Why not a piece of meat of rhea, nutria, yacare, or vicugna for dinner?

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Implications

• South America has incredible biodiversity and a capacity to supply food for humans. Meat from farmed indigenous species is a practical approach to ensure the use and sustainability of the animal biodiversity.

• The indigenous meat-producing species considered in the present work are the most promising animals to produce new and innovative food for Latin America and the world.

• Farming of these indigenous species could be a key strategy to ensure the nutritional security and income for many families inhabiting remote rural zones in South America.

• Nutritional information on the meat from these species is scarce, which is a major challenge.

Key words: fatty acids, indigenous meat, minerals, proteins, South America

Introduction

South America is a rich region in terms of biodiversity. This biodiversity in both plants and animals has long been noted by explorers (Darwin, 1839). The wildlife has been a source of food for people in Latin America for many years, firstly for subsistence and secondly for commercial purposes. In many parts of Latin America, plant and animal biodiversity are used for zoo-therapy as an alternative mode of therapy for humans and sometimes for religious activities (León and Montiel, 2008). It has been estimated that in rural communities in South America, 30 to 50% of food proteins come from wild animals. This meat, a cheap and accessible food, is obtained mainly by hunting or trading with local hunters (León and Montiel, 2008). This pattern of subsistence, performed by human ancestors at least 2 million years ago (Ferraro et al., 2013), is followed worldwide (Hoffman and Cawthorn, 2012) and has probably protected rural households in South America from chronic malnutrition (Brashares et al., 2004; Golden et al., 2011).

There is also a local trade associated with the wildlife in terms of meat and by-products. In fact, this trade consisting mainly of skin, eggs, and fat, represents a supplementary income for the local economy. This point is often neglected when wildlife protection guidelines are implemented in South America.

Of course, the indiscriminate use of native species leads to the risk of some species becoming endangered or extinct. However, it is not realistic to consider that the only cause for this extinction is the hunting and capture of wild animals for consumption by rural households in Latin America. As stated 50 years ago by Buchinger (1965), “The image of the native who shoots at everything that moves is often used as an excuse to explain the vanishing of species. The fact is that most animals have become extinct due to commercial hunting or because their original habitat has been destroyed.” This concept remains relevant today. Fortunately, some countries in South America have defined a legal structure to protect and regulate the use of wildlife, including for farming. The farming of indigenous species for meat production, as an alternative to the unsustainable use of bushmeat, can help minimize the hunting pressure on many species (Damania et al., 2005), particularly those sought for their meat and by-products such as eggs and skin. At the same time, farming and trading of indigenous species can help consolidate the exotic meat niche in the international market in developed countries as well as in the urban areas of South America. This kind of meat provides some advantages when presented and marketed as specialty items for their reduced fat and cholesterol contents or increased amounts in polyunsaturated fatty acids (Saadoun and Cabrera, 2008).

The indigenous species produced for meat are greatly adapted to the familial farming system in South America (FAO, 2014). Furthermore, some countries encourage farmers to begin their own entrepreneurship, particularly those with limited land, insufficient to produce other commodities. This system allows for a predominant use of family labor, with the head of the family, in many cases women, directly involved in the production. However, financial assistance is often very limited for family farmers interested in rearing indigenous species for meat production. In many countries of South America, this kind of production system faces serious disadvantages when they compete for financial support with the established systems of beef, lamb, pork, and poultry.

Accordingly, the aim of this review is to present some indigenous species for farming and meat production at a local scale in South America. At the same time, production parameters and meat composition will be highlighted for those indigenous species.
Table 1. Geographical distribution of some indigenous meat-producing species in South America. (Source: Saadoun and Cabrera, 2008 and IUCN, 2013.)

| Scientific name | Geographical distribution |
|-----------------|--------------------------|
| Agouti Dasyprocta sp. | Southernmost South America, east of the Andes, and in Amazonia. |
| Alpaca Lama pacos | Central and Southern Andes from Peru to Argentina at elevations of up to 4,800 meters. |
| Capybara Hydrochoerus hydrochaeris | In the grasslands from Panama to Paraguay. |
| Cavia Cavia porcellus | Central highlands of Peru and Bolivia. |
| Greater rhea Rhea americana | Large range in northeast and southeast Brazil, east Bolivia, Paraguay, Uruguay, and northeast and east Argentina and South to 40°S. |
| Guanaco Lama guanicoe | North of Peru to Navarino Island in southern Chile. Most of guanacos are found in Argentina. |
| Iguana Iguana iguana | Mexico to northern Brazil and Peru, including a number of Caribbean islands. |
| Llama Lama glama | The Andean highlands, especially the Altiplano of southeast Peru and western Bolivia. |
| Nutria Myocastor coypus | Southern Brazil, Paraguay, Uruguay, Bolivia, Argentina, and Chile. |
| Paca Agouti paca | From southeastern Mexico to Peru, Bolivia, Paraguay, south of Brazil, northeastern Argentina, and east of the Andes, from Ecuador to the island of Trinidad. |
| Peccary Tayassu tajacu | Mexico and Central America all the way to Pira, Peru; on the western side of the Andes; and over most of eastern South America to Paraguay and northern Argentina. |
| Tegu lizard Tupinambis merianae | Center and South of Brazil, in southern Amazon River. |
| Vicugna Vicugna vicugna | Andes of southern Peru, western Bolivia, northwestern Argentina, and northern Chile, at elevations between 3,000 and 5,000 m. |
| Yacare Caiman crocodilus yacare | From Oaxaca, Mexico, to Central and South America to Paraguay River and Argentina. |

Indigenous Meat-Producing Species in South America

Geographical distribution

In this review, we will only consider those indigenous species that have been farmed in South America. There are other potential species, not considered here, which need to be protected first (IUCN, 2013). The species farmed for meat production in South America include: agouti (Dasyprocta sp.), alpaca (Lama pacos), capybara (Hydrochoerus hydrochaeris), cavia (Cavia porcellus), guanaco (Lama guanicoe), iguana (Iguana iguana), llama (Lama glama), nutria (Myocastor coypus), paca (Agouti paca), collared peccary (Tayassu tajacu), rhea (Rhea americana), tegu lizard (Tupinambis merianae), vicugna (Vicugna vicugna), and yacaré (Caiman crocodilus yacare). Table 1 shows the geographical distribution of the species considered in the present review. Information about the biology of these species is in Table 2.

Body weight and yield of carcasses

The body weight and yield of carcasses is obviously very different between the indigenous species considered here (Figure 1). The cavia is the lightest one, with a body weight of around 1 kg when produced for meat consumption in Peru (Figure 1). A recent investigation showed the difference in the body weight (1 vs. 0.5 kg), between the different genetic lines of cavia used in South America when compared with those used as food, in other part of the World (Kouakou et al., 2013). The largest ones are the llama and the guanaco showing body weights around 100 to 120 kg. The llama, which has been domesticated for a long time, is used not only as meat source, but also for traction and transport in the adverse environment of the Andes, where other animals cannot survive. The adaptation to this environment in the Andes (for 5,000 years) has made the llama unique for rural activities and as a local source of meat. For the guanaco, not yet fully domesticated, the production system for meat and fiber implies the use of large land areas available only in communities in the Andes zone of South America. The other species can be divided into two groups: the first consists of alpaca, capybara, rhea, peccary vicugna, and yacare, which exhibit body weights around 20 to 40 kg, and the second group includes tegu, paca, nutria, iguana, and agouti, which have body weights below 10 kg (Figure 1). Furthermore, the second group has the advantage for producers with limited land; this last group, along with cavia, is also adapted to a familial production pattern. For this reason, animals such as agouti and paca were, for a long time, reared by rural people in the Amazonia region to obtain meat and skin (Mayor Aparicio et al., 2007).

The carcass yield of the indigenous species is shown in Figure 2. The values ranged between 50 and 55% except for those species that include skin and head as part of the carcass. For agouti, paca, peccary and yacare, the yield of carcasses often includes the head and the skin. For cavia, the yield of carcasses includes the head, the skin, and the feet. The skin of guinea pigs, eaten by people in South America, seems to be one of the major sites of accumulation of n-3 fatty acids (Kouakou et al., 2013). In most cases, skin is included within the commercial carcasses, and this practice is linked to the fact that there is no established and remunerated market for skin and other by-products. For rhea, the yield of carcasses includes neck, head, and feet. For nutria, the yield of carcasses generally includes the trunk without the head and the feet (Figure 4). The nutria fur, particularly for nutria mutants, is a highly valued product and is sold independently of the meat. Often, depending of the fur market, the monetary value of the nutria fur is much greater than that meat (Cabrera et al., 2007).

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Table 2. Description of the indigenous meat-producing species addressed in this review. If not specified, pictures are from Wikipedia. (Source: Mayor Aparicio et al., 2007; Saadoun and Cabrera, 2008).

**AGOUTI:** Agouti (*Dasyprocta* sp.) is a tropical rodent, which is appreciated for its meat and skin by rural families. The female agouti has a gestation of 100 to 110 days with 2.8 births each year, and a mean litter size of two newborn per birth (Mayor Aparicio et al., 2007).

**ALPACA:** Alpaca (*Lama pacos*) is one of the domestic South American camelids that live in the Andes region of Peru, Bolivia, and Chile in altitudes between 2,800 and 5,000 m. The alpaca produce mainly a highly valued fiber for the textile industry and meat for local consumption by rural families. The female alpaca have a gestation period between 336 and 349 days, giving birth to a litter of one.

**CAPYBARA:** Capybara (*Hydrochoerus hydrochaeris*) is the largest rodent in the world (40 kg), inhabiting rivers and swamps. Its geographical distribution is described in Table 1. The capybara are easily domesticated and are gregarious, living in family groups. The products obtained from the capybara are meat as well as hides for belts, gloves, leather clothes, and highly valued handbags. The female capybara have two birth each year, after five months of gestation, with a litter size of 3.8 newborn per birth.

**CAVIA:** Cavia (*Cavia porcellus*) has been domesticated and used for food for 5,000 years in the Andean region in South America. The cavia, sometimes called cavy and known as the guinea pig, is part of many different cultural aspects of the history of the Andes, including mysticism and zootherapy practices. Today, in many countries of Andes region, cavia meat is sold in supermarkets and is present on many restaurant menus. Furthermore, cavia meat is exported worldwide to be consumed by migrants from the Andes region. The female cavia is very prolific, having four to five births each year, after 58 to 70 days of gestation, with a litter size of four to five newborns per birth.

**GUANACO:** Guanaco (*Lama guanicoe*) is a wild camelid produced in extensive systems in some farms in Argentina and Chile to produce fiber and meat. The gestation period of guanaco is between 345 and 360 days, giving birth to a litter of one newborn.

**IGUANA:** The adult male iguana (*Iguana iguana*), sometimes called green iguana, can weigh between 2 and 4 kg and an adult female between 2 and 2.6 kg. The main products from the iguana are meat and skin. The female lay a clutch of 14 to 76 eggs in a communal nesting site. The incubation period is of three months.

**LLAMA:** Llama (*Lama glama*) is the most common camelid present in the Andeans region. It was domesticated between 4,000 and 5,000 years ago by the Incas to be used for traction and meat production. The llama is an emblematic animal in South America and is very important in Andean cultural activities. The consumption of llama meat is traditional in the Andes, particularly in Bolivia. The development of llama meat is promising, and it has been exported as an exotic meat. After a gestation period between 342 and 345 days, the female llama gives birth to one offspring.

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**NUTRIA:** Nutria (*Myocastor coypus*), or coypu, inhabit the southern part of South America. Male nutria are heavier than females, and a wild adult specimen can weigh between 5 and 10 kg in a favorable habitat. Wild nutria live in freshwater, marshes, and lagoons with abundant emergent vegetation. Nutria have been reared in semi-captivity since the 1920s. However, nowadays in South America, the reared nutria come from genetically selected animals. This selection is focused on the quality and color of fur. Indeed, only selected nutria, called nutria mutants, are reared in farms using an intensive system of production. The gestation duration is between 128 and 138 days with an average of 2.5 L per year and between four and six offspring by litter. The obtained products are principally pelt and meat.

**PACA:** Paca (*Agouti paca*) is a rodent that is appreciated for its meat by rural families. Its rearing by local families, as a meat source, is usual in the Amazonia region. The female paca has a gestation of 145 to 155 days with two births each year and a litter size of one newborn per birth.

**COLLARED PECARRY:** Collared peccary (*Tayassu tajacu*) is a gregarious mammal found in tropical and subtropical areas of South America. Products are mainly meat, but sometimes the skin is also utilized. The gestation period lasts an average of 145 days, twice per year, with a litter size of two to four newborns each time.

**GREATER RHEA:** Greater Rhea (*Rhea americana*) is a large, flightless bird native to South America that inhabits extended areas of South America. The products from greater rhea are egg, meat, feather, and oil. Under captive conditions, the great rhea produces an average of 40 eggs per year with a hatchability of 60%. The incubation time is between 38 and 42 days.

**TEGU:** Tegu lizard (*Tupinambis merianae*) is a large lizard that inhabits South America. Tegus are used for their skin, meat, and sometimes, as pets. Wild Tegus are active only during the hot summer. This behavior makes their farming difficult. However, there are some attempts to produce tegus in farms in Argentina. The female builds a nest and lay 30 to 46 eggs. The duration of incubation is between 60 to 70 days.

**VICUGNA:** Vicugna (*Vicugna vicugna*) is a wild camelid present in South America. The gestation period is between 330 and 350 days, giving birth to a litter of one or, rarely, two newborns.

**YACARE:** The yacare (*Caiman crocodilus yacare*) inhabits various country in South America. There are some commercial farms producing yacare principally for its leather and meat, which is often offered salted to the consumers. The yacare takes six years to reach sexual maturity. The female builds a nest and lays eggs twice per year, with an average number of 29 eggs. The duration of incubation is between 65 and 84 days.
Nutritional Value of Meat
of Indigenous Species from South America

Protein and amino acid content

Considering all the species presented here, the protein content of their meat are between 18 and 23% (Figure 5). The content of protein per se is not sufficient to inform about the nutritive value of this meat for humans; data on amino acid composition are necessary for this purpose. Unfortunately, information on amino acid composition is missing for all the species in this review, except for alpaca and llama (Salvá et al., 2009; Mamani-Linares and Gallo, 2013). Much work is needed to know the amino acid composition of the indigenous meat in South America. The updated information about the nutritive value of such meat is important to help its promotion among consumers in the region and in the international market.

Lipids and cholesterol content in meat

Lipid content in the meat of the indigenous species from South America ranged between 2 and 5% (Figure 6), except for llama and collared peccary, which have lipids between 8 and 10% (Saadoun and Cabrera, 2008). However, in the previously cited investigation which used Kh‘ara llama, the reported quantity of lipids in the meat was 1.56%. In another report from the same authors, the reported lipid content was as low as 0.4% in young llama (18 to 24 months old). The unexplained low lipid content in a ruminant meat species has to be confirmed in future investigations.
Taken together (Figure 6), the lipid content of the different indigenous meat reinforce the idea that this kind of meat has a reduced lipid content—compared with the conventional meats. Moreover, the low lipid level of indigenous meat species seems to be maintained even when these species were reared on an intensive production system. For example, in nutria, the quantity of lipids in meat of wild animals caught in USA was 1.3% (Tulley et al., 2000), while the amount of lipids in meat of nutria reared in an intensive production system, using concentrated food, was around 2% (Saadoun et al., 2006). The very limited selection pressure (for growth and fattening) on these species, compared with other small meat animals like rabbits and chickens, could explain this result. The cholesterol concentrations in the indigenous meat presented here (Figure 6) ranged between 50 and 70 mg/100 g meat.

**Fatty acid content in meat**

The composition of fatty acids of food, and meat in particular, has been associated for a long time with human health concerns (McAfee et al., 2010), and reports from expert consultation are periodically released with respect to the recommendation of fatty acid intake in humans (FAO, 2014). The composition of fatty acids of the indigenous meat considered in this review is shown in Figure 7. To help readers compare between indigenous and conventional meat, proportions of SFA, MUFA, and PUFA for beef, sheep, pig, and poultry are included.

The MUFA content of indigenous meat is shown in Figure 7. Curiously, the cavia meat shows a reduced concentration of MUFA compared with the other indigenous meats and conventional meats, perhaps due to the diet of Panicum maximum (Guinea grass; buffalo grass) fed in that study.

The PUFA content of indigenous meat is shown in Figure 7. The PUFA content of the indigenous meat could be the most important parameter that could clearly advocate for this kind of meat in relation to human health. However, another variable that associates the levels of SFA and PUFA in meat could be considered as a way to classify different meats in regard to the human health. Indeed, the PUFA/SFA ratio (P:S) is a good indicator of the nutritive value of a meat for human consumption. The recommended ratio for human health ranges between 0.4 and 1 (Saadoun and Cabrera, 2008; FAO, 2014). Most indigenous meats showed a P:S ratio within the recommended proportion (Figure 8), except for camelids, namely alpaca, guanaco, and llama. The comparison between the indigenous meat and the conventional ones showed that all the conventional meats demonstrated P:S ratios outside the recommended range. The exception, as expected, was the chicken meat, which contains a substantially high level of PUFA.

**Trace mineral and vitamin content**

There is limited information about the mineral composition of meat produced from indigenous species. In this review, all the available information has been included in Table 3. Camelids, alpaca, llama, and vicugna showed a relatively high content of iron when compared with iguana and cavia and beef meat (Ramos et al., 2010). The quantity of iron is also...
greater in rhea, but this result is expected because all of the ratites (rhea, ostrich, and emu) have greater concentrations of heme iron (Ramos et al., 2010). Considering the number of animals present in the countries of the Andes region and their adaptation to the hard environment of the Andes, this kind of meat will probably contribute to the adequate trace mineral nutrition to Andean people today and tomorrow.

For vitamins, data for tocopherol and retinol in alpaca are presented (Table 3). Alpaca has a relatively lesser tocopherol concentration and greater concentration in retinol than beef. (Williams, 2007). Further research is needed on trace mineral and vitamin contents in indigenous meat to characterize the nutritional value from these meats.

### Conclusion

The farming of some indigenous animal species in South America could be a practical strategy to ensure not only the sustainable management of the animal biodiversity, but also to secure food security of numerous rural households. It could also help secure labor and income if the indigenous meat trade is adequately managed and regulated by local and national governments. Furthermore, in regards to the valuable nutrients present in the meat reported in this review, such as the P:S ratio, the interesting quantity of heme iron in rhea meat and the amount of n-3 fatty acids in cavia meat, it is advisable to continue reinforcing the regional and international trade for this kind of meat to consolidate a niche of human health–valuable exotic and niche meat from South America. However, to achieve all of these objectives, it is necessary to address the lack of knowledge on the nutritive values of these meats, as a way to help producers promote their products as sustainable and innovative in the meat market.

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Table 3. Minerals and vitamin concentration in meat from indigenous species reared in South America.

| Alpaca * | Cavia † | Greater Rhea ‡ | Iguana ‡ | Llama ‡ | Vicugna § |
|----------|--------|---------------|--------|--------|---------|
| **Macrominerals, mg/100 g fresh meat** |
| Calcium   | 10.7   | 13.56         | 1.89   | 10.4   | 11.6    | 28.0    |
| Phosphorus| 295    | 89.6          | 384    | 217    | 379     | 203     |
| Magnesium | 33.8   | -             | 15.0   | 21.9   | 28.4    | -       |
| Sodium    | 88.4   | 210           | 63.7   | 893    | 105     | -       |
| Potassium | 419    | 240           | 257    | 266    | 447     | -       |
| Iron      | 2.69   | 1.18          | 3.20   | 1.93   | 3.26    | 2.90    |
| **Microminerals, µg/100 g fresh meat** |
| Zinc      | 4440   | -             | 1465   | 2530   | 4440    | -       |
| Copper    | 1010   | -             | 141    | 220    | -       | -       |
| Manganese | 15.0   | -             | 11.3   | 460    | -       | -       |
| Selenium  | -      | -             | 82.0   | -      | -       | -       |
| Heme iron, mg/100 g fresh meat |
| -         | -      | -             | 2.34   | -      | -       | -       |
| **Vitamins µg/100 g fresh meat** |
| α-Tocopherol| 0.31 | -             | -      | -      | -       | -       |
| δ-Tocopherol| <0.02| -             | -      | -      | -       | -       |
| γ-Tocopherol| <0.02| -             | -      | -      | -       | -       |
| Retinol   | 0.17   | -             | -      | -      | -       | -       |

*Salva et al. (2009); †Higaonna-O. et al. (2008); ‡ Ramos et al. (2010); § TPCA (2002); ¶ Data not available or not reported.
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