7. Full Professor, Department of Plant Biology, Faculty of Agronomy, UdelaR.

seems to indicate that improving the quality and productivity of agricultural crops can be achieved on the basis of clearly defined local interests through the use of biotechnology tools that are within reach of the country's capabilities. However, in a country that is still dependent on *commodity* exports, the regulation and global acceptance of these products generated by these new technologies is a challenge that must be addressed. Another challenge will be to gain a deeper understanding of the biochemistry and metabolism of plant cells, which is essential to predicting, with a high degree of certainty, the consequences of the new genetic combinations.

4.2 Prospects for innovation at the farm level

4.2.1 Unlocking the Potential of Traditional and Creole Varieties: The case of the "Pantanoso del Sauce" onion

Guillermo Galván[8]

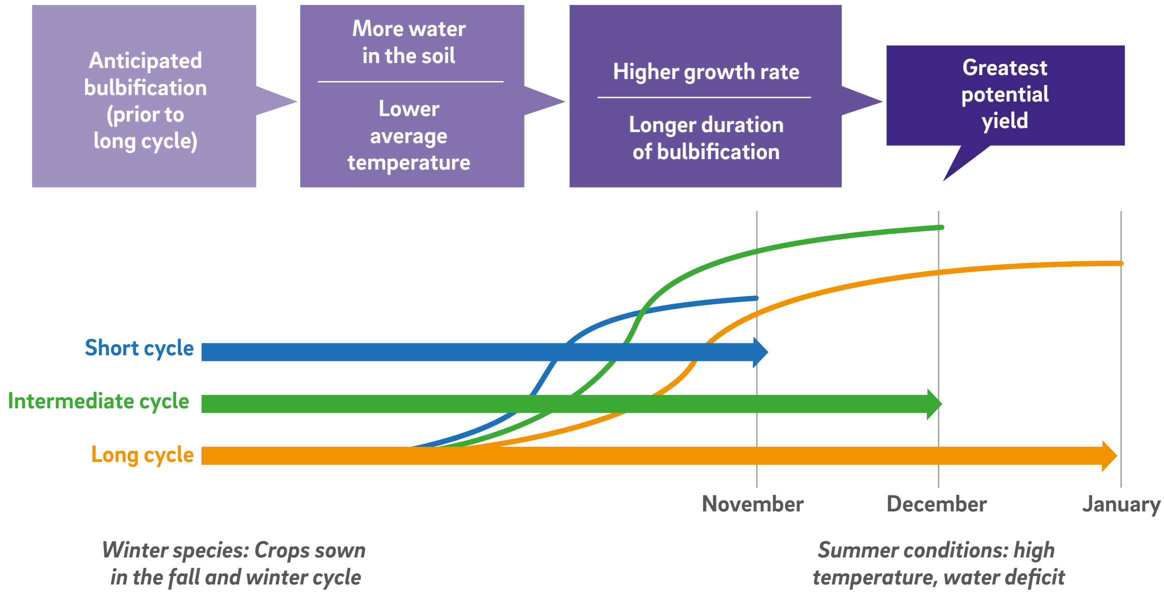
The *Pantanoso del Sauce* onion cultivar is an example of plant genetic improvement that contributes to food sovereignty and security in Uruguay. Local or Creole varieties were introduced into the country by Amerindian and European flows of immigrants (Berreta et al., 2007). This germplasm presents different degrees of adaptation to the local agroecological environment. The adaptation expressed in productivity is the result of a delicate balance between the crop's genetic stock and the environment (Plaisted, 1985). Consequently, seeds maintained by farmers and local breeding have the potential to obtain selections superior to introduced varieties (Pike, 1986). The plants grown today were domesticated in several continents for thousands of years. From the seeds multiplied by farmers and their communities, the development of cultivars[9] expanded in the twentieth century with the application of genetic principles to selection, which made current industrialized food production viable. Despite having been displaced by large industrial agriculture, traditional varieties maintained by farmers persist in association with the logic of family and peasant agricultural production (Frison and Hodgkin, 2016). In many cases, traditional varieties remain economically important and important to food security (McGuire and Sperling, 2016). These varieties constitute a reservoir of genetic diversity for future genetic improvement and generations. Despite the extensive network of institutional germplasm banks, a significant part of the genetic diversity of crops is in the hands of farmers (Jarvis et al. 2008). These traditional varieties offer the necessary diversity for the construction of sustainable production systems in the future (Pautasso et al., 2013). The traditional varieties of onion in Uruguay present diversity at the time of bulbification and harvest, among other characteristics (Galván et al., 1997). Creole intermediate-cycle varieties were extremely interesting, since no similar improved varieties were available (Galván et al., 2005). It was postulated that the intermediate cycle with a harvest in December is the one with the greatest adaptation to conditions in the South of Uruguay (Galván, 1993). In fact, earlier varieties showed lower yield due to lower leaf development at the beginning of bulbification (Galván et al., 2000). At the other extreme, later varieties should achieve higher leaf growth before the beginning of bulbification and consequently higher potential yield, but these later varieties of this winter species are affected by the summer conditions of high temperatures and water deficit (**Figure 8**). High temperatures increase the energy expenditure of leaves, accelerate the entry into senescence of the plant, and shorten the cycle, therefore decreasing the crop's productivity. As a result of a water balance in the surplus soil during the winter, soils typically undergo a progressive drying process in the spring-summer. The water deficit leads to the closure of leaf stomata, which reduces photosynthesis and the crop's growth rate, accelerates senescence and decreases yield.

Based on the intermediate cycle and other favorable characteristics in local varieties of onion, in 1991, a genetic breeding program was launched

8. Associate Professor, Department of Plant Production, Faculty of Agronomy, UdelaR.

9. The term 'cultivar' is used to denote a modern variety, selected by a combination of characteristics, which is clearly distinct from other cultivars, uniform and stable in its attributes when properly propagated. In this text we will retain the term 'variety', which is more commonly used in colloquial language.

Figure 8. Infographic showing the physiological differences associated with cycle differences in onion production in Uruguay



Infographic which determine the greater potentiality of the intermediate cycle. It is important to note the difference between the long cycle, since intermediate and late cycle varieties have the greatest postharvest conservation potential.

that led to the release of the *Pantanos del Sauce* CRS varieties, which occupies more than 60% of the area of the crop in the Southern Region (DIEA-MGAP Surveys, 2009), and "*Canarita CRS*". The potential of the intermediate cycle of the *Pantanoso del Sauce* was evaluated in various production environments. The environment can be defined by technology (plant density, irrigation, fertilization), particularly by soil quality (**Figure 9**). In environments with medium potential (15 to 25 Mg/ha), the *Pantanoso del Sauce's* yield was significantly higher than that of early and late varieties. In high- performance environments (30 to 35 Mg/ha), the long-cycle "*Valcatorce*" variety achieved competitive yields, although in those environments, the intermediate cycle of the *Pantanoso del Sauce* remained higher (**Figure 9**). The dissemination of *Pantanoso del Sauce* is an example of the application of the knowledge generated at the University of the Republic that contributed to food security. In fact, it enabled farmers with limiting technologies and suboptimal productive environments to achieve competitive yields, remain active and contribute to market supply. On the basis of agricultural censuses and production surveys in Uruguay, it is estimated that crop yields have improved positively in recent decades, with increases of 334 kg/ha per year (**Figure 10**). The contribution of the intermediate cycle of the Pantanoso del Sauce is estimated at 20 to 30% of the total, approximately 100 kg/ha per year. Last, a program of certified seed production with family producers was established, which ensured the availability of varieties improved by the University of the Republic and INIA Uruguay. The certification program is a novel experience for horticulture in Uruguay, managed through a public-private partnership that made food sovereignty and food security in Uruguay viable (Peluffo et al., 2016).

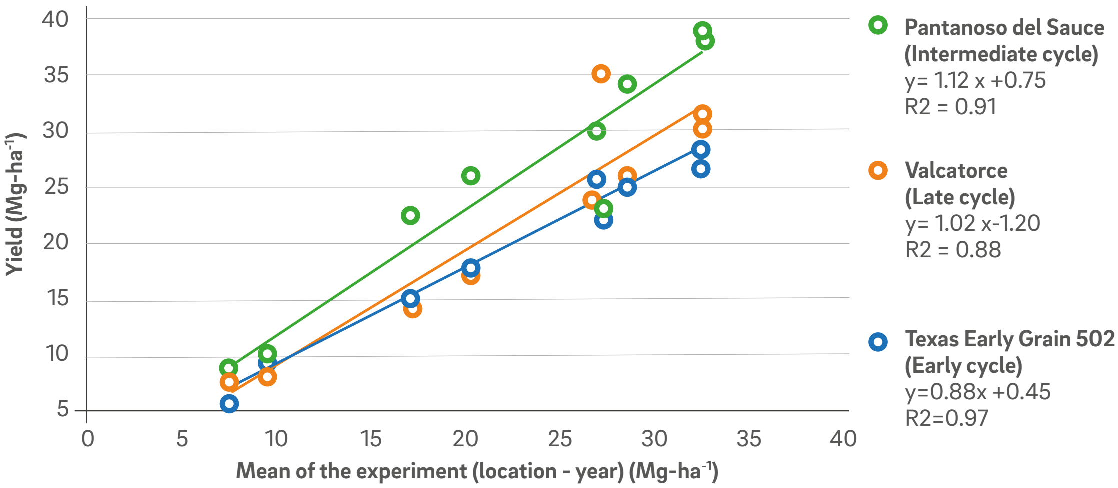
4.2.2 Ensuring milk safety at the farm level

Lucía Grille[10]

Uruguay is one of the main exporters of milk and dairy products in the region, exporting 70% of

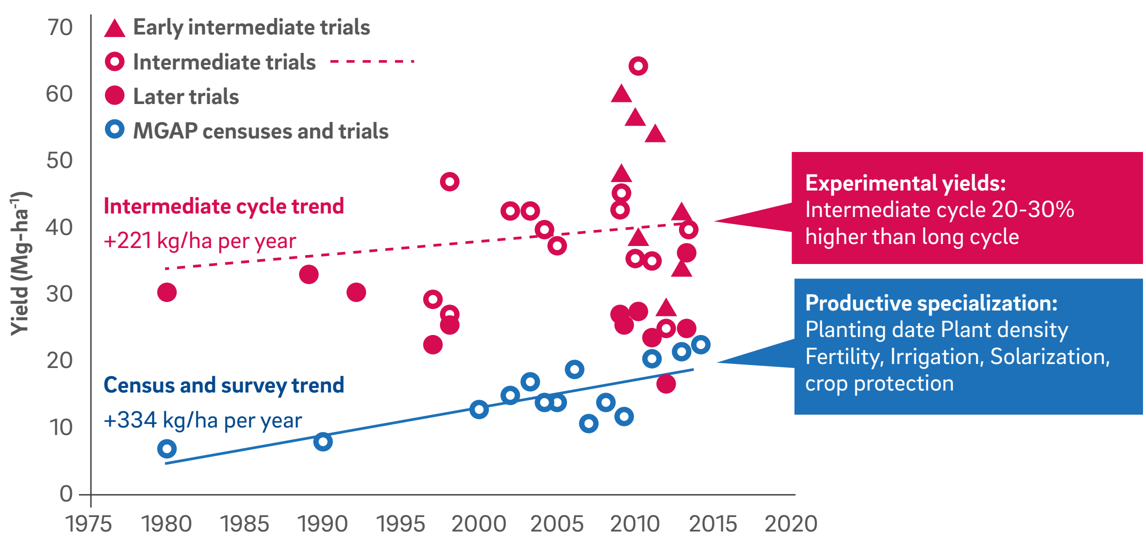
10. Assistant, Department of Science and Technology of Milk, Faculty of Veterinary Medicine, UdelaR.

Figure 9. Comparison of three onion varieties yields



Texas EG 502 (early), Pantanoso del Sauce (intermediate) and Valcatorce (late) yield, as a function of the average yield of each test (locality-year). Localities: (Br) Brunosol of CRS; (Ve) CRS Vertisol; (CG) Canelón Grande; (PS) Pantanosos del Sauce; (Br2) Brunosol 2 from CRS (Galvan et al. 2000).

Figure 10. Evolution of onion yields in experimental trials



Evolution of yields in experimental trials conducted at the Regional Center South and at INIA Las Brujas (red markers), and yields reported by the Agricultural Census and Production Surveys of the Ministry of Agriculture (MGAP) of Uruguay (blue markers).

its production. It primarily exports powdered whole milk (66%), powdered skimmed milk (8.9%), cheeses (18.8%) and butter (6.16%) (INALE, 2016). Most of the milk produced is destined for industrialization. The price of milk is defined by Hygienic-Sanitary quality (HS), evaluated by Bacterial Count (BC) and Somatic Cell Count (SCC). SCC is an indirect indicator of intramammary inflammation (sanitary quality), whereas BC provides information on the hygienic conditions under which the milk was obtained on the farm (hygienic quality). The incorporation of the cold tank in the 1980s (temperatures below 4°C), as well as mandatory pasteurization at the industrial level, are some of the strategies developed to control microbial growth in milk. This has made it possible to control the development of mesophilic microorganisms, but not other bacterial groups, such as thermoresistant, thermoduric and psychotrophic ones, which are difficult to control using these processes (Buehner et al., 2014). The latter also produce thermotolerant enzymes with an enormous potential for damage, affecting the quality of dairy products. That is why some countries (USA, 2004) have incorporated them as indicators of hygienic quality. In Uruguay, the latest HS quality data (January-August 2016) show values of 57,730 Colony-Forming Units (CFU)/ml for BC and 437,610 cells/ml for SCC (Colaveco, 2015). Between 2011 and 2013, a study was undertaken on farms in the NW region of the country, showing BC and SCC values below national and international requirements (Li et al., 2014) and emphasizing the importance of incorporating psychotrophic and thermoduric microorganisms into the control of hygienic quality (Grille, 2016). This demonstrates the permanent progress of milk research in the country, coupled with the maintenance of strict controls even in parameters that are not yet required at the international market level. Since 1995, there has been a National Milk Quality System, created in agreement among producers, industrialists and the state. Since its implementation, it has had a positive impact on the production of quality milk, which has been achieved mainly through economic incentives to the producer and constant updates on the limits of the BC and SCC of milk sent to the plant. In addition to quality, it is important to define when a dairy product is considered safe. By safety, the FAO (2004) means any risk, whether chronic or acute, that can make food harmful for consumer health. Food-safety concerns have focused on microbiological hazards, pesticides, improper use of food additives, chemical contaminants and adulteration. In Uruguay, the requirements for microbiological and physicochemical quality in dairy products are defined in the National Bromatological Regulation (Decree 315/994) (MSP, 1994). At the same time, there has been a National Biological Waste Program (PNRB) in the country since 1978, which controls medicines and environmental contaminants in food of animal origin (Decree 360/003). In dairy products, the following are controlled: bacterial-growth inhibitors, antibiotics (Chloramphenicol, Sulfas, Nitrofurans), anthelmintics, Phenylbutazone, aflatoxins, heavy metals (lead, Pl and Cadmium, Cd), organochlorine pesticides and organophosphates (MGAP, 2009). In order to build a national strategy on safety issues, the Food Safety Coordination and Planning Unit (UCPIA) was also created in the MGAP orbit in 2014. The place currently occupied by safety in core policies demonstrates the evolution of this issue in the country. Consumer demand for safe food with high nutritional quality, as well as natural (non-synthetic) functional foods, has increased in recent years. Since Uruguay has excellent conditions for the production of this type of food (basically pastoral-system), strengthening this production system will allow the production of dairy products with high added value, improving their perception as healthy food. Since safety is a clear attribute of competitiveness in the case of Uruguay, the challenge will focus on generating knowledge for risk analysis, strengthening capacities and training human resources in national needs.

4.2.3 Developing foods of high nutritional value from academia to the poultry farm. Multi-enriched eggs with DHA-Selenium

Ali Saadoun[11]

The development of a multi-enriched egg with DHA-Selenium was the result of a successful alliance between academia (UdelaR, Faculty of Sciences and Agronomy) and the productive sector (national poultry company), within the framework of competitive projects in the Promotion of Agricultural Technologies Fund (FPTA, INIA). Bird feed was used to produce an egg that contained eight times more DHA and twice as much selenium as a common egg. Since egg is a high protein food that is tasty and economical, which, when enriched, makes it possible to deliver DHA and selenium to consumers through a regular diet, this advance provides the opportunity to contribute to the nutritional quality of food, providing micronutrients

11. Full Professor, Animal Production and Pastures Department, Faculty of Agronomy and Physiology & Nutrition. Faculty of Sciences, UdelaR.

of which there is a clear deficiency in the Uruguayan diet (Observatory for Food and Nutrition Security, 2017). This food regains its place in a nutritionally intelligent diet, since the USDA (2016) discontinued the recommendation to limit the daily consumption of cholesterol to 300 mg. The latter has been the main obstacle to the consumption of eggs for half a century. The multi-enriched egg with DHA-selenium, a product of national scientific research, has been present in Uruguayan stores since December 2011 and bears the logos of the institutions that participated in this development.

5. Imporving Food Systems Efficiency and Value

5.1 Status of wheat and prospects for improvement

Daniel Vázquez[12]

Wheat (*Triticum aestivum*) is key to the Uruguayan food culture, to such an extent that it is the main energy source of Uruguayans' diet: 790 kcal per capita (OBSAN, 2017), approximately one-third of the total of a 2,400 kcal diet, and more than 80% of total cereal intake (INE, 2005). The volume of production fluctuated around the volume consumed (around 400,000 t per year) for decades until, during the last ten years, it increased to the point where Uruguay became consolidated as a net exporter, featured on the list of the top 20 exporters on several occasions, with a maximal production of 2 million t in 2011.

Uruguayan wheat's entry into international markets increased the demand for quality. The lack of vertical integration created a system in which the best wheat is not rewarded, causing marketing problems and penalizing prices. As a consequence, since the production peak in 2011, the area-under-cultivation and, consequently, production, has declined year after year, although a high exportable balance has been maintained. The industrialization of wheat means that complex quality requirements are created, and can be summarized in three broad groups. On the one hand, it is crucial to have good-quality physical grain, for which there has traditionally been a demand in Uruguay, without technical or commercial problems. On the other, good baking quality is required. The main limitation of national wheat is the protein content, which must be high, which cannot be achieved with the current production system unless economic incentives for fertilization for this purpose are encouraged. Last, like all food, it must be safe. Annual surveys have shown that, in this respect, the only limitation is the content of mycotoxins caused by fungal infections of the genus *Fusarium*. Given the importance of these infections, the country is at the forefront of research on how to minimize its effect. Nevertheless, in years with adverse climates, it is extremely difficult to obtain wheat without this problem.

5.2 Appraising local vegetables on the basis of their nutritional quality

Fernanda Záccari[13]

Uruguay produces more than 50 vegetables that are commercialized in the country's market, through production systems that promote the application of good agricultural practices. Potato, onion, pumpkin, sweet potato, tomato and carrot are the most important vegetables because of the weight and volume they occupy in the family food basket (OBSAN, 2017). Vegetables are a source of nutrients and antioxidants in the human diet, due to the vitamins, dietary fiber, minerals and essential oils they contain. Potatoes, sweet potatoes and squash, rich in carbohydrates, are also perishable and suffer loss of nutrients. Using tools that combine variety selection, ripeness status during harvesting, storage system and how vegetables are prepared contributes to reducing the loss of food and nutrients (Zaccari et al., 2015). In the Faculty of Agronomy (UdelaR), local cultivars are studied from a nutritional approach with the aim of contributing to food and nutrition security. A study of carrots adapted to local conditions showed that, in addition to being rich in minerals, they have provitamin A

12. Principal Investigator, National Program for Rain-fed Crops, INIA

13. Associate Professor, Postharvest Fruits and Vegetables, Faculty of Agronomy, UdelaR.

contents (6.1 mg of betacarotene/100 g) similar to that of foreign varieties (7.1 mg/100 g), despite their pale color, which are not affected by cooking (Zaccari et al., 2015). At the same time, a study on local pumpkin and sweet-potato varieties shows that they are richer in provitamin A (15 and 33 mg/100 g) in the fourth month (July) of conservation, whereas bioaccessible glucose (0.5-1 and 5-7.7 g/100 g cooked pulp) is maintained for prolonged periods of conservation (six months). The supply of provitamin A and available carbohydrates increases the nutritional interest of pumpkin and sweet potato, staples of the Uruguayan diet. Improving storage conditions to avoid high temperatures (12-14°C and 80% Relative Humidity, RH) reduces loss of quality up two times more than traditional preservation, without temperature and humidity control (Zaccari et al., 2015). Simple culinary practices for consumption *in natura* or with minimal processing are issues to be developed in a nutrition-sensitive approach to agriculture.

5.3 Fruticulture, status and outlook for climate variability

Milka Ferrer[14] y Gianfranca Camussi[15]

Eighty percent of fruit and vine production, concentrated in the southern part of the country, is focused on the domestic market, with 90% of production comprising three types of fruit: apples; peaches and pears. Average total production of the past three years is 630,000 t, which includes the production of citrus fruits, deciduous fruits, vegetables and potatoes. Grape production stands at approximately 90,000 t in 2017 with 5% being consumed as fresh grapes. The average volume of wine is 90 million liters per year (INAVI, 2012). On average, during the same period, 54,000 t of tropical fruits, including banana, and 26,000 t of fruits and vegetables were imported to complement local supply. Estimated fruit consumption in Uruguay is 245 g/day (OBSAN, 2017), below the amount recommended by the World Health Organization (WHO), the optimum being 400 g/day of fruits and vegetables, which is below average consumption in Europe (389.96 g/day) and above that of Chile (168.3 g/day). Wine, consumed in moderation, has been regarded as a food since ancient times, due to its energy contribution, a concept that is now being re-assessed from a health approach. It is an antioxidant due to its phenolic compounds, which protect against diseases related to aging. The beneficial effect of this beverage is associated with sustained consumption not exceeding 250 cc/day, equivalent to the WHO recommendation of a maximum of 30 g/day of alcohol in men and 20 g in women. Wine consumption in Uruguay is 27.5 L year (France, 38.5 L), 1/3 of the recommended limit.

In some years, the variability in production volume and quality of fruits due to the effects of the climate requires the importation of fruits and vegetables. Within the framework of the FAO-sponsored Project "New Policies for Adapting Agriculture to Climate Change-Response to Climate Change and Variability" (Ferrer et al., 2013), the chapter on Fruit Trees and Vines states that, for fruit trees, the insufficiency of low winter temperatures restricts the volumes produced. Longer-term mitigation strategies are proposed, rather than the current technologies available in the country (costly and not 100% effective), based on the use of varieties with low cold requirements. This is mainly possible for peaches, while the varieties internationally available for apples, whose fruit production is of good quality, have medium-to-high cold requirements. The models for probable climate-change scenarios indicate the possibility of an increase in precipitation in spring and summer, average monthly temperature, the number of days with temperatures over 30°C and the more frequent occurrence of extreme events. These predictions will heavily influence the occurrence of pests and diseases. In fruit trees, insects with tropical behavior, such as the fruit fly (Ceratitis capitata Wied) and apple scab (Venturia inaequalis FP), are observed more frequently and earlier during the growing season. Vines have experienced cluster rot (Botrytis spp., Alternaria spp., Aspergilus spp., Penicillum spp.), which affects the quality, safety and useful life of wine, which in turn leads to lossof-yield. There is a need to generate

14. Full Professor, Department of Plant Production, Faculty of Agronomy, UdelaR

15. Associate Professor, Department of Plant Production, Faculty of Agronomy, UdelaR.

products that take into account the environmental impact and consumer health such as: knowing the predisposing conditions of pests and diseases, using cultivation techniques that minimize the use of phytosanitary products, having proper machinery for their application, keeping records of the correct use and dose of permitted phytosanitary products, respecting the waiting times between applications and use, training staff to apply them, incorporating natural biodegradable products, and biological control. In the long term, it is essential to introduce and test disease-resistant varieties, in order to reduce phytosanitary applications. Another result related to climate variability is the need to rethink the current technological package: instead of making irrigation a priority (60% of the irrigated area for fruit trees), attention should focus on the choice of the site to be planted, its topographic location and building good drainage, while irrigation would, in this case, be used to supplement occasional water deficits. The chemical composition of grapes is strongly negatively associated with temperature and positively associated with precipitation, which raises the need for changes in the management of winemaking and alteration in the typicity of the variety.

5.4 Ecological intensification of livestock in Uruguayan native grasslands

Pablo Soca[16]

Livestock systems on native grasslands are the main economic and social activity of agriculture in Uruguay. The native grasslands constitutes 90% of fodder resource and provides ecosystem services such carbon sequestration, reduction of GHG emissions, water regulation and nutrient dynamics. In recent decades, and in order to intensify the production of foods with a human destiny, native grasslands systems have suffered increases in animal stocking rate and the expansion of afforestation and soybeans. Meat production and average weaning rates in the native grasslands were lower than the potential - 70 kg of meat/ha/year versus 200 kg of live weight/ha/year (Do Carmo et al., 2016). Feeding rates, averaging 63% over the past 10 years, could reach 80-85%. These indicators are explained by low energy consumption, which determines a negative energy balance (BEN), poor body condition (CC) at calving, a long period of postpartum anestrus, a low probability of pregnancy and a live weight of calves at weaning (150 kg). Production levels explain livestock with poor economic results, vulnerable to climate and economic changes, and with a limited capacity to compete with agricultural and forestry incomes, compromising the long-term sustainability of livestock. Achieving the greatest amount of animal product-per-unit area, with the lowest cost and economic risk possible, without damaging natural resources, has been the central objective of the line of research on the native grasslands (Do Carmo et al., 2016). Native grasslands are the main productive opportunity to ecologically intensify livestock and guide the increase in production with quality, capture value and improve livestock competitiveness and sustainability. Controlling grazing intensity is the main tool for simultaneously improving the uptake, use and conversion of solar energy to animal products, in order to improve the physical and economic competitiveness of the meat chain (Carriquiry et al., 2012; Do Carmo et al., 2016). Its effect on the energy flow is expressed through the Fodder Supply (FS) (kg DM / kg LW).

This was the basis for the design of experiments to study the effect of changes in the fodder supply and the Genetic Group (GG) of cows on primary productivity, and the use and efficiency of energy use for livestock raising in the native grasslands. Two FS treatments were used: High (HFS) and Low (LFS) treatments (10 vs. 6 kg DM/100 kgLW/day on average, HFS vs. LFS, respectively) as well as cows from two GG (pure: Aberdeen Angus and Hereford and crosses: their respective crosses, F1, Pure (PU) vs. Cross (CR)). A change from LFS to HFS increased the amount of fodder (50%) and fodder production (30%) without modifying the animal load, as well as improving reproductive efficiency, weaning weight and meat production per hectare (Do Carmo et al., 2016). CR cows were productively and reproductively superior (heterosis) to pure cows

16. Full Professor, Animal Production and Pastures Department, Faculty of Agronomy, UdelaR.

(Angus and Hereford), particularly so in restrictive environments (LFS) (Do Carmo et al., 2016). It is possible to double meat production by unit--of-area in Uruguay and contribute to the design of production systems that combine diversity and economic factors. This confirms that there is enormous scope for physically and economically viable intensification for Uruguayan livestock, with no changes in financial resources. This route will be synergistic with the rest of the meat chain since it will encourage the reduction of the production cost per kilo of product, the use of the "denomination of origin" tool and improvements in the sustainability of the productive apparatus. This will allow us to move toward "precision farming" and plan a future where food production is linked to technology.

5.5 Valorizing the pastoral meat chain within a nutrition and health paradigm

María Cristina Cabrera and Ali Saadoun

Foods of animal origin have accompanied humans throughout their evolution and have been associated with the intellectual development of hominids and the differentiation from their ancestors. Nevertheless, some philosophical currents recommend eliminating meat in favor of a strictly plant-based diet. That would ignore the contribution of food of animal origin to human development. Two million years ago, the first humans added game meat, bone marrow and aquatic animals to their diet, and there is convincing scientific evidence that this food innovation caused brain weight growth of 350 g to 1,350 g. The acquisition of cognitive abilities is associated with the main components of the brain, such as docosahexaenoic acid, haem iron, selenium, zinc and vitamin B12. Meat and animal foods are the main source of haem iron, zinc and vitamin B12. Their deficiency in the diet causes serious deficiencies of global importance and are the main cause of anemia incidence in children, adolescents and pregnant women worldwide and in Uruguay (WHO/OPS, 2016; Food and Nutrition Security Observatory, 2017). Since its introduction into America, beef has been a very important food which, in Uruguay, accompanies the local population in several expressions of everyday life. Uruguay produces 1% of the meat consumed worldwide, ranking 23rd in the world's producing countries. It consumes the third largest amount of beef worldwide (58.6 kg per capita) and is the sixth largest beef and sheep-meat exporting country (USDA, 2016). Despite the abundance of this food, there is a proportion of the population that lacks access to it. This is due, on the one hand, to their low purchasing power and the high cost of meat for the domestic market and, on the other, to changes in food patterns and consumer perception of animal well-being.

The importance of lean, good-quality meat in a modern, varied and balanced diet is indisputable because it is a complete food, which not only provides proteins with a high biological value, but also essential micronutrients. Meat is the main source of bioavailable haem iron and zinc iron (Cabrera and Saadoun, 2014) and helps maintains optimal body weight. In children, the contribution of haem iron makes it possible to meet the requirements of optimal cognitive development, impacting learning capacity and future intellectual development. It is a rich source of peptides associated with maintaining muscle mass and delaying aging. Since meat differs in its nutritional composition depending on the type of feed cattle are given, it has been suggested that a pasture-based production system creates meat with better nutritional indicators (lipids, fatty acids, minerals, vitamins) and higher resistance to oxidation (Cabrera and Saadoun, 2014; Trevino et al., 2015). Considering today's consumer, meat from pastoral systems would be better positioned because of its nutritional quality, in addition to other attributes that include environmental and social sustainability, and animal welfare. Within the scientific sphere, and with the aim of recovering consumers who practice a flexitarian diet both within the country and in markets that purchase Uruguayan meat, research has been conducted to describe beef from pastoral systems from a nutritional point of view. The strategic objectives sought are as follows: revalorize the Uruguayan pastoral meat chain within a nutritional value paradigm, and valorize cuts by relating cost to the specific contribution of nutrients, in order to obtain accurate, sustainable nutrition for children, adolescents, expectant mothers and senior citizens. Our study attempts to contribute to the food policies of a country where, although the quantity of food is sufficient for the population, some people, especially children, do not have access to sufficient amounts of meat (WHO/OPS, 2016). Meat from pastoral systems provides the main essential minerals. A 100-gram serving covers 100% of selenium requirements, between 8% and 60% of iron and between 21% and 145% of zinc requirements, considering adults and children. Each cut presents a particular mineral profile, which would allow meat intake to be adapted to specific iron, zinc or selenium needs (Cabrera and Saadoun, 2014). Meat from pastoral systems also contains more creatine (4.308 vs. 3.588 mg/kg) and carnosine (3.877 vs. 3.162 mg/kg) compared to feedlot beef in Uruguay (Cabrera, et al., 2015). These peptides are considered part of the so-called "meat factor": they promote the absorption of non-haem iron from plant foods, increasing the nutritional value of a mixed meal, even it only contains few grams of meat. As for lipids, meat from pastoral systems is richer in linolenic acid (C18:2n3), DHA and CLA, and has less palmitic acid (C16:0), an atherogenic fatty acid, compared to that from cattle fed on concentrate (Saadoun and Cabrera, 2015). Moreover, meat from pastoral systems has high levels of β-carotene and α-tocopherol, which explains the antioxidant capacity of this meat, despite its higher profile in unsaturated fatty acids (Saadoun and Cabrera, 2015). These studies provide information for precision nutrition and the rational use of an expensive food, as well as for the evaluation of pastoral production systems. If we regard meat as a sustainable way to fight anemia and micronutrient deficiencies, the challenge for the next years will be to expand detailed knowledge of the nutritional composition of the meat, considering breeds, type of pasture and type of cut as well as the changes brought about by technological processes.

5.6 The case of the Uruguayan dairy industry

Pablo Chilibroste[17]

In response to the changes in the conditions of competition with other agricultural activities and the increase in land prices (DIEA, 2011), the Uruguayan dairy industry has steadily increased its productivity. In recent decades, the Uruguayan dairy sector has grown at a rate of 5% per year (DIEA, 2009). This sustained pace of growth has accelerated in the last six years with growth rates of 7% per year (INALE, 2016). This growth has mainly been based on productivity increases (liters per hectare), as the dairy area has decreased by 10% during this period (DIEA, 2009). Productivity per cow is the factor that accounts for a greater proportion of growth (>60%), while the increase in animal load explains 25-30% of the sectors productivity increase. This strategy for intensifying milk production in Uruguay has been based on a significant increase in the use of concentrates and fodder reserves (DIEA, 2009), while the direct harvest of fodder by livestock has remained largely unchanged (Chilibroste et al., 2011).

This model of Uruguayan dairy intensification has been extremely demanding with respect to the levels of investment required for feeding processes (Mixer, feeding beaches), milking capacity, infrastructure (road, corrals, irrigation), effluent management and livestock management. Estimates made in the Conaprole cost project (Artagavéytia sp.) show that in the last three fiscal years, between 50 and 75% of capital income from dairy farms has been re-invested in assets (infrastructure and animals). The intensification process has also led to major changes in the area of human resources, significantly increasing the demands of qualified human capital and the levels of complexity in the organization of work. Difficulties in accessing and subsequently retaining skilled labor are one of the first constraints experienced by milk producers on sustaining future growth and/or introducing innovations in systems (ANII Innovation Survey, 2013). The problem of training human capital affects the entire dairy chain (as it does other agri-food chains). In general terms, the intensification process has resulted in production systems with higher productivity levels, improved economic performance, better levels of conversion efficiency (liters of milk produced/kg DM consumed), higher unit production costs, investment, increasing levels of complexity and greater pressure on natural resources.

17. Professor, Animal Production and Pastures Department, Faculty of Agronomy, UdelaR.

The most intensive production systems remain extremely competitive at the international level, with Uruguay achieving the lowest international milk-production costs (IFCN, 2013). The low cost of production of Uruguayan systems is explained by the fact that fodder (direct harvest plus reserves) continues to account for a relatively high share of animal feed (Chilibroste et al., 2011). Redesigning systems requires changes in feeding strategy, animal management and pasture. Evaluating how response variables are affected by modifying these aspects is a matter of concern for the dairy industry. The analysis of the problem must include the fact that Uruguay is a net exporting country (more than 60% of the milk produced), meaning that aspects related to the quantity and type of solids produced, animal health and welfare, waste management (in the milking hall and feeding beaches) and controlling production costs are central to the competitiveness of production systems and the dairy chain as a whole.

It is necessary to lay the foundations and produce the necessary tools to study the efficiency pillars – broad, integrated aspects - of production systems, and generate knowledge about the main components that make the system competitive. The problem is complex and the research undertaken has tended to focus mainly on improving food to maximize production. There has been a predominance of reductionist approaches in the absence of an integral vision of the problem and, in general, without integrating actors from the primary sector of the dairy industry. Information has not reached the productive sector in time, or rather, has been used to provide guidelines that do not make it possible to predict the behavior of the production system as a result of strategic decisions. In response to these demands, over the past two years, Sectorial Innovation Networks have been created in conjunction with academia and the productive sector to provide solid answers based on scientific information from larger-scale experiments, commercially obtained and experimental data, working in a network with professionals who provide commercial services. The proposal implies a methodological change in the type of partnership between actors in the sector to jointly undertake functions in research and outreach.

6. Health Considerations

Carmen Marino Donangelo[18]

6.1 Foodborne diseases

Food safety is a global public health concern since the incidence of foodborne diseases is increasing in many countries, particularly in industrialized countries (WHO, 2015). Although recent changes in primary food production and technological processing, preparation and preservation have generally resulted in better control of the most common food and waterborne diseases - such as typhoid fever, tuberculosis and brucellosis - new practices in farm and agricultural production and the increased time required in the food distribution chain have led to the emergence of new foodborne pathogens such as *Escherichia coli* O157, *Campylobacter jejuni*, *Salmonella enteritidis*, *Listeria* and *Vibrio cholera*. These changes have also increased the risk of food exposure to antibiotic-resistant pathogens, such as *Salmonella typhimurium* DT 104, different noroviruses and rotavirus, agents that cause transmissible encephalopathies (prions) and chemical residues and contaminants originating from the environment and/or agricultural and industrial practices (mycotoxins, persistent organic pollutants, heavy metals). In addition, modern lifestyles are increasingly dependent on the availability of convenience foods, which may contain ingredients from various parts of the world and involve more time between preparation and consumption, which contributes to increasing the risk of foodborne disease.

Food safety is a key aspect of food security since all food available for consumption should be safe. At the international level, WHO and FAO have established global food-safety standards through the Food Codex Commission to harmonize the food-safety legislation of various countries for the whole world and facilitate international trade (WHO/FAO/CODEX).

Uruguay has national regulations to control the safety and quality of food and food products (National Bromatological Regulation, 1994) and to ensure plant biodiversity and biosafety (Decree,

18. Full Professor, School of Nutrition, Clinical Hospital, UdelaR.

2008). The actions related to compliance with these regulations are undertaken by the Ministries of Public Health (MSP) and Livestock, Agriculture and Fisheries (MGAP), the National Meat Institute (INAC), the Uruguayan Technological Laboratory (LATU), Municipalities and other state institutions. There is coordination and integration among the actions of the various institutions, especially with regard to monitoring and compliance with international standards (FAO, 2011).

Ensuring food safety is a high priority for Uruguay, both for national public health goals and for food exports. Indeed, the incidence of foodborne diseases is extremely low in the country, with less than 400 cases per year, 30% of which involve salmonella (WHO/OPS, 2016, MSP, 2016). Prior to 1994, *S. typhimurium* was the serotype most frequently isolated in outbreaks of salmonellosis; from 1997 to 2004, *Salmonella enteritidis* was the most prevalent serotype, but as of 2005 there has been a dramatic reduction in the number of cases related to both serotypes (Betancor et al., 2010). The World Organization for Animal Health has certified Uruguay as a country free of foot-and-mouth disease with vaccination and free from bovine spongiform encephalopathy (International Organization of Epizootics).

Regarding the presence of pesticide residues in food in Uruguay, a report from the Municipality of Montevideo corresponding to the analysis of 831 samples of fruits and vegetables, including fresh, frozen and juice samples, indicated that 2% of the samples had concentrations above the *Maximum Residual Limit* (MRL) established by CODEX (IMM, 2012). These results are in line with the European Union' 2013 report on pesticide residues in food imported into Europe from different countries, where 1.4% of the samples from Uruguay are above the CODEX MRL, a much lower percentage than that of other countries in South America.

6.2 Chronic non-infectious diseases related to food consumption and dietary habits

The health and well-being of populations depend on the complex interaction among socioeconomic, environmental and lifestyle factors, among which food intake and nutrition play an important role. In most countries, overweight, especially when associated with low physical activity, increases the risk of Chronic Noncommunicable Diseases (NCD) such as obesity, metabolic syndrome, cardiovascular disease, type 2 diabetes and certain types of cancer. Smoking, stress and alcohol abuse are also important factors involved. These diseases are generally characterized by an excessive intake of macronutrients or an insufficient supply of micronutrients. Therefore, overconsumption of food often coexists with vitamin and mineral deficiency, and the low intake of bioactive components of healthy food protectors (WHO, 2015). Non-Communicable Diseases (NCD represent the main cause of morbidity and mortality in Uruguay (WHO/OPS, 2016). In 2014, the total mortality rate (per 100,000 population, adjusted for age) was 402.5 for NCD, 38.6 for infectious diseases and 57.4 for other causes. Key information to the general health of the Uruguayan population is that life expectancy in 2016 was 77.5 years (73.9 years for men and 80.9 for women). Two national surveys conducted in 2006 and 2013 by the Ministry of Public Health evaluated the prevalence of major risk factors (metabolic, behavioral, lifestyle) associated with NCD in the urban adult population in Uruguay. In the 2013 survey, younger individuals (≥15 years) were also included. The most recent data (2013) indicated that the prevalence of overweight (Body Mass Index, BMI ≥25 kg/m^2 and <30 kg/m^2) was 42.1% in males and 32.7% in females, while the prevalence of obesity (BMI ≥30 kg/m^2) was 26.0% in men and 29.2% in women. The combined prevalence of overweight and obesity was greater at a higher age range regardless of gender: 78.1% in the 55-64 year range compared to 38.5% in the 15-24 year range. The combined prevalence of overweight and obesity in adults increased by 8.1% from 2006 to 2013.

A recent survey (MSP/PPENT, 2016) indicated that the prevalence of hypertension in adults was 40.4% in men and 33.1% in women. The prevalence of hypertension by combining genders was higher in the higher age range, 62.8% in the 55-64 year range of compared with 8.7% in the 15-24 year range. In adult population, the prevalence of hypertension increased 6.0% from 2006 to 2013. In the same survey, high blood cholesterol (≥200 mg/dL) was observed in 22.1%

of adult men and in 20.9% of adult women. This prevalence increased with the age range, from 8.6% in the 15-24 year range to 35.0% in the 55-64 year age range. Similarly, the prevalence of high levels of fasting blood glucose/diabetes was higher in the 25-64 year (11.1%) than in the 15-24 year (2.0%) range. Considering behavioral and lifestyle factors, the prevalence of daily smoking in 2013 was slightly lower in adult women (25.4%) than in adult men (32.5%), and even lower (16.7%) in younger individuals (ages 15-24). On the other hand, the prevalence of habitual alcohol consumption was 37.4% and 64.2% among adult women and men, respectively, with higher prevalences in the younger age groups (48.8% and 40.2% in men and women, respectively, ages15-24 years). Low physical activity was present in 18.5% and 24.5% of men and women, respectively, with no variations by age range. The addition of salt to prepared meals was observed in 21.6% of adults (25-64 years) and in 32.4% of younger individuals (15-24 years). Insufficient daily consumption of fruits and vegetables (less than five servings per day) was present in 92.2% of men and 89.1% of women, with no significant differences by gender or age. The prevalence of three or more concurrent risk factors (metabolic and behavioral) was 47.2% and 39.9% in adults (25-64 years) and 12.6% and 17.5% in the youngest age group (15-24 years) in men and women, respectively.

In these national surveys, information has been obtained, albeit limited, on the nutritional status and dietary habits of the Uruguayan population. However, no attempt has been made to establish associations between nutritional/food information and the presence of risk factors for CNCD.

In a different national survey conducted in urban and rural Uruguay, household expenditures were assessed in different areas, including expenditure on the purchase of food and beverages (Bove and Cerruti, 2008). The information made it possible to estimate average values of daily apparent consumption of food and beverages, stratified by household income levels. Given that aspects such as food waste and intrafamilial distribution within the household were not considered, the results obtained represent per-capita averages of apparent consumption of food and beverages in the population rather than consumption at the individual level.

Considering the results as a whole, it was estimated that approximately 50% of energy consumption from food and beverages comes from the combination of baked goods, refined cereals, fats and oils, 13% from meats - especially red meats - 9% from milk and dairy products, 8% from fruits and vegetables, and 12% from sugar and sugary drinks. In general, typical foods consumed in the country (processed grilled and fried meats, dairy products, breads and pastries, potato chips) promote exposure through the diet to animal protein, simple sugars and starch, saturated fat and trans-fatty acids.

In urban households, the highest values for average per-capita consumption were observed for milk and dairy products (360 g/day); breads, pastries and refined cereals (260 g/day); sugary beverages (138 g/day); and meats, cold cuts and sausages (123 g/day). Very low consumptions were observed for fish (8 g/day) and legumes (5 g/day). On the other hand, consumption of yerba mate (25 g/day) was higher than that of coffee (2 g/day). Indeed 80% or more of the population consume maté (an infusion prepared from the leaves of the Ilex paraguayensis plant), averaging about half a liter per person per day (MSP/PPENT, 2016).

Average per-capita consumption was higher in rural than urban households for milk and dairy products (530 g/day); breads, pastries and refined cereals (313 g/day); (35 g/day), but similar for fruits and vegetables (220 g/day), legumes (6 g/day), fish (5 g/day), fats and oils (38 g/day) and alcoholic beverages (45 g/day).

Household income level was a very important factor that affected the populations per-capita consumption of food and beverages. Households in the highest-income quintile had lower intakes of refined grains, higher consumption of fruits/vegetables and fish, and more frequently selected lean meat cuts compared to households in the lowest-income quintile. Total consumption of energy, sugary desserts and beverages, and alcoholic beverages was also higher in households in the highest-income quintile. Moreover, these households had higher consumption of foods with high total fat and cholesterol. In contrast, households in the lowest income quintile had the lowest consumption of dairy products and lean meats.

Regardless of the household income level, average apparent consumption of food and beverages by the Uruguayan population seems to cover the nutritional requirements of protein and certain micronutrients such as niacin, riboflavin, folate and vitamin B12, yet appears to be insufficient in terms of fiber, vitamin C, vitamin A, vitamin E, potassium and calcium.

6.3 Nutrition and child development

Optimal growth and development from conception to early childhood are well-recognized necessary conditions for ensuring health and well-being from the earliest years of life to adulthood. Interactions between genes and adverse environmental factors such as under- or overnutrition during the early stages of embryonic and fetal development may predispose to chronic degenerative diseases in the later stages of the life cycle (Barker, 1990). Information on dietary intake and nutritional status during pregnancy, lactation and early childhood is therefore crucial to public health.

A recent survey in Uruguay (ENDIS, 2015) was the first to simultaneously assess the nutritional status, health conditions and development of children under 4 nationwide. Information on the income level and educational attainment of families, child-raising practices and total number of persons per household were also examined.

As a general result, it was observed that overcrowding was present in 25% of households, especially those below the poverty line (44.5%), and that the father figure was absent for 20% of children. Pregnancies were unplanned in approximately 50% of cases. Smoking and alcohol consumption were present in 16.7% and 11.4% of pregnant women, respectively, particularly in adolescent mothers and those with lower educational attainment. Less than half the women (39%) received prenatal iron and folic-acid supplements during pregnancy. The prevalence of low birth weight (<2,500 g) was 7.7% while the prevalence of prematurity was 10.7%, with no differences due to maternal age or geographical location.

Stunted growth (height-for-age Z score ≤2) was present in 4.5-5.0% of children, mainly in households below the poverty line (6.7%). Overweight was found in 9.6% and 11.3% of children under 2 and between 2 and 4 years, respectively. Obesity was present in 1.9% and 2.1%, respectively, in the aforementioned age groups. The prevalence of reported anemia was 9%, especially high in children of households below the poverty line (13.1%). In a previous survey of children under 2 in public and private health services, there was a higher prevalence of clinically diagnosed anemia (31%) and stunted growth (10.9%), yet a lower prevalence of overweight and obesity combined (9.5%) (Bove and Cerruti, 2011).

Food insecurity assessed in the ENDIS survey (ENDIS, 2015) through the ELCSA scale (FAO, 2012) indicated that 4.3% of children live in severely food-insecure households, and that 8.9% live in households with moderate food insecurity. In general, children's food intake was low in fruits, vegetables and fish, and included excessive amounts of snacks and sweets. In more than 50% of households, salt was added to foods for children under one year. About 20% of children did not consume water when thirsty, and instead drank processed juices or beverages, particularly in lower-income households.

7. Policies that contribute to food and nutrition security

María Cristina Cabrera

7.1 Comparative advantages in agriculture: competitive yet vulnerable

Uruguay has comparative advantages in agriculture, with a food-production capacity for 30 million people. However, due to the productive specialization of the Uruguayan economy, based on the production and export of primary products with low added value, the country has a risk of vulnerability. The United Nations Common Country Analysis (CCA) warns of the risk of this economic model, which is vulnerable to alterations in world markets, weakens sustained growth and generates negative conditioning in the population¿s economic expectation levels of investment and technological innovation, as well as a propensity to migrate among people of high educational attainment, all key factors for sustaining long-term growth. Comparative advantages are an opportunity to invest in added value and transformation with innovation, strengthening existing agroindustrial chains and creating knowledge-intensive activities. The ultimate goal, according to FAO, is to use environmentally sustainable natural resources, reduce regional disparities in per-capita income levels and develop nutrition-sensitive agriculture.

7.2 Policies that promote technological innovation through skilled human capital

The specific public policies Uruguay launched in 2005 created a new institutional framework for innovation (Ministerial Cabinet of Innovation and ANII) to promote an "innovative Uruguay". Within this framework, innovation is promoted by strengthening and orienting strategic areas, such as the agricultural and agroindustrial sector, through value chains, and generating instruments to strengthen human capital (National System of Researchers, Scholarship Programs, Tertiary Technical Training and National Graduate Programs). Innovation is stimulated through specific R&D&I programs, clusters, innovation consortia, poles and technology parks, innovation in companies and various programs linked to the productive sector, with public funding from UdelaR and ANII. There are a number of aims: training of highly skilled human resources; strengthening of consolidated researchers who contribute to the efficiency and competitiveness of productive resources, with less deterioration of natural resources, more social inclusion, and effective linkage with all aspects of the business and productive environment.

7.3 Policies that promote the consumption of healthy foods

With regard to Food and Nutrition Security policies, actions have been more recent and intended to palliate serious situations arising from the poverty and extreme poverty recognized as existing in the country (ENDIS, 2015). Although the educational attainment of the Uruguayan population is satisfactory, their knowledge, attitudes and eating habits are deficient, meaning that nutritional education programs for the entire population should urgently be undertaken to achieve a healthy diet. In recent years, fruit and vegetable consumption promotion programs have been carried out, with the participation of several institutions -INIA, Rural Montevideo, Mercado Modelo, MGAP (2010-2012) and healthy snacks for school cafeterias (MSP, 2014). Moreover, as a result of inter-agency actions, Food Based Food Guidelines (GABA, 2005; 2016) have been published. In 2013, Health Law 19.140 was promoted at Education Centers, which seeks to contribute to the prevention of overweight and obesity, high blood pressure and chronic noncommunicable diseases linked to poor eating habits and a sedentary lifestyle. It was established that salt shakers would not be available in school cafeterias, as a way to discourage salt consumption. MSP and MIDES, through Uruguay Grows with You and the INDA Food Institute, are working to design strategies to promote healthy habits, since 30% of the food consumed in the country is ultraprocessed, which has led to high obesity and overweight rates. High prices of food such as fruits, vegetables, meats and fish make it difficult to include them in the daily family diet (Barboza, 2007). The challenge is to create public policies for food education and standards for the regulation of ultraprocessed products, as well as labeling that reflects not only the composition of prepared foods (which already exists), but also provides information about the characteristics of the food. Another challenge is to be able to influence prices to achieve greater access to quality food.

7.4 International trade in Uruguayan meat: an interesting case for economic development with equity

Pablo Caputi[19]

Uruguay produces between 550 and 600 thousand t epc of beef per year that are not absorbed by domestic consumption, generating 400 thousand t epc for the international market.

The Markets. The main destination of Uruguayan meat is Europe, the U.S., Russia, China, Israel and Mercosur. Brazil and Argentina are specific markets, while Chile, a net importer, is able to purchase large volumes. Europe was the first natural destination for the continent linked to the industrialization of meat in Uruguay in the 19th century (Liebig Company) until its retraction after World War II. Today there is a regular flow linked

19. Manager, Knowledge Manager, INAC.

to quotas or tariff quotas (from the exporting country or importing bloc), such as the Hilton Quota (6,300 t of valuable cuts) and a very interesting alternative, the so-called quota 481 (or HQB, High Quality Beef). This quota has several strategic advantages: no tariff is paid; nearly all cuts are placed and business is conducted with pre-defined prices. Israel, a consistently solid market, imports 25 to 30 thousand t epc. The two destinations (Europe and Israel) account for 25% of the total amount exported.

The U.S. was an interesting market until the foot-and-mouth disease crisis (2000/2001) and once again in 2004, when it changed its safety policy and allowed Uruguay to export deboned and matured meat. Russia subsequently emerged as a key buyer because of its enormous economic power. The Uruguayan industry showed great flexibility in interpreting movements in markets, redirecting the product to the market that paid most. In recent years, China has emerged in the world beef market, as a strong buyer of all species. It is Uruguay's main importer, accounting for over 45% of the total volume in 2016. The main markets (China, the U.S., Europe, Israel) import 80% of the total. The other 20% is placed in the rest of the world, with no tariff preferences and major logistical disadvantages of localization in comparison with competing countries (such as Australia and New Zealand in the Asian markets). Uruguay has created a strategy of penetration of the country, supported by a rich, relatively complex institutionality that suits the needs of this trade.

The insertion strategy. The organization responsible for setting agricultural policies in Uruguay is the Ministry of Livestock Agriculture and Fisheries (MGAP). For the specific case of meat, MGAP has access to the advice and executive capacity of the National Meat Institute (INAC). This body is a public non-state person, with a mixed Board of Directors: three cattle-rancher delegates, three industrialist delegates, two delegates from the Executive Branch (the president is appointed by the MGAP). In addition to this Board of Directors, INAC has a specialized body of technicians responsible for the main aspects related to the business: Internal Commercial Control (particularly in exports); Information and Economic Analysis, Marketing in both the domestic and international markets and, more recently, the so-called knowledge function, which seeks to accelerate innovation processes in the chain.

Access to the world's markets requires fine-tuning the country's political and commercial priorities, for which coordination with the Foreign Ministry is essential. Thanks to this joint action among MGAP, the Foreign Ministry and INAC, all the world's markets (with the exception of Japan's, which is about to open) have been opened for deboned and mature beef. The so-called "aphasic circuit" ceased to be a non-tariff barrier, thanks to the action of Uruguay, which leads this process.

The biggest constraint for Uruguay is the lack of trade liberalization agreements. It has been estimated that for beef alone, approximately $200 million USD are paid in tariffs, which shows the scale of the problem. Advances in health aspects must be accompanied by advances in the field of international trade, to prevent a weakening of the country's current position.

The future road. Uruguay has 100% of its cattle identified electronically, in a system controlled by MGAP (National Livestock Identification System, SNIG). It is linked to another system of industrial traceability that controls 100% of the meat produced, which in turn is run by the INAC (Electronic Information System of the Meat Industry, SEIIC). It also adapts to demand by creating animal welfare programs and protocols. All this shows the confidence global consumers can have in Uruguayan meat, as a result of the following: natural production, mostly on natural pastures, open air, with an abundance of water and shade, with a law prohibiting the use of hormones and antibiotics as growth promoters. For this reason, the slogan for meat marketing is "We pack nature, we sell trust". However, these marketing supports do not suffice: today's consumer wants more. That is why efforts are being made to improve the sustainability of the entire process, by measuring and demonstrating the fact that Uruguayan meat is indeed sustainable. There are therefore several projects underway. It also attempts to attack specific consumer niches, emphasizing the nutritional aspects of the country's meats that have specific profiles due to their strong pastoral content. Cattle are derived from good British stock (Angus, Hereford), a strength that can be leveraged. Last, all the information incorporated into the chain must be summarized in order to be a useful by-product to sell in the future. The challenge and the opportunity are to sell a meat product with added value, and the engineering and the know how that enabled it to be obtained. Perhaps this is the largest contribution livestock can provide to Uruguay in its path toward sustainable and equitable economic development.

8. Final Considerations

Uruguay has increased its agricultural production over the past 30 years based on productivity increases, yet at the cost of losing part of its resources (soils, water quality), issues that the country will prioritize on its agenda over the next few years.

The abundance of food in the country, and in the region as a whole, fails to reach part of the population, which displays significant nutritional deficiencies, reflecting unequal access to food, either as a result of prices or distance. Other factors with an impact on the population are changes in dietary patterns. The prevalence of protein-energy and micronutrient deficiencies is similar to that of overweight and obesity in young individuals, meaning that specific policies are required to reverse the current food and nutritional security situation.

In order to reduce the risks and vulnerability of Uruguayan agriculture and its impact on Food and Nutrition Security (FNS), policies should be adopted to improve the competitiveness and integration of value chains, as well as to improve food safety and quality. It will therefore be necessary to establish policies for land management, planning and management of natural resources and biodiversity, as well as for the diversification of agricultural and agroindustrial production, which will increase added value and make it nutrition-sensitive. At the same time, local rural-development policies that contribute to FNS should also be promoted.

References

Barker, D.J. (1990). The fetal and infant origins of adult disease. British Medical Journal, 301 (6761): 1111.

Becoña, G.; Astigárraga, L.; Picasso, V. (2014). Greenhouse gas emissions of beef cow–calf grazing systems in Uruguay. Sustainable Agriculture Research, 3 (2):89-105.

Berretta A., Condón F., Rivas M. (2007). Segundo informe país sobre el estado de los recursos fitogenéticos para la alimentación y la agricultura. https://goo.gl/sHZkts

Betancor, L.; Pereira, M.; Martínez, A.; et al. (2010). Prevalence of Salmonella enterica in poultry and eggs in Uruguay during an epidemic due to Salmonella enterica serovar enteritidis, J. Clin Microbiol, 48 (7): 2413-2423.

Bonnecarrère; V.; Garaycochea S.; Fernández S.; Rosas J.; Quero G.; Pérez de Vida F.; Blanco P.; Gutiérrez L. (2014). Genome-wide association mapping in rice for yield and grain quality. Plant and Animal Genome Conference, San Diego, CA, USA.

Bove, M.I. y Cerruti, F. (2011). Encuesta nacional sobre estado nutricional, prácticas de alimentación y anemia en niños menores de dos años, usuarios de servicios de salud de los subsectores público y privado del Uruguay. Montevideo: UNICEF, MSP, MIDES, RUANDI.

Bove, M.I. and Cerruti, F. (2008). Los alimentos y las bebidas en los hogares. Encuesta Nacional de Gastos e Ingresos 2005-2006. Instituto Nacional de Estadística. 2008

Buehner, K.; Anand. S.; García, A. (2014). Prevalence of thermoduric bacteria and spores on 10 Midwest dairy farms, Journal of Dairy Science, 97: 6777-6784.

Cabrera, M.C. and Saadoun, A. (2014). An overview of the nutritional value of beef and lamb meat from South America. Meat Science 98, 435-444.

Cabrera, M.C.; Terevinto, A.; Zaccari, F. y Saadoun, A. (2015). Creatina, carnosina y anserina en el músculo Longissimus dorsi de novillos Aberdeen Angus alimentados a pasto versus concentrado. XXIV Congreso de la Asociación Latinoamericana de Producción Animal (ALPA). 9-13 noviembre. Puerto Varas, Chile.

Carriquiry, M.; Espasandin, A.C.; Astessiano, A.L.; Casal, A.; Claramunt, M.; Do Carmo, M.; Genro, C.; Gutiérrez, V.; Laporta, J.; Meikle, A.; Pérez-Clariget, R.; Scarlato, S.; Trujillo, A.I.; Viñoles, C.; Soca, P. (2012). La cría vacuna sobre campo nativo: un enfoque de investigación jerárquico para mejorar su productividad y sostenibilidad. Veterinaria (Montevideo), 48(Supl. 1): 41-48.

Cayssials, R. y Álvarez, C. (1983). Interpretación agronómica de la Carta de Reconocimiento de Suelos del Uruguay. Dirección de Suelos y Fertilizantes-MGAP, Boletín Técnico No. 9, Montevideo, p. 29.

Cayssials, R.; Liesegang, J.; Piñeyrúa, J. (1978). Panorama de la erosión y conservación de suelos en Uruguay. Dirección de Suelos y Fertilizantes-MGAP, Boletín Técnico No. 4.

Chilibroste, P.; Soca, P.; Mattiauda, D.A. (2011). Balance entre oferta y demanda de nutrientes en sistemas pastoriles de producción de leche: potencial de intervención al inicio de la lactancia. In: XV Congreso Latinoamericano de Buiatría, XXXIX Jornadas Uruguayas de Buiatría. Eds. Centro Médico Veterinario de Paysandú–SUB. Paysandú, Uruguay. 8-10 Junio 2011. pp. 91-97. ISSN 1688-6674.

Cooperativa Laboratorio Veterinario de Colonia (Colaveco) (2015). Estadísticas de Calidad de leche de tanque. Available at: https://goo.gl/iwsyCb Retrieved: December 2016.

Da Silva, C.; Zamperin, G.; Ferrarini, A.; Minio; A.; Dal Molin, A.; Venturini, L.; Delledonne, M. (2013). The high polyphenol content of grapevine cultivar Tannat berries is conferred primarily by genes that are not shared with the reference genome. Plant Cell, 25(12): 4777-4788.

De León, L. (2016). Abordaje de la temática de la calidad de agua por la DINAMA. En: Mesa: Calidad de Agua: Una Visión Multidisciplinaria. Libro de Resúmenes III Jornadas Interdisciplinarias en Biodiversidad y Ecología (JIBE) 'Desafíos Socio-Ambientales para el Uruguay del Futuro' 28 de noviembre al 2 de diciembre. Rocha, Uruguay: Centro Universitario Regional del Este; 2016: 129. https://goo.gl/VZTiLN

DIEA (2009). La producción lechera en Uruguay. Anuario Estadístico Agropecuario 2009. MGAP, p. 79.

DIEA (2011). Anuario Estadístico Agropecuario 2011. MGAP, p. 246.

DIEA (2013). Anuario estadístico agropecuario 2013. MGAP, p. 246.

DIEA-MGAP (2009). Encuesta frutícola de hoja caduca: 1994, 1996 a 2009. Available at www.mgap.gub.uy

Do Carmo, M.; Claramunt, M.; Carriquiry, M.; Soca, P. (2016). Animal energetics in extensive grazing systems: rationality and results of research models to improve energy efficiency of beef cow-calf grazing Campos systems. J. Anim Sci., 94(S6):84-92.

Durán, A.; Califra, A.; Molfino, J.H. (2002). Mapa de suelos del Uruguay y memoria explicativa, con leyenda basada en la clasificación de suelos de EEUU, Taxonomía de Suelos. Facultad de Agronomía-UdelaR..

ENDIS (2015). Encuesta nacional de salud, nutrición y desarrollo infantil.

EU (2015). European Union on pesticide residues in foods. EFSA Journal 13(3):4038..

EU (2004). Regulation (EC) Nº 853/of the European Parliament and of the Council of 29 April 2004. Laying down specific hygiene rules for food of animal origin. Official Journal of the European Union 47: L226/22-L226/82.

FAO (2004). El Control de los Alimentos en el Uruguay. Segundo Foro Mundial FAO/OMS de Autoridades de Reglamentación sobre inocuidad de los Alimentos. Bangkok, Tailandia.

FAO (2011). Marco de Programación País para la cooperación de la FAO en Uruguay 2011-2015.

FAO (2012). Escala Latinoamericana y Caribeña de Seguridad Alimentaria, ELCSA. Available at: http://www.fao.org/3/a-i3065s.pdf

Farley, K.A.; Jobbágy, E.G.; Jackson, R.B. (2005). Effects of afforestation on water yield: a global synthesis with implications for policy. Global Change Biology, 11(10):1565-1576. doi: 10.1111/j.1365-2486.2005.01011.x

Ferrer, M.; Camussi, G.; Fourment, M.; Varela, V.; Pereyra, G. (2013). MGAP-FAO. Sensibilidad y capacidad adaptativa de la viticultura y la fruticultura frente al cambio climático. Volumen VI de Clima de cambios: nuevos desafíos de adaptación en Uruguay, p. 60.

Frison, E. and Hodgkin, T. (2016). Strategic opportunities to strengthen community based approaches to seed agrobiodiversity. In: The Future of Food: Seeds of Resilience. A Compendium of

Perspectives on Agricultural Biodiversity from Around the World. p. 29.

Galván et al. (2000). La adaptación productiva del germoplasma local de cebolla y morrón y su utilización en el desarrollo de cultivares. Informe Final del Proyecto CSIC I+D. Universidad de la República. p. 18.

Galván, G.; González, H.; Vilaró, F. (2005). Estado actual de la investigación en poblaciones locales de hortalizas en Uruguay y su utilización en el mejoramiento. Agrociencia, 9(1-2):115-122.

Galván, G. (1993). Poblaciones locales de cebolla. En: Capra et al. (Editores). Cultivo de cebolla en la región Sur. INIA Boletín de Divulgación, 29:19-20.

Galván, G.; González, H.; Sollier, S. (1997). Productive adaptation of onion (Allium cepa L.) landraces used for postharvest storage. Acta Horticulturae, 433:165-170.

García Préchac, F.; Hill, M.; Clérici, C. (2015). EROSION versión 6.0.20, Programa de computación para el uso de la USLE/RUSLE en Uruguay y la Región Sur de la Cuenca del Plata. Operating version in Windows. Available at: www.fagro.edu.uy Dpto. de Suelo y Aguas, Manejo y Conservación.

Grille, L. (2016). Caracterización estacional de la calidad de la leche de tanque en predios de la región litoral norte del Uruguay. Efecto del tiempo de almacenamiento y tamaño del rodeo sobre la calidad higiénico-sanitaria. Master thesis in Animal Production. Facultad de Veterinaria, Universidad de la República.

IMM (2012). Informe sobre control de residuos de plaguicidas en frutas y hortalizas. Available at: https://goo.gl/bUiarU

INALE (2016). Información del Uruguay, exportaciones, productos y destinos. Available at: https://goo.gl/rvBCcU

INAVI (2012). Estadísticas de vino y viñedos. Disponible en: www.inavi.com.uy

IPCC (2006). Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme. In: H. S. Eggleston, L. Buendía, K. Miwa, T. Ngara, y K. Tanabe (Editors). Japan: (Hayama: IGES).

Jarvis, D.I., et al. (2008). A global perspective of the richness and evenness of traditional crop-variety diversity maintained by farming communities. Proceedings of the National Academy of Sciences, 105:5326-5331.

Lizarralde, C.; Picasso, V.; Rotz, A.; Cadenazzi, M.; Astigárraga, L. (2014). Practices to reduce milk carbon footprint on grazing dairy farms in southern Uruguay: Case studies. Sustainable Agriculture Research, 3(2).

Lozano-Juste J. & Cutler S.R. (2014). Plant genome engineering in full bloom. Trends Plant Sci, 19(5):284-287. doi: 10.1016/j.tplants.2014.02.014

McGuire, S. and Sperling, L. (2016). Seed systems smallholder farmers' use. Food Security, 8(1): 179-195.

MGAP (2009). Manual de Calidad del Programa Nacional de Residuos Biológicos. Departamento de Sanidad Animal. Departamento Control Sanitario de Lácteos. Available at: https://goo.gl/RBnnTW Consultado: diciembre 2016.

Modernel, P.; Astigárraga, L.; Picasso, V. (2013). Global versus local environmental impacts of grazing and confined beef production systems. Environmental Research Letters, 8(3).

Mondelli, M., y Bervejillo, J. (2015). "Desempeño, desafíos y oportunidades del sector." Capítulo: El Desarrollo Agropecuario y Agroindustrial de INDA. (2017). Observatorio de Seguridad Alimentaria y Nutricional (OBSAN). Indicadores. Consumo y utilización biológica de nutrientes.

MSP (1994). Reglamento Bromatológico Nacional. Decreto N° 315/994 del 05/07/1994. 2ª ed. Montevideo, IMPO.

MSP (2016). GABA, Guía alimentaria para la población uruguaya, p. 104.

MSP (2016). División Epidemiología. DIGESA.

MSP/PPENT (2016). 2a Encuesta Nacional de Factores de Riesgo de Enfermedades no Transmisibles.

MVOTMA (2015). Primer Informe Bienal de Actualización de Uruguay GEI . Montevideo. Available at: https://goo.gl/KZ94nn

OBSAN (2017). Observatorio de Seguridad Alimentaria y Nutricional. Indicadores. Consumo y utilización biológica de nutrientes. Available at: http://obsan-inda.mtss.gub.uy/indicador/?id=101 Retrieved: February 6 2017.

OMS/OPS (2016). Organización Mundial de la Salud y Organización Panamericana de la Salud. Salud en las Américas. Uruguay. Available at: https://goo.gl/weU9xX

Panario, D. (2016). Efectos del Cambio Global sobre la Calidad del Agua. Una Visión desde las Geociencias. In: Mesa: Calidad de Agua: Una Visión Multidisciplinaria. Libro de Resúmenes III Jornadas Interdisciplinarias en Biodiversidad y Ecología (JIBE) 'Desafíos Socio-Ambientales para el Uruguay del Futuro' 28 de noviembre al 2 de diciembre. Rocha, Uruguay: Centro Universitario Regional del Este; 2016:129. Available at: http://www.cure.edu.uy/sites/default/files/Libro de resumenes III JIBE.pdf

Paolino, C. y Hill, M. (2011). "Perfiles de especialización agro/agroindustrial y eficiencia en el uso de los recursos naturales: Uruguay frente a otros países de América Latina". Anuario OPYPA 2011, 223-238, MGAP.

Pautasso, M., Aistara, G., Barnaud, A. et al. (2013). Seed exchange networks for agrobiodiversity conservation. A review. Agronomy for Sustainable Development, 33(1):151-175.

Peluffo, S.; González-Idiarte, H.; Galván, G.A.; Hirczak, A. (2016). Production of certified onion seeds in Uruguay: an experience of public-private articulation. Acta Horticulturae, 1143:15-22.

Picasso, V.; Modernel, P.; Becoña, G.; Salvo, L.; Gutiérrez, L.; Astigárraga L. (2014). Sustainability of meat production beyond carbon footprint: a synthesis of case studies from grazing systems in Uruguay. Meat Science, 98:346-354.

Pike, L. 1986. Onion breeding. In: Bassett, D. (Editor). Breeding Vegetable Crops. CT, USA: AVI. pp. 367-395.

Plaisted, R.L. 1985. Population breeding applied to improvement of unadapted Solanum cultivated species. In: Present and Future Strategies for Potato Breeding and Improvement. Lima, Peru, International Potato Center. pp. 143-162.

PNUD (2016). Informe Regional sobre Desarrollo Humano para América Latina y el Caribe. Progreso multidimensional: bienestar más allá del ingreso. Available at: https://goo.gl/EbKb16

Quezada, M.; Pastina, M.; Ravest, G.; Silva, P.; Vignale, B.; Cabrera, D.; Hinrichsen, P.; García, A.; Pritsch, C. (2014). A first genetic map of Acca sellowiana based on ISSR, AFLP and SSR markers. Scientia Horticulturae, 169:138-146.

Revenga, C. (2000). Will There Be Enough Water? Mock, G. (Editor). World Resources Institute; 2000. Available at: http://www.earthtrends.wri.org Retrieved: December 12 2016.

Royo Pallarés, O.; Berretta, E.J.; Maraschin, G.E. (2005). The South American Campos ecosystem. In: J.M. Suttie, G. Reynolds, and C. Batello (Editors). Grasslands of the World. (pp. 171-219). Rome, Italy: FAO.

Saadoun, A. y Cabrera, M.C. (2015). Calidad nutricional de la carne bovina y ovina de sistemas pastoriles: desde Uruguay para el mundo. En: La ganadería en América Latina y el Caribe: alternativas para la producción competitiva, sustentable e incluyente de alimentos de origen animal. Capítulo XV. Rafael Núñez Domínguez et al. (Editores). COLPOS, UACh, ALPA, FAO, IICA. pp. 623-641.

Saavedra, C. (2011). Un siglo de agricultura. Rev. del Plan Agropecuario No. 137, p: 46-49.

Sganga, J.C., Víctora, C.D. y Cayssials, R. (2005). Plan de acción nacional de lucha contra la desertificación y la sequía. ROU, DINARA-MOTVMA, RENARE-MGAP, Proy. GM2/020/CCD, p. 168.

Terevinto, A.; Cabrera,. M.C.; Saadoun, A. (2015). Influence of feeding system on lipids and proteins oxidation, and antioxidant enzymes activities of meat from Aberdeen Angus steers. Journal of Food and Nutrition Research, 3(9):581-586.

WHO/FAO/CODEX. International Food Standards.

Zaccari, F.; Cabrera, M.C.; Ramos, A,; Saadoun, A. (2015). In vitro bioaccessibility of β-carotene, Ca, Mg and Zn in landrace carrots (Daucus carota, L.). Food Chemistry, 166(1):365-371.

Zaccari, F., Galeazzi D., Rahi V. (2015). Efecto del tiempo de almacenamiento en condiciones controladas de temperatura sobre atributos físicos y químicos de zapallos "tipo kabutia" (Cucurbita maxima x Cucurbita moschata). Revista Iberoamericana de Tecnología Poscosecha.

Acknowledgments

Thanks are due to **Zulma Saadoun** for her help with copyediting and editing and the cover photograph.