Food and Agriculture Organization of the United Nations

Production, products and services

CAMELIDS

HEROES OF DESERTS AND HIGHLANDS, NOURISHING PEOPLE AND CULTURE

VOLUME 3

Production, products and services

CAMELIDS

HEROES OF DESERTS AND HIGHLANDS, NOURISHING PEOPLE AND CULTURE

VOLUME 3

Food and Agriculture Organization of the United Nations
Rome, 2026

Recommended citation
FAO. 2026. *Production, products and services*. Camelids: Heroes of Deserts and Highlands, Nourishing People and Culture. Volume 3. Rome. https://doi.org/10.4060/cd8253en

ISBN 978-92-5-140449-2

Cover photos: (left) © Giulia Pompilj, (centre) © Edgardo Solórzano Palacín, (right) © Osama Awad Elfaki

Contents

Figures

Tables

About this series

This volume forms part of the series *Camelids: Heroes of Deserts and Highlands, Nourishing People and Culture*, which includes five volumes:

Volume 1. History of camelids

Volume 2. Camelid biodiversity, population trends and geographic distribution

Volume 3. Production, products and services

Volume 4. Roles and values of camelids and their products

Volume 5. Current needs and challenges: solutions and future perspectives

The series was developed within the framework of the International Year of Camelids 2024, declared by the United Nations.

Contributors

Editors: Maria Wurzinger, Bernard Faye, Gustavo Gutierrez-Reynoso, Pamela Burger, Gaukhar Konuspayeva, Nakami Wilkister and Giacomo de' Besi.

Copy editing: David Mc Donald.

Design: Lucia De Canio and Enrico Masci.

Section contributors

1.1. Gustavo Gutierrez-Reynoso, Hugo Lamas, Sergio Lizeca, Luis Raggi and Maritza Lucia Vaca (alpacas and llamas); Bernard Faye and Maria Wurzinger (Bactrian camels and dromedaries).

1.2. Gabriela Lichtenstein and Pablo Carmanchahi.

2.1. Bettit Karim Salvá Ruiz (alpacas and llamas) and Bernard Faye (Bactrian camels and dromedaries).

2.2. Gaukhar Konuspayeva.

2.3. Edgar Quispe and Diego Sacchero (alpacas, llamas, guanacos and vicuñas); Kawther M. Akbar and Hasan Alhaddad (Bactrian camels and dromedaries).

2.4. Julisa Candio (alpacas and llamas) and Touhami Khorchani (Bactrian camels and dromedaries).

2.5. Julisa Candio and Celso Ayala (alpacas and llamas) and Bernard Faye and Carlos Iglesias Pastrana (Bactrian camels and dromedaries).

3.1. Bernard Faye and Tarun Kumar Gahlot (Bactrian camels and dromedaries); and Maria Wurzinger and Gustavo Gutierrez-Reynoso (llamas).

3.2. Douglas Baum (Bactrian camels and dromedaries) and Maria Wurzinger and Gustavo Gutierrez-Reynoso (llamas).

4.1. Daniel Arestegui, José Luis Quispe Huanca, Gabriela Lichtenstein, Gustavo Gutierrez-Reynoso and Maria Wurzinger (alpacas, llamas and guanacos); and Bernard Faye and Inna Punda (Bactrian camels and dromedaries).

4.2. Bernard Faye and Inna Punda.

4.3. José Luis Quispe Huanca and Maria Wurzinger (alpacas and llamas); Gabriela Lichtenstein (guanacos); and Bernard Faye and Inna Punda (Bactrian camels and dromedaries).

Acknowledgements

The annotated outline of the publication series was prepared during a meeting held at the headquarters of the Food and Agriculture Organization of the United Nations (FAO) in Rome in March 2024, involving FAO staff and camelid experts. The volumes were subsequently drafted by over 60 camelid experts from various regions. The drafting process included a regional writing workshop held in Lima on 9 July 2024 and a global writing workshop held in Vienna from 26 to 30 August 2024.

We wish to thank all workshop participants and all those involved in the preparation of Volume 3, including Kawther M. Akbar (Kuwait University), Hasan Alhaddad (Kuwait University), Daniel Arestegui (Asociación Internacional de la Alpaca), Celso Ayala (Universidad Mayor de San Andres), Douglas Baum (Texas Camel Corps), Pamela Burger (University of Veterinary Medicine Vienna), Julisa Candio (Universidad Nacional Agraria La Molina), Pablo Carmanchahi (Universidad Nacional del Comahue), Giacomo de' Besi (FAO), Bernard Faye (CIRAD), Tarun Kumar Gahlot (University of Bikaner), Gustavo Gutierrez-Reynoso (Universidad Nacional Agraria La Molina, Iowa State University), Carlos Iglesias Pastrana (University of Córdoba), Touhami Khorchani (Arid Regions Institute), Gaukhar Konuspayeva (Al-Farabi University), Hugo Lamas (Instituto Nacional de Tecnologia Agropecuaria), Gabriela Lichtenstein (Instituto Nacional de Antropologia y Pensamiento Latinoamericano/CONICET), Sergio Lizeca (Universidad Mayor de San Simon), Inma Punda (FAO), Edgar Quispe (Natural Fiber's Tech SAC), José Luis Quispe Huanca (Instituto Nacional de Innovación Agropecuaria y Forestal), Luis Raggi (Universidad de Chile), Diego Sacchero (Instituto Nacional de Tecnologia Agropecuaria), Bettit Karim Salvá Ruiz (Universidad Le Cordon Bleu), Maritza Lucia Vaca (Escuela Superior Politécnica de Chimborazo), Nakami Wilkister (University of Nairobi) and Maria Wurzinger (BOKU University, Iowa State University).

We acknowledge the valuable feedback and input received from the two peer reviewers of Volume 3: Omar Alhaj and Angelika Stemmer. We also wish to acknowledge those FAO colleagues who reviewed drafts of the document and provided valuable feedback, including: Roswitha Baumung, Ana María Rueda García and colleagues from the Food and Nutrition Division.

We acknowledge the overall guidance and comments from the International Steering Committee of the International Year of Camelids.

The preparation of this publication was led by the FAO Animal Production and Health Division. In particular, Badi Besbes (Chief, Sustainable Animal Production, Feed and Genetics Branch) supported the production of the document, Giacomo de' Besi (Animal Production Officer) provided overall coordination, and Claudia Forte Díaz (Communications Specialist) and Andreas Violides (Intern) supported the drafting process.

Abbreviations

ITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
FAO	Food and Agriculture Organization of the United Nations
ha	hectare
masl	metres above sea level
PUFA	polyunsaturated fatty acids
SFA	saturated fatty acids
µg	microgram
µm	micrometre, micron

Introduction

Camelids are raised in diverse production systems ranging from nomadic pastoralist extensive systems to specialized intensive systems. They play a key role in the culture, economy, food security and livelihoods of communities in Andean highlands and the arid and semi-arid lands of Africa and Asia, including Indigenous Peoples. Even in extreme climatic conditions, they provide a wide range of products such as meat, fibre and hides, as well as milk in the case of Bactrian camels and dromedaries. Camelid fibre, meat and milk are sold in a variety of local, national and international markets, with the involvement of different actors. Domestic camelids also provide multiple services including transportation of goods and people, draught power for agricultural activities, and they are increasingly employed in tourism.

This volume presents a comprehensive overview of the diverse production systems in which camelids are raised around the world, including regions where their presence has recently emerged or expanded, highlighting the wide range of products and services that camelids provide. It also explores the role of camelids and their products in both national and international markets, emphasizing their growing economic importance. Finally, this volume assesses efforts to manage wild camelid species.

© Daniela Golac Garron

Key points

1. From alpacas to Bactrian camels, dromedaries, guanacos, llamas and vicuñas, camelids contribute to food security, nutrition and economic growth, while also holding cultural significance for communities around the world.

2. Domestic camelids, including alpacas, Bactrian camels, dromedaries and llamas, are traditionally raised by pastoralists on extensive rangelands with low resources.

3. Camelids are multipurpose animals that provide a wide range of products and services to their owners, communities and society at large. These include milk, meat and fibre as well as transport for goods and people, and organic fertilizer.

4. Appropriate management of wild camelids can contribute to ecosystem conservation and can support sustainable rural development in the Andean highlands.

5. The camelid sector is undergoing changes including the development of more intensive, specialized farms for dairy, meat and racing dromedaries, as well as an increasing number of medium-scale alpaca farms for fibre production.

6. The market for camelid products is predominantly local and regional, with the exception of fibre and dromedary milk.

1 Production systems and management

1.1. Production systems of domestic camelids

Domestic camelids, including alpacas, Bactrian camels, dromedaries and llamas, contribute to the livelihoods of millions of households across the world. Traditionally, they are kept in extensive, rangeland-based systems where other forms of agriculture are either very limited or impossible. Domestic camelids are reared mainly in pastoral and agro-pastoral systems at varying altitudes in countries worldwide. In South America, alpacas and llamas are kept at elevations of more than 3 500 metres above sea level (masl), while in Europe, North America and Oceania, they are kept below 2 500 masl.

Domestic camelids live in harsh semi-arid environments such as the Puna or steppe regions for domestic South American camelids and Bactrian camels, respectively, or the deserts of Asia and Africa for dromedary camels. Even in these fragile environments, they provide meat, milk, fibre and hides to support the livelihoods of their keepers, as well as ecosystem and cultural services. Indeed, domestic camelids form part of the traditions, beliefs and cultures of many local communities. They also help build resilience to climate change, being well adapted to living on poor-quality pasture and require less water than other livestock such as cattle and sheep.

Globally, most camelid keepers are small in scale, including in countries where camelids have been introduced recently. In the last few decades, a shift from keeping camelids for subsistence to rearing them for markets has been observed, leading to changes in production systems. This includes the introduction of intensive dairy camel farms or racing stables, notably in Central Asia and the Near East, and semi-intensive alpaca farms for fibre or pets in Europe, North America and Oceania.

Camelid production systems can be characterized based on factors such as feeding management, availability of feed and water, herd size and composition, ownership of land and animals, access to input and other services, and market integration.

Alpacas and llamas

Alpacas and llamas are raised mainly in the Andean highlands of Argentina, the Plurinational State of Bolivia, Chile, Ecuador and Peru, at altitudes ranging from 3 500 to 5 000 masl in a region known as the Puna. The majority of alpacas are found in Peru – equivalent to about 4 million out of 6 million animals reported worldwide in 2018 (MINAGRI, 2019). Meanwhile, approximately 60 percent of the global llama population (around 2 million) is located in the Plurinational State of Bolivia (INSA, 2023), and 30 percent in Peru (Vilá and Arzamendia, 2022). Animal ownership is private, but land ownership is mostly communal, as in the case of the Plurinational State of Bolivia and Peru (**Table 1**).

Table 1. Main features of alpaca and llama production systems by country

	Argentina	Bolivia (Plurinational State of)	Chile	Ecuador	Peru	Others*
Production system	Extensive, pastoralist	Extensive, pastoralist	Extensive, pastoralist	Extensive, pastoralist	Extensive, pastoralist	Semi-intensive
Farm size	Small	Small	Small	Small	Small, medium and large	Small, medium and large
Animal ownership	Private	Private	Private	Private	Private, communal	Private
Land ownership	Communal, state, private	Communal, private	Private	Communal, private	Communal, private	Private
Indigenous groups	Kolla, Atacama, Quechua	Aymara, Quechua	Aymara, Lican Antai, Quechua, Kolla, Mapuche	Quechua, Puruaes, Cañaris	Quechua, Aymara	None

Notes: *Other countries in Europe, North America and Oceania.
Source: Authors' own elaboration.

Small-scale extensive production systems

Most llamas and alpacas are raised in small-scale extensive grazing systems characterized by low inputs and low outputs (**Table 1**). For example, in Peru, which has the largest population of alpacas, on average, alpaca producers own about 50 animals (MIDAGRI, 2017). A similar trend is observed with llamas, with 76 percent kept on farms smaller than 50 hectares (ha), and 41.5 percent raised on farms with less than 3 ha (Fernandez-Baca, 2005). Similarly, in the Plurinational State of Bolivia, which has the largest population of llamas, approximately 70 000 families are dedicated to raising alpacas and llamas, approximately 90 percent of which are small-scale producers (Programa Pro-Camélidos, 2024).

Alpacas and llamas graze on natural grasslands with low carrying capacity due to overgrazing and water scarcity in the Puna region. A variety of natural vegetation types is found in this region such as *pajonales* (tussock grassland), *bofedales* (mountain wetlands), *césped de puna* (short grassland), *tolares* (shrubland) and *canllares* (thorny bushes), as well as *totorales* and *juncales* (cattail and bulrush wetlands). Although alpacas and llamas are closely related, they make different demands on their respective habitats and, accordingly, occupy different ecological niches. Preferably, alpacas are raised in the *bofedales* and llamas in the *pajonales* with drier conditions and low-quality feed resources (Flores, 1991; Flores and Gutierrez, 1995). Water availability fluctuates throughout the year with a rainy season between November and March.

Traditionally, farmers implement a rotational grazing system, keeping alpacas and llamas at lower altitudes and in flat areas during the dry season, and bringing them uphill to higher altitudes during the rainy season. This strategy also helps to control the increased parasite load during the wet season. Despite its benefits, the practice of rotational grazing is decreasing due to land shortages and labour scarcity, among other reasons. In addition, farmers manage alpacas and llamas differently, as llamas are usually brought to graze in higher, dryer and more remote areas.

Alpaca producer in Cuzco, Peru

© FAO/Yván Ardiles

Llamas in Pica, Chile

© FAO/Bernarda Claure

Alpacas are reared primarily for their fibre, which serves as a main source of income for keepers, though their meat is also an important resource for both self-consumption and supplementary income. Llamas, on the other hand, are raised primarily for their meat and as pack animals, with fibre playing a less significant role. Beyond their economic value, both alpacas and llamas hold cultural and spiritual significance (Turin and Quiroga Mendiola, 2024), forming an integral part of the Andean cosmovision – a holistic view of life with myriad links and interactions between the cosmos, nature (animals, water and land) and human beings.

Animal and land ownership share similar characteristics across countries in the Puna region. In the Plurinational State of Bolivia and Peru, for example, animals can be owned by families or individuals, but the land is owned mainly by peasant communities (Gutierrez *et al.*, 2018; Huanca *et al.*, 2018). Farmers often keep mixed herds of sheep, alpaca and llamas, but only rarely cattle. Depending on the altitude, they either combine crop and livestock activities (agropastoral production system) or restrict themselves to raising livestock, usually in the form of alpacas and llamas (pastoralist system). This diversification is considered a strategy to increase resilience in the face of fluctuating prices for products and environmental phenomena such as drought, extremely low temperatures and hail (Radolf, Wurzinger and Gutiérrez, 2022). Alpacas and llamas also function as an important "savings" investment for families (Valdivia, Gilles and Turin, 2013), enabling them to meet their household needs (health, education, etc.).

Shearing of alpacas, Ecuador

Alpaca and llama keepers belong predominantly to ethnic groups such as the Quechua and Aymara in Peru and the Plurinational State of Bolivia, and the Aymara, Lican Antai, Quechua, Colla and Mapuche in Chile. Over generations, they have developed an extensive corpus of local and traditional knowledge related to camelid raising. The family is the main source of labour for animal care, with women playing a particularly important role in the day-to-day management of animals (grazing, health care, etc.), notably when men are involved in off-farm work (Valdivia, Gilles and Turin, 2013). Over the last 30 years, the rural population has decreased significantly, particularly in communities that support the largest number of domestic camelids. This trend has led to the deterioration of activities related to grazing, pasture maintenance, shearing management and marketing.

Geographic isolation, poor infrastructure and limited access to markets has historically resulted in a commercial structure dominated by intermediaries, known as *rescatistas*. These intermediaries purchase small quantities of camelid products from producers at low prices and sell them in bulk on urban markets. In recent years, however, some countries and regions, such as the provinces of Jujuy and Catamarca in Argentina, have seen improvements in the commercialization of llama and alpaca fibre. The formation of cooperatives and associations, quality-based marketing, value addition, direct linkages with buyers, the formation of strategic alliances (mainly with the textile sector) and the incorporation of technology (e.g. electric shearing) have boosted production and enabled access to national and international markets.

Llamas in the departament of Oruro, Plurinational State of Bolivia

© FAO/Carlos Pallacán

Similarly, while meat remains an important component of the family diet, marketable surplus is being directed increasingly to cities with developing tourism sectors. However, numerous changes still need to be addressed to improve the production and processing of llama and alpaca products, including limited access to inputs and services such as credit, training, information and animal health services. These challenges are exacerbated by the impacts of climate change.

Alpacas and lamas are also increasingly being reared in countries such as Australia, Austria, Canada, the United Kingdom of Great Britain and Northern Ireland, Germany, New Zealand and the United States of America. The average herd size remains small but the animals are raised in semi-intensive production systems (e.g. grazing and feed supplementation with hay or concentrate). A major constraint on improving production systems is the gap in knowledge in fields such as reproduction, nutrition and health management practices (Boughey, Hall and Bush, 2024).

Medium- and large-scale semi-intensive production systems

In some countries, medium- and large-scale semi-intensive and intensive production systems are being developed, with specialized farms to produce alpacas for breeding purposes (Wurzinger and Gutiérrez, 2022) and, a smaller number of farms dedicated to llamas. In Peru, these farms keep between 300 and 20 000 alpaca breeding females, accounting for about 1 percent of the national alpaca population, while in Australia the number of alpacas in medium-scale farms ranges from 50 to 249, with more than 250 alpacas on large-scale farms (Boughey, Hall and Bush, 2024). Innovative practices such as single-sire mating, animal identification, selection for fibre quality and conformation, vaccination, antiparasitic control, annual shearing with electromechanical equipment, feed supplementation, and so on, are all implemented on these farms. These practices help to improve the survival of young animals, improve fibre and meat production, and increase the number of breeding animals for sale. In recent years some of these farms have adopted an international recognized certification such as the Responsible Alpaca Standard, which encompasses animal welfare, workers' welfare and environmental protection (Textile Exchange, 2021). This voluntary standard implemented changes in 2025 and will continue to do so in 2026, including a unique standard for all fibre animals and required audits to maintain certification.

Alpacas in Puno, Peru

Bactrian camels and dromedaries

Bactrian camels

The current status and development of production systems for Bactrian camels is different due to the history of central Asia. Collectivization in the former Soviet Union and the Cultural Revolution in China drastically changed agriculture and livestock management (Konuspayeva and Faye, 2020). Following the independence of the former Soviet Republics in Central Asia, the collective structures were dismantled and privatized (with the exception of Turkmenistan). For example, in Kazakhstan, between 1990 and 2012, the number of agricultural production structures (private farms or cooperatives) increased from 5 000 to 188 616 (OECD, 2013). The changes in camel production systems can be categorized into three main types: i) large agricultural enterprises derived directly from the collective structures of the Soviet era; ii) large farms with varying statuses, more or less specialized in milk or meat/fibre production, resulting from the buying back of family farms abandoned after bankruptcy; and iii) small family structures. The increasing number of large farms (type ii) led to market concentration with a decreasing number of farms.

Nomadic pastoralists with Bactrian camels, Mongolia

In Mongolia, however, semi-nomadism is still practised, although the same trend towards the development of peri-urban structures for dairy production has been observed. Infrastructure is limited, few external inputs are bought, herders rely primarily on standing grass and natural water sources, and labour is provided primarily by household members. Milk self-consumption remains important (around 40 percent), but producers are increasingly connected to markets in terms of outputs produced, despite limited access to inputs (Joly, Tulganyam and Hubert, 2019).

Dromedaries

Production systems for dromedary camels are often categorized into three types: *extensive*, *semi-intensive* and *intensive* (Dowelmadina *et al.*, 2015). **Table 2** shows the main characteristics for the extensive and intensive systems. The extensive system is often referred to as a "traditional" or low input system, where a strong relationship generally exists between the camel and owner (**Figure 1**). It is mainly but not exclusively practised by a large variety of ethnic groups in Africa (including different Arab tribes, Touareg, Toubou, Maure, Somali, Afar) and Asia (Bedouin, Mongol, Kazakh). Globally, traditional extensive systems still dominate, but face increasing challenges and pressures including the impacts of climate changes and globalization.

Figure 1. A nomadic pastoralist woman from the Gabra community herding camels in Marsabit County, Kenya

© Denish Ochieng

Table 2. Characteristics of extensive and intensive camel production systems

Characteristics	Extensive system	Intensive system
Herd composition	Mixed herds with small ruminants, cattle, horses and donkeys.[i]	Specialized camel farms for dairy production, fattening in feedlots, racing or touristic events, wool production (for Bactrian).
Herd movement	Irregular (nomadism) or regular (transhumance) mobility, occasionally disturbed by political insecurity or recurrent drought.[ii]	No mobility, especially in indoor systems, or mobility limited to "exercise" outside for 1–2 hours.[iii]
Feed base	Natural rangelands in large expanses, with long grazing time (at least 8 hours/day).	Irrigated fodder and concentrates with high energy/protein concentration rather than grazing, leading animals to devote less time to feeding.
Use of products	Mainly self-consumption of camel products, especially milk and less often meat.[iv]	Selling milk (processed in a factory belonging to the same farm), fattened camels for slaughtering, racing camels involved in the "race economy"[v] or in other cultural events such as wrestling in Turkey[vi] or camel shows.[vii]
Type of camel	Multipurpose camels able to produce milk, walk in harsh weather conditions, carry goods and people, be satisfied with poor feeding resources and cope with water shortages.[viii]	Selection of camels for specific performance (milk yield, growth, speed), using reproductive biotechnologies for embryo transfer.[ix]
Access to inputs (supplementary feed, veterinary products) and services	Limited access to inputs and services (supplementary feed, veterinary products, credit, information, etc.[x]	Easier access to and wide use of inputs in terms of veterinary care, farm equipment and special feed. Entrepreneurial management of the farm.
Integration into markets	Integration into solidarity networks based on the exchange of animals or products in cases of climatic or security crisis. Low integration into market economy except for occasional sale of live animals on local markets.	Market integration of camels and their products (milk, fattened camels for meat production, racing camels, wool, leather).

Note: Semi-intensive systems exist between these two "extremes" but present different characteristics.

Sources: See References.

In intensive systems, also known as modern settled farms or highly intensified farms, camels can be reared for dairy purposes (Nagy, Skidmore and Juhasz, 2022), in feedlots for fattening (**Figure 2**) or even as "champions" for camel racing.

Figure 2. Camel feedlot, Saudi Arabia

However, classification of camel production systems into the three types described above may not be representative of the wide panoply of intermediate systems observed throughout the world. These form part of a schema comprising at least three main gradients: (i) *geographical* based on greater or lesser proximity to cities (from pastoral to peri-urban areas), (ii) *technical* based on the degree of intensification; and (iii) *economic* based on greater or lesser integration into markets. For example, in pastoral areas, extensive systems with low market integration include traditional nomadic and transhumant systems. They also include the "H'mil system", which is common in Algeria and Mauritania, where camel herds are left in the desert without a herder (wandering) for weeks or even months, and the owner visits occasionally to select young camels to sell to slaughterhouses and collect milk from females for self-consumption (the "picking system"). Non-productive animals are also kept in pastoral areas, while productive (lactating) camels remain in peri-urban areas under more intensive management. The traditional pastoral system (with lower mobility) can also supply live camels for export (a common system in Sahelian countries). More intensive systems include small-scale family-based systems as well as dairy farm enterprises with employed labour, feedlots, "Kleenex" farming systems (see description below) and transitory peri-urban systems (where the animals stay temporarily in peri-urban areas before returning to pastoral areas). Many linkages can be observed between these different systems.

New trends in dromedary camel production systems

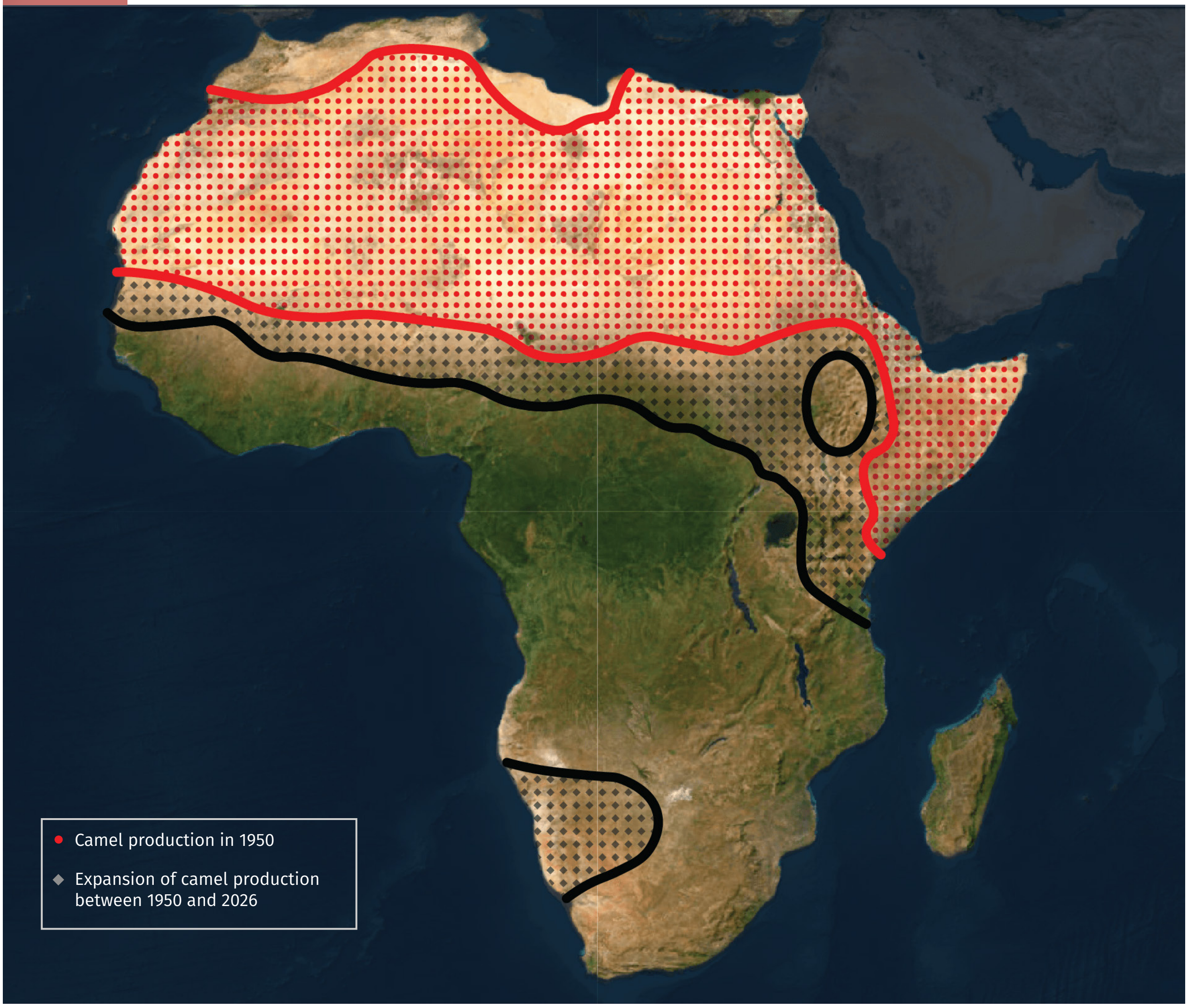
Camel production systems have recently experienced profound changes linked to drivers including climate change, the growing introduction of camel products (milk, meat, wool and leather) into national and international markets, and the changing status of camel owners (Mortimore and Adams, 2001).

Climate change. A number of climatic changes in arid and semi-arid regions where camels are kept have been observed, notably persistent drought and shifting rainfall patterns. These lead to aridification, particularly in the Sahel, pushing camel farming progressively southward on the continent (Faye, Chaibou and Vias, 2012) or to higher altitudes as reported in Ethiopia and Kenya (Megersa *et al.*, 2014; Wilson, 2020). This expansion of the camel distribution area (**Figure 3**), notably on the African continent reaching as far as equatorial countries such as Uganda, is not necessarily linked to the movement of camel herds usually present in the northern part of Sahelian countries and reared by nomadic people, but is rather due to the adoption of the camel by former cattle breeders such as the Peul in West Africa or the Maasai in East Africa. The adoption of camel rearing by other ethnic groups is referred to as "ethnic transfer". This strategy is sought to help secure a viable farming strategy in the face of recurrent droughts affecting countries such as Cameroon or Uganda (Asiimwe *et al.*, 2020). Consequently, the camel has the potential to become increasingly present in crop-livestock systems where it can play a role as an auxiliary of agricultural work (Ali, 2023).

Growing introduction of camel products into national and international markets. Boosted by increasing demand from growing urbanized populations, camel farmers are seizing the commercial opportunities offered by greater proximity to urban areas. This leads to the development of more intensive peri-urban livestock systems. The intensification process includes the use of concentrates in diet, frequent utilization of veterinary inputs, and a reduction in or even a halt to herd mobility. In some cases, on-farm processing of camel products, especially milk, is performed, and in certain cases, reproductive biotechnologies are applied.

Additionally, the economic status of camel milk is altering significantly. Formerly intended as an offering for guests or given to poor members of the community, camel milk is gradually entering national and even international markets (Konuspayeva, Faye and Duteurtre, 2022), with camel milk producers moving away from a gift economy towards a market economy (Faye and Corniaux, 2024). In some cases, animals no longer belong to small-scale producers but rather to large-scale entrepreneurs, who own large herds of several thousand heads. Such systems, which may range from indoor management to keeping animals outdoors, are associated with intensive management and modern processing of camel products (Nagy, Skidmore and Juhasz, 2022).

Figure 3. Expansion of the limits of camel production in Africa between 1950 (red line) and 2026 (black line)



Note: Refer to the disclaimer on the copyright page for the names and boundaries used in this map.
Source: Adapted from **Earthstar Geographics** [Cited 12 January 2026]. http://www.terracolor.net

Status of camel owners. In this new climatic and economic context, camel owners are tending to diversify income sources. Studies in Algeria (Ben Semaoune, Senoussi and Faye, 2019), Mauritania (Biya *et al.*, 2021), Morocco (Kamili *et al.*, 2020) and Saudi Arabia (Abdallah and Faye, 2013) show that income is generated not only from livestock but also increasingly from other sources. Camel rearing may also become an economic or emotional investment for an urban population with sufficient capital. In Mauritania, for example, some businessmen invest solely in lactating dairy camels, using them to produce milk for dairy factories and selling them after drying off – referred to as a "Kleenex" farming system (Faye, 2018). In the Gulf countries, a new concept has emerged: "a camel for the weekend" (Faye, 2016). These camels – owned by urban dwellers working professionally in non-agricultural sectors and living in a Bedouin tent alongside their small herd at weekends – remain under the care of a herder and are often raised without commercial intent.

1.2. Management of wild South American camelids

Wild South American camelids, namely guanacos and vicuñas, share their range with livestock, which leads to conflicts over the use of rangelands. This conflict has intensified in recent years, particularly in the province of Santa Cruz in Argentina, where some ranch owners have even proposed the classification of guanaco as a pest species. However, appropriate management of wild South American camelids has the potential to play a fundamental role in halting the desertification process of arid environments, promote grassland conservation and rural development, and function as a diversification strategy in the context of climate change (Carmanchahi *et al.*, 2022a).

Management programmes for guanacos and vicuñas have the same underlying logic as community-based natural resource management initiatives. The rationale is that permitting the commercial utilization of fibre obtained from individuals that are captured, shorn and released back into the wild, will encourage the development of positive local attitudes towards conservation. In turn, this should result in some or all of the following: a decrease in poaching, an increase in tolerance for guanacos or vicuñas on communal and private lands, better management of grazing pressure, reduced land degradation, improved vegetation and biodiversity outcomes, and greater support for conservation measures (Lichtenstein, 2010). The hope is that rather than remaining antagonistic, producers will assist government efforts in monitoring and protecting the species. Getting local people involved in conservation is key to decreasing conflict with domestic livestock and ensuring effective stewardship over the vast areas inhabited by this species.

Guanacos and vicuñas are managed in the wild or in captivity (either in small or large corrals), (**Table 3** and **Table 4**). Wild management involves the temporary capture of individuals that are released back into the wild after being shorn. For both species, capture is carried out by herding on foot or on horseback, leading the animals to a "capture structure" where the animals are immobilized, sheared and then released. In some cases, good practice protocols are used which, in the case of guanacos in Argentina, or vicuñas in Peru, are regulated by national legislation. Moreover, the government plays an important role in the control of vicuña or guanaco captures, ensuring the welfare of the animals and guaranteeing the traceability of the fibre obtained. In Peru, for example, the *Servicio Nacional Forestal y de Fauna Silvestre* (National Forest and Wildlife Service, SERFOR) plays a crucial role in the management and conservation of vicuñas, overseeing and approving management plans. The country has also established technical standards to ensure good animal welfare practices in vicuña management.

Table 3. Guanaco beneficiaries, legal products and management systems

	Beneficiaries	Wild management	Captive management	Fibre	Meat
Argentina	Mostly private landowners, few cooperatives	Yes	Yes	Yes	Yes
Bolivia (Plurinational State of)	N/A	No	No	No	No
Chile	Private landowners	Yes	Yes	No	Yes
Paraguay	N/A	No	No	No	No
Peru	N/A	No	No	No	No

Note: N/A = not applicable. Due to the very low population density and the conservation risk indicated in national red lists, the use of this species is not considered viable in the Plurinational State of Bolivia, Paraguay and Peru.

Source: Authors' own elaboration.

Table 4. Vicuña beneficiaries, legal products and management systems

	Beneficiaries	Wild management	Captive management	Fibre	Meat
Argentina	Indigenous communities, private landowners, National Institute of Agricultural Technology (INTA)	Yes	INTA and very few ranches	Yes	N/A
Bolivia (Plurinational State of)	Indigenous communities	Yes	No	Yes	N/A
Chile	No	No	No	No	N/A
Ecuador	Indigenous communities	Yes	No	Yes	N/A
Peru	Indigenous communities, private landowners	Yes	Yes	Yes	N/A

Note: N/A= not applicable. Neither the Vicuña Convention nor national legislation permits the killing of vicunas to commercialize meat. The Convention on International Trade in Endangered Species of Wild Fauna and Flora only permit international trade of fibre obtained from live-shorn individuals.

Source: Authors' own elaboration.

Managing wild animals involves significant costs related to infrastructure (e.g. shear corral, holding pen, wooden posts, wire fences), labour, and the opportunity cost of choosing to maintain vicuñas or guanacos rather than livestock on private or communal lands. In the case of captive management, these costs are even higher, requiring substantial investment in permanent infrastructure such as fencing ranging from large areas (e.g. 1 000 ha in Peru) to much smaller enclosures (those installed in Argentina), as well as ongoing provision of food, water, veterinary care and other essential services. Whereas wild management has the potential to create economic incentives for the conservation of wild South American camelids and their habitat, the link between captive management in small confinements and conservation is less obvious (Lichtenstein, 2006). Furthermore, maintaining populations in enclosures has a potentially negative impact on vicuña populations by disrupting the natural organization of the animals, inhibiting genetic flow between populations, and increasing the likelihood of inbreeding, genetic drift, artificial selection and transmission of diseases (Vilá, 2002).

Chaccu – the traditional practice of shearing wild vicuñas, Peru

© FAO/Milza López Cerda

Vicuña and guanaco management projects have important differences. Guanacos overlap their range mostly with large sheep ranches (*estancias*) in Patagonia, whose owners have a long tradition of extensive sheep herding. Indeed, most guanaco management occurs on private lands and the beneficiaries are individual ranch owners. In the case of vicuñas, these overlap their range with Indigenous Andean communities that live above 3 200 metres. Most of the management in Argentina, the Plurinational State of Bolivia and Peru occurs in communal lands or areas inhabited by Indigenous communities that have ancestral relationship with the species.

At present, vicuña management for fibre production is performed in Argentina, the Plurinational State of Bolivia and Peru, whereas Argentina is the only country that produces guanaco fibre. Chile has produced guanaco meat for 20 years, an activity that has also recently been adopted in the Argentinean province of Santa Cruz.

Guanacos

Argentina is the home of the largest guanaco population in the whole Andean region. The guanaco live-shearing model started in Argentina during the 1980s, with intensive captive breeding operations, such as those used for livestock, established with technical support from the *Instituto Nacional de Tecnología Agropecuaria* (National Institute of Agricultural Technology, INTA). Attempts to capture, shear and release guanacos into the wild began in the late 1990s, when several large sheep ranches started to manage guanacos, producing fibre for export. Good practice management protocols, grounded in animal welfare criteria, were developed to enable the sustainable use of wild guanaco fibre through capture shearing, and subsequent release of individuals (Carmanchahi *et al.*, 2022b). These protocols are embedded within national and provincial regulations governing the extraction of fibre from this species in the wild. An alternative model to private management for guanacos was also developed in Argentina by low-income goat pastoralists that lived widely dispersed in the La Payunia Reserve (Mendoza Province) and was adopted by a cooperative in Somuncura plateau, Chubut province. However, the uncertainty of obtaining a good price for the fibre added to low market demand, and a lack of government support resulted in most projects suspending their operations (Lichtenstein, 2013).

Due to strong pressure from the livestock sector in Argentina, the Guanaco National Management Plan was modified in 2019 to allow their use for commercial purposes, including meat and fibre production, and recreational hunting. This setback in conservation regulation for the species was aggravated by poaching (Carmanchahi *et al.*, 2022a). The Plan was repealed in November 2024 and replaced by a series of even less stringent guidelines, leaving this species highly vulnerable.

Guanaco in the Parque Torres del Paine, Chile

© FAO/Max Valencia

There are information gaps surrounding the commercialization of wild guanaco meat leading to questions about its feasibility. For example, no information is available on the costs and economic benefits of meat commercialization. Furthermore, guanaco meat shows high incidence of *sarcocystiosis* (Carmanchahi *et al.*, 2022a) caused by two parasites (*Sarcocystis aucheniae* and *Sarcocystis masoni*), leading to the development of intramuscular macro- and micro-cysts. The consumption of infected meat, raw or undercooked, results in gastroenteritis in humans caused by the action of a toxic substance contained in the cysts. Symptoms include nausea, diarrhoea, colic and chills. The presence of macro-cysts between muscle fibres is thus one of the main arguments for rejecting the commercialization of guanaco meat.

Meanwhile, fibre from slaughtered guanacos is collected and commercialized. However, the supply of fibre from dead animals poses a risk for enterprises that shear live animals because the same product is obtained at a much lower cost. In addition, it undermines the positioning of guanaco fibre, both nationally and internationally, since the public for this fibre represents a select niche market that values the process of collection, and considers dead animal fibre an undesirable raw material. Additionally, the poor image that results from commercializing fibre obtained from dead animals can have a negative impact on the commercialization of all natural fibres (Carmanchahi *et al.*, 2022a).

Vicuñas

The vicuña's highly prized fibre resulted in centuries of overexploitation following the arrival of the Spanish to the Americas. By the 1960s, the species was driven to the brink of extinction. However, through the implementation of effective conservation measures supported by both international agreements and national legislation, vicuña populations have since recovered to levels that allowed for the reclassification of certain populations from Appendix I to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), thereby enabling local communities to sustainably harvest fibre from live-shorn animals. Argentina, the Plurinational State of Bolivia, Chile and Peru have each implemented distinct vicuña management models that align with their respective social structures, livelihoods, and national and local legal frameworks regarding wildlife utilization and land tenure.

In 1979, Argentina, the Plurinational State of Bolivia, Chile, Ecuador and Peru signed the Convention on the Conservation and Management of the Vicuña. In Article I of the Convention and in the signatory states' subsequent submission to CITES, the Andean communities, who historically had borne the burden of vicuña conservation, were designated as the primary beneficiaries of vicuña use.

The initial management frameworks, established in the Plurinational State of Bolivia and Peru, involved vicuña management by Indigenous communities under common property regimes (Lichtenstein and Ros, 2021). These used a capture and release system evolved from the Inca *chaku* tradition, whereby large numbers of community members holding colourful flags chase vicuñas into a funnel from where individuals are taken to be shorn. Today's *chakus* incorporate animal welfare considerations during management. In the 1990s, a growing trend in Argentina, Chile and Peru encouraged the management of vicuñas in captivity, with management entities varying between single producers and communities.

A vicuña in the Serranía del Hornocal, Province of Jujuy, Argentina

© FAO/Perla González Macías

At present, most of the vicuña population is managed in the wild in Argentina, and either in the wild or in large corrals in Peru. Chile suspended vicuña management in 2015 because of the limited revenues that resulted from captive breeding and the sustained migration of rural inhabitants, among other reasons. Since the very beginning of vicuña management in the Plurinational State of Bolivia, the country remains committed to managing vicuñas in the wild under common property regimes, with 130 managing communities registered. However, translating the first Article of the Vicuña Convention, which states that the beneficiaries of vicuña use should be the Andean population, into national legislation and guaranteeing exclusive benefits to local people has proven difficult in other countries. In recent decades, in Argentina and Peru, associative and communal enterprises and private initiatives have been allowed to manage vicuñas for fibre harvesting and marketing.

2 Products

Alpacas, Bactrian camels, dromedaries, guanacos, llamas and vicuñas are versatile animals that provide a wide array of products, which are either consumed by their owners or sold on local, national and, in some cases, international markets.

Meat from all camelid species (except vicuñas and wild camels) is consumed, while hides, a by-product of slaughter, are used to create various leather goods. The manure from these animals serves as fertilizer for crops or as a substitute for firewood for heating. Both domestic and wild South American camelids, as well as Bactrian camels, are known for their fibre, while the dromedary produces fibre in smaller quantities, and is generally raised for other reasons. Milk from Bactrian camels and dromedaries represents a significant food source for their owners and has recently found its way into both national and international markets. Additionally, camel urine is used in traditional medicine. Since most camelids are raised in low-input pastoralist systems, their products are generally considered environmentally friendly.

2.1. Meat and meat products

Alpacas and llamas

Nutritional composition

The proximate composition of alpaca and llama meat resembles that of other red meats such as beef and lamb (**Table 5**), though alpaca and llama meat have a low level of intramuscular fat (up to 0.4 g/100 g) and cholesterol ranging between 22 mg/100 g and 51 mg/100 g. Their ratio of polyunsaturated fatty acids to saturated fatty acids (PUFA/SFA) ranges between 0.1 and 0.26, between those reported for ruminant meat, while the ratio of omega-6 to omega-3 fatty acids (n-6/n-3) is less than 4 (Mamani-Linares and Gallo, 2014; Salvá, 2009).

Table 5. Chemical composition of llama, alpaca, beef and lamb raw meat (per 100 g edible portion on fresh weight basis)*

Components		Llama[i, ii, iii, iv]	Alpaca[iii, v, vi]	Beef[i, vi]	Lamb[vii]
Energy# (kJ)	Average	426	435	444	471
	Range	396–464	415–462	421–466	
	n	8	3	2	1
Energy# (kcal)	Average	101	103	105	112
	Range	93–110	98–109	100–110	
	n	8	3	2	1
Water (g)	Average	74	73.9	74.8	74.8
	Range	72.1–75.9	73.6–74.1	73.7–76	
	n	8	3.0	2	1
Total protein (g)	Average	23.0	23.4	21.9	21
	Range	20.0–25.5	22.7–24.1	21.3–22.5	
	n	8	3	2	1
Total fat (g)	Average	1.0	1.0	1.9	3.1
	Range	0.4–1.6	0.5–2.0	1.6–2.3	
	n	8	3	2	1
Ash (g)	Average	1.4	1.6	1.1	1.11
	Range	1.0–2.4	1.1–2.5	1.1–1.2	
	n	8	3	2	1
Cholesterol (mg)	Average	37.9	51.1	49.9	38.1
	Range	22.4–56.3			
	n	5	1	1	1

Notes: #Energy calculated using energy conversion factors (www.fao.org/3/y5022e/y5022e04.htm) as follows: protein, 17 kJ/g or 4 kcal/g; fat, 37 kJ/g or 9 kcal/g. Carbohydrates were assumed as zero for non-processed animal muscle. n= number of data points. All raw meat samples for llama and alpaca are from Longissimus lumborum. *Composition changes with most processing, preparation or cooking methods.

Sources: See References.

Conjugated linoleic acid has been found to account for 1.2 percent of total fatty acids in alpaca meat (Salvá *et al.*, 2009), which is slightly higher than the range reported for beef (0.12–1.0 percent) by Schmid *et al.* (2006). Overall, higher amounts of conjugated linoleic acid are found in the meat of extensively reared animals, which is attributed to the high levels contained in pasture (Butler *et al.*, 2021; Kearns *et al.*, 2023). The perceived health benefits of conjugated linoleic acid inclusion in diets are well documented, including effects on obesity and inflammation as well as anti-carcinogenicity, atherogenicity, immunomodulation and osteosynthesis (Badawy *et al.*, 2023; Davis *et al.*, 2022).

The scientific literature contains limited data on the content of myoglobin in alpaca and llama meat. This is an important protein for its heme-iron content, which also influences meat colour and quality. Ramos Ramírez (2019) found values of up to 3.64 mg/g in llama meat from Peru's central highlands, while Salvá *et al.* (2009) reported values of 4.99 mg/g in Peruvian alpaca meat from the Puna region. These values are similar to those found in beef.

Alpaca and llama meat contain some important minerals including potassium, phosphorous, iron and zinc (**Table 6**), which are crucial for growth, development and immunity (Gropper, Smith and Carr, 2021; McCann, Perapoch Amadó and Moore, 2020). Salvá *et al.* (2009) reported potassium and phosphorous as the major minerals found within Peruvian alpacas. In addition, Polidori *et al.* (2007) reported similar results in male Peruvian llamas, as well as high levels of iron and zinc. Compared to beef and lamb, llama and alpaca meat contain higher amounts of iron, phosphorous and zinc.

Table 6. Mineral content of llama, alpaca, beef and lamb, raw meat (mg/100 g edible portion on fresh weight basis)

Components		Llama[i]	Alpaca[i, ii, iii]	Beef[iii, iv]	Lamb[iv]
Calcium (mg)	Average	12	10	10	7
	Range		9–11	4–47	
	n	1	3	2	1
Potassium (mg)	Average	447	415	276	265
	Range		412–419		
	n	1	2	1	1
Phosphorus (ng)	Average	379	283	183	179
	Range		216–338	151–208	
	n	1	3	3	1
Magnesium (mg)	Average	28	28	16	25
	Range		23–34		
	n	1	2	1	1
Zinc (mg)	Average	4.44	4.16	3.82	3.85
	Range		3.87–4.44	3.32–4.32	
	n	1	2	2	1
Iron (mg)	Average	3.3	2.6	2.6	2.7
	Range		2.2–3.0	1.8–4.6	
	n	1	3	2	1

Sources: i. **Polidori, P., Antonini, M., Torres, D., Beghelli, D. & Renieri, C.** 2007. Tenderness evaluation and mineral levels of llama (*Lama glama*) and alpaca (*Lama pacos*) meat. *Meat Science*, 77(4): 599–601. https://doi.org/10.1016/j.meatsci.2007.05.011
ii. **Salvá, B.K.** 2009. Caracterización de la carne y Charqui de Alpaca (*Vicugna pacos*) [Characterization of Alpaca Meat and Jerky (*Vicugna pacos*)]. Universidad de León, Facultad de Veterinaría, Departamento de higiene y tecnología de alimentos. Ph.D. dissertation. http://hdl.handle.net/10612/826
iii. **Reyes García, M., Gómez-Sánchez Prieto, I. & Espinoza Barrientos, C.** 2017. Tablas peruanas de composición de alimentos. 10ma ed [Peruvian Food Composition Tables. 10th edition]. Lima, Ministry of Health, National Institute of Health. www.gob.pe/institucion/ins/informes-publicaciones/4231115-tablasperuanas-de-composicion-de-alimentos-tpca
iv. **USP (University of São Paulo).** 2022. Brazilian Food Composition Table (TBCA). Version 7.2. S.o Paulo, Brazil, Food Research Center (FoRC). www.fcf.usp.br/tbca

Alpha-tocopherol (vitamin E) content in meat is a relevant parameter for its quality, as it has an inhibitory effect on fatty acid oxidation and colour loss during refrigerated and frozen storage (Wood *et al.*, 2008). Salvá *et al.* (2009) found an alpha-tocopherol content of 0.31 ± 0.21 µg/g in alpacas grazed in the Peruvian grasslands, which is much lower than the other reported values of 3.2 µg/g (Arnold *et al.*, 1993; Ponnampalam *et al.*, 2017) and 6.1 ± 0.62 (Smith *et al.*, 2019). The low levels of tocopherol in Peruvian alpaca meat may be due to their diet, which consists of highland vegetation that could contain low amounts of tocopherol (Smith *et al.*, 2019).

Processing, products and consumption

The most common form of processed meat from alpaca and llama is "charqui", which is mainly consumed in Argentina, the Plurinational State of Bolivia, Chile and Peru. The method for making charqui in the Andes seems to be approximately 6 000 years old. The Incas developed this preservation method further, allowing them to store the meat for long periods and use it as part of their diet, as well as for feeding their army (Ampuero, 2006; Bonavia, 2008).

Traditional preparation techniques may vary slightly from one place to another, depending on the slicing method, the amount of salt used, the pressing time or the drying process, but they share a common foundation. Charqui can be made with the bone, using relatively large, sliced pieces, or boneless, thin fillets. The former has a darker appearance, while the latter is straw-coloured (**Figure 4** and **Figure 5**). The most common steps in charqui preparation are: (i) slicing the meat; (ii) sprinkling with coarse salt; and (iii) natural drying of the meat, placed on surfaces with direct sun exposure, and stored in a protected environment overnight. In most cases, the entire process lasts between 15 and 25 days.

© Uriel Montúfar

Figure 4. Shredded alpaca charqui

Figure 5. Whole leg alpaca charqui

Charqui's nutritional composition and value

Charqui is a salted dried meat that provides protein to the diet of high-Andean inhabitants. **Table 7** shows the values for the main characteristics of alpaca charqui (Salvá *et al.*, 2012), highlighting the high protein content, which represents approximately 50 percent on a wet basis (protein content is expressed as a percentage of the total weight of the product, including both water and solid components) or 60 percent on a dry matter basis (protein content is calculated based on the weight of the product excluding the water). The low moisture content of charqui, together with its high salt content confer remarkable microbial stability to meat products during storage at room temperature (Leistner, 1987). This explains the long conservation of charqui at room temperature for up to 12 months, without the growth of pathogenic or spoilage microorganisms.

Table 7. Average ± standard deviation of chemical composition of alpaca charqui (per 100 g edible portion)

Characteristics	Shredded charqui (n=30)	Whole leg charqui (n=22)
Moisture (%)	12.87±5.49	17.25 ±7.52
Fat (%)	3.33±1.64	4.68 ±2.66
Protein (%)	49.99±3.64	49.04±6.92
Ash (%)	36.41±4.83	29.99±8.08

Note: n = number of samples.

Source: **Salvá, B.K., Fernández-Diez, A., Ramos, D.D., Caro, I. & Mateo, J.** 2012. Chemical composition of alpaca (*Vicugna pacos*) charqui. *Food Chemistry*, 130(2): 329–334. https://doi.org/10.1016/j.foodchem.2011.07.046

Before being consumed, the charqui is desalted by soaking in water, with a hydration ratio of water to charqui of almost 2:1, and then used as an ingredient in regional dishes. It is cooked or fried, preferably accompanied by onion, garlic and chili. In addition to charqui, alpaca and llama meat have been utilized in the production of various meat products (without added fat). Alternatives to add value to alpaca and llama meat, and improve its commercialization with a longer shelf life, include jerky (seasoned and dehydrated meat flakes for direct consumption) and sausages (70 percent meat and 30 percent quinoa or cooked yellow potato), among others. In moderation, these products can provide missing nutrients in the lean season and offer organoleptic characteristics that are appreciated by consumers.

Bactrian camels and dromedaries

Camel meat and meat products are a traditional part of the diet in countries where camels are reared, especially in Central Asia, the Near East and North Africa. Camel meat forms part of local cuisines, and is often served for religious and cultural celebrations, with the liver and hump considered important delicacies.

Nutrient composition and value

The composition of camel meat has been widely studied (Bekhit and Farouk, 2013; Faye *et al.*, 2013; Herrmann and Fisher, 2004; Kadim *et al.*, 2020) and can vary according to the type of camels, their age, sex and rearing conditions. In general, the quantity of water (70–77 percent) is comparable or slightly higher than in other livestock species (Abdelhadi *et al.*, 2012; Kadim, Mahgoub and Purchas, 2008). Camel meat is also an important source of proteins, with different sources estimating a proportion of the total carcass in the range of 17–23 percent (Abdelhadi *et al.*, 2012; Al-Owaimer, 2000; Kadim, Mahgoub and Purchas, 2008). Camel meat is also known for its relatively low fat content with most of the fat concentrated in the hump. After discarding the hump, the fat rate can vary between 1 percent and 4 percent (Babiker and Yousif, 1990); the muscle *longissimus dors*i has a rate of 5.2 percent (Al-Owaimer, 2000) rising to 7 percent (Dawood and Alkanhal, 1995) or even 10.5 percent for older animals (Kadim *et al.*, 2006), intramuscular fat tending to increase as a function of age. Conversely, the percentage of protein tends to decrease with age (Abdelhadi *et al.*, 2011).

Ash, which mostly consists of minerals, accounts for 1.1–1.5 percent of meat. Calcium content (around 6.5 mg/100 g) appears to be higher than in beef (Al-Owaimer, 2000; Kadim *et al.*, 2006), possibly explaining in part the firmer structure of camel meat (Kadim, Mahgoub and Purchas, 2008). Data on vitamin content in camel meat indicates the presence of 0.12 mg/100 g for thiamine (vitamin B1), 0.18 mg for riboflavin (vitamin B2), 0.25 mg for pyridoxine (vitamin B6) and 0.61 mg for α-tocopherol (vitamin E) (Kadim, Mahgoub and Purchas, 2008; Ulmer, Heermann and Fisher, 2004).

Comparative studies conducted in Kazakhstan where dromedaries and Bactrian camels live in the same environment, and even sometimes on the same farms, compared the amino acid composition of six muscles from dromedary and Bactrian camel meat. Raiymbek *et al.* (2015) observed a higher essential amino acid index for all muscles in the dromedary meat compared to Bactrian meat and all other red meats. The essential amino acid index value is an indicator of the protein quality of food which shows how closely the amino acid profile of a food meets the standard amino acid requirements for human nutrition. However, the variability of the amino acid profile between muscles was higher in dromedary than in Bactrian meat. Both meats, however, were characterized by their richness in methionine and leucine.

A similar study conducted for fatty acid composition (Raiymbek *et al.*, 2019) showed that the mean fatty acid profiles differed to a greater degree between species than between muscles. According to Rawdah, Zamil El-Faer and Koreish (1994), monounsaturated fatty acids account for a third of total fatty acids in meat and are dominated by oleic acid (C18:1) and palmitoleic acid (C16:1). Polyunsaturated fatty acids (PUFA) are also present in relative abundance (18.6 percent), in particular linoleic acid (C18:2) and spinal acid (C20:4). The PUFA/SFA ratio therefore appears to be favourable (0.36) compared to that found in beef (0.22) or mutton (0.26) despite the higher atherogenicity index found in both dromedary and Bactrian camels. In particular, the linoleic/linolenic ratio is much higher in camel meat (10.9) than in other meat (2.0 in beef, 2.4 in sheep and 2.8 in goats), which can increase the risk of non-communicable diseases (Simopoulos, 2008; Zhang *et al.*, 2024). However, few studies are available to confirm this point, and given that the ratio is highly dependent on diet, further analyses are necessary. Differences between the two camel species also manifest in mineral and vitamin composition (Raiymbek *et al.*, 2025). However, these species differences appear less important than inter-muscle differences, with *Longissimus thoracis* presenting a different amino acid pattern compared to other muscles (Raiymbek *et al.*, 2013).

Organoleptic properties

The organoleptic properties of camel meat are very similar to those of beef. For example, the shear force (indicator of resistance to chewing) is comparable between the longissimus muscle of a 2–4-year-old camel (6.98) and that of a 2–3-year-old beef (6.45). The colour parameters are also very similar between camels and cattle (Kadim and Mahgoub, 2006), although variations exist depending on the different rearing systems and origins of the meat of animals being studied.

Camel meat is described as “raspberry red” in colour and sometimes brown in older animals (due to a higher concentration of myoglobin, a protein that plays a key role in meat’s colour) with a slightly sweet taste due to a relative richness in glycogen, a form of glucose (Kadim, Mahgoub and Purchas, 2008). The fat in the meat is very white in colour. With age, the meat becomes less tender and palatability decreases (Kadim and Mahgoub, 2006). From these results, the optimum age for slaughter appears to be between 1 and 3 years, which corresponds to current practices for young males.

Indeed, lack of tenderness is frequently linked to the fact that many animals are slaughtered after 10 years. The shear force is between 40 percent and 48 percent higher in a 6–8-year-old camel compared to a 3–5-year-old and a 1–3-year-old animal, respectively. Loss of water during cooking is also lower in meat from older animals.

Processing, products and consumption

Traditional processing of camel meat includes smoking, drying, brining, confit and cooking. Many ethnic camel meat-derived products are available on local markets (Baba *et al.*, 2021; Gagaoua and Boudechicha, 2018) including *maynama*, *cachir*, *khliaa ezir*, *tarfa-gara*, *fregat*e (Algeria and Morocco); *tidkit*, *mkila*, *Khili, tehal/tehane* (Morocco); *soudjouk*, *nakane*k, *suçuk*, *merdouma* and *Pastirma* (Egypt); *madfoon* (Saudi Arabia and the United Arab Emirates); and *otkac/nyirnyir* (Kenya). It should be noted, however, that excessive consumption of smoked, dried, brined, confit meat products has been linked to non-communicable diseases (Jabbari *et al.*, 2023).

Nowadays, bags of dried camel meat can be purchased in supermarkets in some countries. Modern technologies are also being used to prepare burgers and sausages from camel meat, which are sold in urban centres. In Morocco, the meat-processing industry valorizes camel carcasses according to the characteristics of their different muscles. Dried or cooked ham, mortadella, cooked or fermented sausage, and even camel merguez (hallal sausage) are offered for sale. In Türkiye, sausage (**Figure 6**) prepared with the meat of culled wrestling camels has obtained a PGI (Protected Geographic Index). Meanwhile, in China, stuffed camel feet (**Figure 7**) and terrine are available on the market.

Figure 6. Camel sausage, Türkiye

© Bernard Faye

Figure 7. Stuffed camel feet, China

The chemical composition of camel meat products is comparable to that of beef products, albeit with a higher level of moisture (73.6 percent) and ash (4.1 percent). Taste tests have shown increased acceptance of camel burgers among consumers when compared with beef burgers (Kadim, Mahgoub and Purchas, 2008). In Central Asia, the advent of processed Bactrian camel meat is relatively recent, and includes the preparation of “corned-camel” (**Figure 8**) for the army in Kazakhstan (Shoman *et al.*, 2018). In Mongolia, natural drying of camel meat under the sun is a longstanding traditional practice.

Figure 8. Corned-camel and dried camel meat in bags, Kazakhstan

2.2. Milk and milk products

This section provides an overview of milk and milk products derived from dromedaries and Bactrian camels. South American camelids produce only limited quantities of milk, which are not used for human consumption or other uses.

Nutrient composition and value

The reputation of camel milk as a "superfood" (Mustafa, Faraz and Bashari, 2023) linked to health claims (Faye and Konuspayeva, 2024) has given rise to numerous publications, often questionable (Mihic *et al.*, 2016), regarding the "therapeutic effect" of camel milk consumption. These properties are attributed to the specific composition of camel milk (Alhaj *et al.*, 2022), although its gross composition is comparable to that of cow milk (Gaucheron, 2011). Among the components that could have a potential beneficial effect are the high quantity of vitamin C, the presence of specific proteins such as whey acidic protein and peptidoglycan with antibacterial properties, the high bioactivity of lactoferrin, the absence of allergen protein beta-lactoglobulin and the presence of hydrolysates with anti-hypertensive effects.

The milk is white in colour and slightly opaque, and may sometimes have a salty taste and a sweet smell. Based on a compilation of 121 references published between 1905 and 2019 (Konuspayeva, 2020), the *general composition* (in percent) of camel milk includes solids not fat of 8.9–14.3, a fat content of 3.68 ± 1.00 in the range of 2.9–6.7, protein of 3.28 ± 0.59 (2.5–4.5), dry matter of 12.2 ± 1.62 (8.25–16.7), carbohydrates of 4.47 ± 0.66 (2.9–5.8) and ash of 0.81 ± 0.19 (0.35–0.95). However, if the concentrations of the different gross components of milk (fat matter, total proteins, carbohydrates) are similar between camel and cow milk, there are differences in the *fine composition* (notably the vitamin C and B3 content, the low concentration of vitamin A, the iron content, the presence of specific proteins such as whey acidic proteins or peptidoglycan recognition proteins, and the presence of glucose in carbohydrates), all of which have an impact during processing. The differences between Bactrian and dromedary milk are slight, partly due to the dilution effect, milk production volumes being higher in Bactrian compared to dromedary. Globally, Bactrian milk contains more fat, iron, calcium, phosphorus and vitamin C (**Table 8**), while the fatty acid composition is higher in polyunsaturated acids in dromedary milk (Faye *et al.*, 2008; Konuspayeva *et al.*, 2008; Khaliq *et al.*, 2024).

Table 8. Differences in the gross composition of Bactrian, dromedary and hybrid milk in animals reared in the same farms from Kazakhstan

Parameters	Bactrian	Dromedary	Hybrid	*P* value
Fat (%)	6.67 ± 2.93	5.94 ± 2.26	6.09 ± 1.81	<0.05
Protein (%)	5.23 ± 1.17	4.76 ± 1.13	5.15 ± 1.59	NS
Lactose (%)	2.77 ± 0.96	3.12 ± 0.92	3.04 ±0.60	NS
Vitamin C (mg/L)	177 ± 109	152 ± 91	133 ± 33	<0.001
Calcium (g/L)	1.30 ± 0.29	1.16 ± 0.27	1.26 ± 0.27	<0.003
Phosphorus (g/L)	1.08 ± 0.18	0.92 ± 0.19	1.07 ± 0.27	<0.001
Iron (mg/L)	2.11 ± 1.63	1.93 ± 1.1	2.01 ± 0.78	NS

Note: NS= Not significant.

Source: Adapted from **Faye, B., Konuspayeva, G., Messad, S. & Loiseau, G.** 2008. Discriminant milk components of Bactrian camel (*Camelus bactrianus*), dromedary (*Camelus dromedarius*) and hybrids. *Dairy Science & Technology*, 88(6): 607–617. https://doi.org/10.1051/dst:2008008

A pastoralist milks a camel in Kapoeta, South Sudan

© FAO/Eduardo Soteras

Milk product types and processing

As with milk from other species, camel milk can be processed into three forms: liquid, gel and solid. Traditionally, camel milk is mainly self-consumed as raw fresh milk, in pastoral areas or in fermented form depending on the region. With the development of modern processing industries for camel milk, the main liquid form available on the market is pasteurized milk. At present, it is not possible to obtain sterilized camel milk by heat treatment, despite significant research on the heat resistance of whey and casein proteins, fat globules, vitamins and other compounds (Alhaj, Metwalli and Elsayed, 2011).

Camel milk in clay bowls in Akshi village, Kazakhstan

© FAO/Didar Salimbayev

Pasteurized milk

The pasteurization protocol for camel milk can differ from one dairy processing unit to another, but generally the same protocol used for cow milk is applied. However, camel milk does not respond to heat treatment in the same manner as cow milk. For example, alkaline phosphatase, usually used as an indicator of full pasteurization in cow milk (bovine alkaline phosphatase disappears above 72°C), is not a suitable indicator of successful pasteurization in camel milk, as camel alkaline phosphatase is heat resistant and still shows activity at 90°C (Elagamy, 2000). Other enzymes have been tested but a dependable indicator of pasteurization in camel milk has yet to be found (Lorenzen *et al.*, 2011).

The pasteurization process also modifies sensory characteristics (Lund *et al.*, 2020), nutrient composition (Hattem *et al.*, 2011), physical and other properties (Kherouatou and Attia, 2003), and milk stability, and causes denaturation of proteins and whey protein degradation (Attia *et al.*, 2000; Saleh *et al.*, 2008). However, a recent study (Genene *et al.*, 2019) tested the effect of heat treatment on camel and cow whey proteins using different pasteurization protocols, and showed that 67 percent of α-lactalbumin, a protein found in milk, was not denatured in camel milk, compared to only 5 percent in cow milk. This result indicates that cow milk pasteurization protocols should not be used for camel milk.

The belief that camel milk has sufficient natural antimicrobial activity to preserve it from natural degradation at ambient temperature, over extended periods, is a misconception, as proven by a rigorous microbial contamination protocol (Sela *et al.*, 2003). In such contexts, pasteurization is the best way to prolong the shelf-life of milk for up to 7–10 days, depending on the contamination of the raw milk prior to heat treatment (Mohamed and El Zubeir, 2014).

Fermented milk

Fermentation is a traditional ancestral method commonly used for the preservation of camel milk worldwide (Konuspayeva *et al.*, 2023). It consists of the transformation of lactose into lactic acid by the natural microflora of milk dominated by lactic bacteria and, in some cases, by yeasts. Fermented products from camel milk have for centuries been the result of spontaneous fermentation, with most studies focusing on the microflora composition of these products (see Kaindi and Njage, 2020; Konuspayeva *et al.*, 2023). The main microflora are highly diverse and include bacteria from the genus *Lactobacillus*, *Enterococcus*, *Leuconostoc*, *Lactococcus* and *Pediococcus* (Akhmetsadykova *et al.*, 2015; Al-Otai, Al-Zore and El-Derm, 2013; Yateem *et al.*, 2008). Some of the bacteria strains may have strong probiotic effects (Manaer *et al.*, 2021). Yeast genus like *Kluyveromyce*s, *Saccharomyces*, *Candida* and *Trichosporo*n have also been verified (Baubekova *et al.*, 2015; Bilal *et al.*, 2024a).

The complexity of the microflora ecosystem in fermented milk leads to highly variable final products. Examples include *shubat* in Kazakhstan (Bilal *et al.*, 2024a), *khoormo*g in Mongolia (Guo *et al.*, 2021), *garris* in the Sudan (Abdelgadir, Ahmed and Dirar, 1998), *suusac* in Kenya (Maitha *et al.*, 2019), *laben (lben)* in Arabic countries (Algruin and Konuspayeva, 2015), and *ititu* and *dhanaan* in Ethiopia (Berhe *et al.*, 2019; Seifu *et al.*, 2012). Other traditional fermented beverages based on the mixture of camel milk with other beverages (often water) are available under the name of *zrig* in Mauritania (Boulay, 2008), as *lfrik* in Morocco (Ismaili *et al.*, 2017), and as *chal* in the Islamic Republic of Iran and Turkmenistan (Soleymanzadeh, Mirdamadi and Kianirad, 2016). These fermented products have their own specific tastes, textures and flavours. Nowadays, these traditional fermented milks are distinguished by their microbiological, physico-chemical and chemical properties and sometimes volatile organic compound profiles (Bilal *et al.*, 2024b).

Some projects have aimed to develop fermented camel milk with standardized organoleptic properties (Faye and Konuspayeva, 2016), emphasizing the potential contribution of fermented products to healthy diets. For example, one study found that camel milk inoculated with a specific lactic acid bacteria isolated from raw camel milk showed promising functional properties in the laboratory (Ayyash *et al.*, 2018; Shukla *et al.*, 2022). However, more higher quality data are needed to reach a conclusion.

Butter, ice cream and yoghurt

Butter, ice cream and yoghurt are milk products consumed worldwide in gel form. However, fresh camel milk is not commonly processed into butter or yoghurt. Camel milk fat is low (0.5 percent) in butyric acid (Konuspayeva *et al.*, 2008) compared to cow milk (5 percent) and the fat globules are smaller (Attia *et al.*, 2000). In addition, butter yield, which is the quantity of butter that can be produced from milk, is low and has undesirable organoleptic properties (Berhe, Seifu and Kurtu, 2013). Camel ghee (clarified butter) has also a very low yield compared to buffalo or cow milk, and the final product is more susceptible to rancidity (Parmar, 2013). Conversely, the use of camel milk to produce different flavoured ice cream is a relatively easy process that uses the same technology used for producing ice cream from other dairy animals. The resulting products are sold in Kazakhstan, Morocco and the United Arab Emirates, and have proven highly popular among consumers, especially when compared with other camel dairy products (Ahmed and El-Zubeir, 2015). Camel milk is also used to produce various sweet products including *Balkailmak*, a form of caramel prepared in Kazakhstan, and camel milk jam.

Camel milk panna cotta, Türkiye

© Bernard Faye

It is also possible to make yoghurt with camel milk (Hashim, Khalil and Habib, 2009); however, the gelling process poses a problem in terms of texture, as the final product is sticky and ultimately unpleasant to the palate. To obtain a better texture, the addition of gelatine, alginate, biosynthesized xanthan, calcium or starters producing exo-polysaccharides have been tested (Shegaw *et al.*, 2020). Improvement in the texture can also be obtained by mixing camel milk with milk from other species, or adding fruit, but technological difficulties have limited industrial development (Konuspayeva and Faye, 2021).

Cheese

Camel cheese has a relatively short history as coagulation is difficult to achieve using traditional cheese-making methods due to the casein composition of camel milk. This impediment has been overcome thanks to technological innovations based on the research of Kappeler *et al.* (2006), following preliminary trials using bovine rennet, or different plants with clotting properties (Konuspayeva, 2020). The use of camel chymosin, obtained by introducing its coding gene into *Aspergillus niger*, enabled the production of this rennet, which was commercialized in 2008. Its high clotting performance produces a cheese yield similar to cow milk.

Camel cheese in olive oil, Saudi Arabia

© Bernard Faye

The problem of camel milk coagulation being solved, many trials were undertaken to produce different types of cheese using different starters and technological protocols. Scientists and industries tested technologies to produce types of hard cheese (Konuspayeva *et al.*, 2012), fresh soft and pressed cheese (Konuspayeva *et al.*, 2017), mozzarella (Konuspayeva *et al.*, 2014), fresh white cheese (El-Gendy, 2018), cheese spread (Abdeen, El-Shafei and Khalifa, 2019) and *Domiati* (Elkot *et al.*, 2024). Other types of camel cheese were tested in different parts of the world. Research into rheological properties, microstructure and texture have been conducted to understand the specific behaviour of camel milk during the cheese production process (Hailu *et al.*, 2016; Soltani, Boran and Hayaloglu, 2016). However, further investigation is necessary to obtain hard cheese due to technological constraints during cheese processing, notably: (i) continuous removal of serum from the curd; and (ii) slow acidification of the curd. At present, industrial development of camel cheese remains a marginal endeavour.

Milk powder

Camel milk powder is easy to transport, and retains the nutritive and dietetic properties of the raw milk, making it an ideal product for export. Two main technologies are used to make milk powder: spray-drying (hot-drying) and lyophilization (freeze-drying). The latter process maintains all component elements (Ibrahim and Khalifa, 2015), but the solubility of the final product in water is not optimal. Trials are therefore being conducted beyond the laboratory. The spray-drying process has been tested using a variety of protocols (Sulieman *et al.*, 2014), and even though the solubility and fluidity of camel milk powder is lower than that of cow milk, the component proportions remain the same. However, in protocols using high temperatures and high spray pressures, vitamin C concentrations decreased, and atomization pressure increased the fatty acid content (Habtegebriel, Wawire and Sila, 2018).

While the spray-drying method seems preferable to ensure better reconstitution of the liquid milk, significant investment is required for the milk-drying tower and sprayer. Freeze-drying technology, which is less costly, can be used to provide ingredients for products such as biscuits or chocolate. At present, camel milk powder is produced in China, Kazakhstan, the Kingdom of the Netherlands and the United Arab Emirates.

Other milk products

Camel milk products are also used in cosmetics and soaps, which are widely produced by small-scale processors, especially at the handicraft level in many countries, as well as at a semi-industrial scale in Australia, China and France. No specific difficulties have been cited regarding the use of camel milk in the production of cosmetics by the private sector, and few research studies are described in the literature. The commercial argument for cosmetics produced using camel milk is based on the hypo-allergenic properties of the proteins (Maryniak *et al.*, 2018). The cosmetics are considered to be photoprotective and moisturizing, functioning as anti-wrinkle and anti-aging skin softeners (Mehta *et al.*, 2020).

2.3. Fibre

Alpacas and llamas

Alpacas

Alpaca fibre is considered a luxury fibre, its particular attributes including thermoregulation, light weight and softness (McGregor and Quispe, 2018). Its market share makes it the most important textile fibre among South American camelids (accounting for 6 200 tonnes per year), and places it third among animal fibres globally after wool and cashmere (Textile Exchange, 2024).

The quality and quantity of alpaca fleece are influenced by a wide range of factors, including the breed/type (Huacaya, Suri), sex and age of the animals. Environmental and management factors such as shearing, feeding and place of rearing, among others, also play a key role in fibre production, with Suri fibre being longer, straighter and more lustrous than Huacaya (**Figure 9**).

In general, young animals produce lighter fleeces than adults, and females produce lighter fleeces than males. Research carried out in Peru shows that at first shearing (10 months) the fleece weighs on average 1.15 kg and increases according to age, reaching 1.61 kg, 1.87 kg and 2.0 kg, at 2, 3 and 4 years, respectively. Once it reaches its maximum weight, the fleece starts to become lighter (Bustinza Choque, 2001). Improving feeding and management can increase fleece weight by up to 30 percent (Bryant, Florez and Pfister, 1989).

The fibre diameter – one of the most important traits for defining fibre quality – varies widely from 18 µm to 36 µm, the thinner categories being the most highly valued (Gutiérrez *et al.*, 2009; Olarte *et al.*, 2023; Quispe *et al.*, 2010). Average fibre diameters ranging between 24 µm and 30.1 µm have been reported for alpacas raised in Australia and the United States (Lupton, McColl and Stobart, 2006; McGregor, 2006).

Figure 9. Huacaya alpaca (left) and Suri alpaca (right) fibre

The fibre measures about 105 mm in length.

The fibre measures about 170 mm in length.

Some alpaca fibres are medullated. These fibres have a cavernous central channel that can store air and water. According to their location along the fibre, these can be classified as continuous or fragmented. The textile industry dislikes medullated fibre as it provokes problems during the dyeing process. The average medullation percentage reported in alpacas ranges from 39–66 percent (Contreras, 2010; Gandarillas Espezua *et al.*, 2022), and increases with age (Olarte *et al.*, 2023) and fibre diameter (McGregor, 2006).

Fibres that provoke itching when users wear clothing in contact with the skin (Gandarillas Espezua *et al.*, 2022) are called objectionable fibres. These fibres generally are continuously or strongly medullated and are chalky white in colour (Paucar *et al.*, 2024). Objectionable fibres can be separated by mechanical dehairing (Wang, Wang and Liu, 2003) or manually using tweezers (Hunter, Smuts and Botha, 2013). These fibres are considered undesirable by the textile industry because they are extremely coarse and have little flexibility (Hunter, Smuts and Botha, 2013), triggering negative prickly sensations in skin (Frank *et al.*, 2014) and reducing the comfort of the garments (Frank *et al.*, 2021).

White alpaca fibres are preferred due to ease of dyeing during textile processing. Accordingly, white alpaca fibres receive a higher price. As a result, more than 80 percent of alpacas are white in Peru (Caballero Armas and Flores Mere, 2004). However, the National Institute of Quality (*Instituto Nacional de Calidad*, INACAL) in Peru recognizes a total of 16 colours for alpaca fibres, with 8 basic colours (white, beige, light fawn, dark fawn, light coffee, dark brown coffee, dark black coffee and black), 6 grey colours and 2 undefined colours (light and dark) (INCAL, 2022).

Llamas

In Andean regions, a significant proportion of llama fibre is used as a raw material by artisans who make and sell traditional crafts, such as blankets, socks, sweaters, hats and leggings in local markets. Llama fibre is also used (and transformed) by industries for export purposes, often with a view to repositioning the fibre through novel designs as part of limited textile collections.

There are two breeds of llamas: K'ara or Q'ara (non-woolly, bred for meat) and Thampulli or Ch'aku (woolly), as well as intermediate types between these breeds. K'ara llamas have a lighter fleece weight (800–1 000 g) than Thampulli (1 100–1 200 g) (Quispe *et al.*, 2009). Fleece weight increases with age and stabilizes after 3 years.

Fibre diameter depends mainly on the breed and type of llama, age and location. Llamas have a double coat with a fine down and coarse guard hair. The diameter of down fibres varies from 20 µm to 24 µm (Poma and Ayala, 2022; Quispe *et al.*, 2023). The guard hair content varies between 15 percent in K'ara and 12 percent in Thampulli and intermediate types. The diameter of this coarse hair ranges between 40 µm and 60 µm (Berolatti Obando *et al.*, 2021; Quispe *et al.*, 2023; Quispe, Chipa and Pinares, 2015; Rodriguez Claros, 2006).

Fibre length is related to the growth period since animals are usually not shorn every year. However, the length of fine down is shorter than coarse guard hair (Martinez, Iniguez and Rodríguez, 1997). Fibre length reaches about 8.5 cm/year in Thampulli (Bernabé Soles, 2015) and 6.2 cm/year and 11.6 cm/year in the down and coarse fibres of K'ara (Bernabé Soles, 2015), respectively (**Figure 10**).

Figure 10. Llama fibre

The llama fibres measure about 125 mm in length.

As in alpacas, some llama fibres are medullated. Medullation in llama fibre can reach 21 percent in K'ara and 15 percent in Thampulli. Medullated fibres affect the comfort of the garment and its uniformity in dyeing. The presence of medullated fibres can be reduced through dehairing; however, the presence of medullated fibres favours thermoregulation due to heat retention in the medulla (Moore, Blache and Maloney, 2011; Wang, Liu and Wang, 2005). Llama coats are found in a large variety of colours and are either uniform in colour or mixed (Mueller *et al.*, 2010; Frank *et al.*, 2006; Stemmer *et al.*, 2005). The fibre can consist of over 23 different colours ranging from white, brown and chestnut, to grey and black.

Guanacos and vicuñas

Guanacos

Guanaco fibre is the least used and known of the South American camelid fibres in the textile and fashion industry due to the low volume available and its limited presence on the textile market. However, its distinctive features of exclusivity and fineness suggest potential for future use among specialty and luxury fibres.

Shearing of guanacos is performed with mechanical scissors and usually focuses on the fleece and belly, with the neck generally left unshorn.
The same free-ranging guanaco is rarely caught for shearing in consecutive years. As a result, shearing events generally feature animals of different fibre growth periods, contributing to variability in fleece weight and fibre length (Mueller *et al.*, 2015).

The fleece weight of adult guanacos can range between 300 g and 700 g (Mueller *et al.*, 2015), while guanaco calves (animals of up to 1 year of age but with primary incisors) have a fleece weighing about 159 g, and yearlings (animals of 1–2 years of age with permanent incisors) have a fleece weight of about 254 g (Bacchi, Lanari and von Thüngen, 2010).

Fibre diameter varies between age groups and is finer in calves than in yearling guanacos (14.2 µm versus 15.0 µm), whereas the fibre diameter of adults can range between 14.5 µm and 19.3 µm (Sacchero, Maurino and Lanari, 2006).

Guanaco coats are red and tan on the back and flanks of the animal, and white on the belly. Vicuña fleeces have two types of fibres: fine and short down fibres and coarse and long guard fibres. The mean coarse hair content varies from 1.5–2.5 percent. Although the guanaco down fibre proportion ranges from 64.9–94.5 percent, the down fibre yield obtained after mechanical dehairing is usually about 45–55 percent (Mueller *et al.*, 2015). Guanaco fibres are often tender and break due to tensions during processing: short fibre dropping from dehairer or carder machines is discarded as waste, reducing the yield.

Down fibre length averages 27.7 mm, with an overall range of 14.4–38.1 mm (Sacchero, Maurino and Lanari, 2006). The fibres must be processed through the woollen system, a textile process that does not straighten the short fibres, resulting in yarns that are soft and bulky. There are also numerous fibre ends on the surface of the yarn, which gives them a fuzzy appearance (**Figure 11**). Air trapped within the yarn ensures excellent insulation properties. Despite the high variation in fibre length, a high proportion of fibre is below 10 mm, which produces pilling in finished products (Mueller *et al.*, 2015).

Figure 11. Guanaco fibre

The fibres measure about 25 mm in length.

Vicuñas

Vicuña fibre is one of the finest animal fibres (Quispe *et al.*, 2010). As a textile material, it is considered exclusive due to the small quantities internationally available and its high price. As such, it represents a market niche where few textile companies possess the necessary expertise and technological capacity to transform the fibre into luxury products with the highest standards of quality.

Vicuñas are either shorn with scissors or with shearing equipment adapted from sheep. To reach an appropriate staple length, it is recommended to shear individuals every 2 years. Fibre length remains constant after the first shearing and females produce in general 10 percent less fibre than males.

The coat colour of the vicuña varies between the two subspecies *mensalis* and *vicugna*. *Mensalis* has a dark brown coat and white long chest hairs, while *vicugna* has a lighter beige pelage colouration with larger white countershading, and no white pectoral hair (**Figure 12**) (Quispe *et al.*, 2014; Yacobaccio, 2006).

Figure 12. Vicuña fibre

The fibres measure about 25 mm in length.

Fibre quality may present some differences between the subspecies *Vicugna vicugna mensalis* and *Vicugna vicugna vicugna*, as well as between animals from wild and captive management schemes. Fleece weight ranges between 200 g and 250 g in adults and 170 g and 210 g in yearlings (animals of 1–2 years of age with permanent incisors). The fibre of other parts of the body, such as the white bellies, are normally kept separately because of their lower quality. In the subspecies vicugna, fleeces from females are 11.5 percent lighter than those of males (Sacchero *et al.*, 2022). Such differences are not observed in the subspecies *mensalis*.

Vicuña fleeces have two types of fibres: fine and short down fibres and coarse and long guard hairs. The coarse hairy fraction (30–60 µm) represents less than 3 percent of total fibres and ranges from 10–15 percent of overall fleece weight. These must be separated either manually or mechanically (dehairing process) and reduced to the minimum to obtain a highly valuable fibre. Downy-fine fibres account for about 85–95 percent of the weight. These values represent yields that can be achieved through manual dehairing, whereas down fibre yields attained by mechanical dehairing are lower at about 70–75 percent (Sacchero *et al.*, 2024).

Vicuñas have superfine and ultrafine fibre with a diameter of 13.6 µm in adults and 12.6 µm in yearlings (Quispe *et al.*, 2010; Sacchero *et al.*, 2022). In the case of captive-bred vicuñas, average fibre diameters range up to 14.1 µm for fleeces and up to 14.9 µm for white belly fibre. The down fibres vary in length from 30.1 mm to 47.3 mm, with a large range of values between animals, herds and locations. Guard hairs can be twice as long as the down fibres (Sacchero *et al.*, 2024).

© FAO/Milza López Cerda

Bactrian camels and dromedaries

The coat and hair fibres of Bactrian and dromedary camels are highly adapted to the extreme environmental conditions of cold and hot deserts. The coat consists of a thick overcoat layer of coarse guard hair and a thin undercoat layer of fine down hair. The overcoat protects camels from the sun, rain and dust, whereas the undercoat provides an insulating layer against cold weather. The undercoat reaches its maximum length and density during winter and sheds during the summer leaving the thick short guard hair for better heat dissipation from the skin. Accordingly, camel fibres exhibit superior thermal and water resistance properties that can be utilized for textiles applications. Although not industrially exploited as much as sheep, goat and alpaca, camel fibres are readily used by local communities, camel herders or nomadic societies as a textile for coats, jackets, blankets, tents and carpets. Globally, camel fibres are produced for luxury garments or collectable antiques.

Camel fibres are collected during the moulting period (spring to early summer) and fibre harvest is conducted by combing, clipping, pulling or simply collecting the fibres that shed on the ground. Coat shearing, as a method of fibre collection, is not preferred because it is usually time-consuming and labour intensive. Camel hair covers the shoulders, neck, hump, mid-side (mid-torso) and thigh, but the mid-side produces fibres of the highest strength and smallest diameter.

Almost all camel fibres that are used in the textile industry are obtained from the Bactrian camel. The main producers of Bactrian camel fibres are China and Mongolia with an annual worldwide production of around 4 500 tonnes (Lakshmanan, Jose and Chakraborty, 2016). Mongolian camel fibres are reported to have a quality and softness comparable to that of cashmere. The majority of Bactrian fibres are exported as raw material to Europe, Japan and the United States, these three countries accounting for the largest market share of Bactrian fabric production worldwide.

Dromedary camel fibres are considered short, coarse, of minimal strength and unsuitable for the global textile industry. In Tunisia, dromedary camels produce around 100 000 kg of fibres annually (Hunter, 2020) that are used predominantly in traditional clothing. In India, dromedary fibres are used in some small villages to produce blankets, ropes, carpets, bags and mattresses. However, recent studies have shown that dromedary camel fibres have industrial potential given the observed variation in fibre qualities, colour, length and shape (**Table 9**, **Figure 13**).

Figure 13. Colour, length and shape variation of dromedary camels

Table 9. General fibre characteristics of Bactrian and dromedary camels

	Diameter	Length	Colour	Shape
Bactrian	18–26 µm[i]	30–120 mm[i]	Low variability	Unknown
Dromedary	19–78 µm[ii]	26–70 mm[ii]	High variability	Variable (5 crimps)

Sources: i. **Lakshmanan, A., Jose, S. & Chakraborty, S.** 2016. Luxury hair fibers for fashion industry. In: S.S. Muthu & M.A. Gardetti, eds. *Sustainable fibres for fashion industry: Volume 1*. pp. 1–38. Singapore, Springer. https://doi.org/10.1007/978-981-10-0522-0_1
ii. **Akbar, K.M., Alhajeri, B.H. & Alhaddad, H.** 2024. Fiber characteristics of the dromedary camel in the Arabian Peninsula. *Small Ruminant Research*, 235: 107276. https://doi.org/10.1016/j.smallrumres.2024.107276

The processing of dromedary and Bactrian fibres is quite similar and involves the following stages: collection; sorting based on colour and age; removal of dust, dirt and vegetable matter; washing; and dehairing (i.e. separating fine and thick guard hairs). Fibres are then spun using either the woollen or worsted system depending on the properties of the fibre. Long-coarse fibres are rolled using the worsted system and are used to make ropes, tents, carpets and industrial belting. Camel fibres are often blended with other fibres such as wool, nylon, polyester, cotton and silk to either improve their properties (e.g. enhance softness and shininess) or reduce their price. Wool-blended camel fibres are used to produce coats, jackets, blazers, skirts, sweaters, gloves, scarves, caps, dressing gowns and robes, whereas fibres blended with nylon are used in knitted products.

Processing wool derived from dromedaries in Nouakchott, Mauritania

2.4. Hides and leather

Alpacas and llamas

Alpaca and llama hides are used not only for making handicrafts like belts, ropes and rugs, but also for the fabrication of leather products such as bags, shoes, coats and jackets.

Differences between alpaca and llama adult hides have been reported in respect to histology, thickness, size (0.6 m^2 alpaca and 0.9 m^2 llama) and resistance characteristics (Alvarez Ascue, 2018; Doria, 2005). The commercial parts of the hide are referred to as the *bend*, *shoulder* and *belly* (Alvarez Ascue, 2018; Doria, 2005). Fresh llama hides presents a thickness of approximately 3 mm in the bend, 5 mm in the shoulder and 2.5 mm in the belly. Due to their thickness, these hides are suitable for leathercraft products and footwear manufacturing. Fresh alpaca skin shows a thickness of around 2 mm in the bend, 1.5 mm in the belly and 3 mm in the shoulder. Being thinner, they are more suitable for producing lining leather for shoes and garments. Products derived from alpaca and llama hides thus have different commercial characteristics (Candio, Tolentino and Trejo, 2024).

The preservation of alpaca and llama hides is often carried out in inadequate conditions and ways, significantly affecting the quality of the hide. The result is leather and fur of low quality and lower market value. Preservation methods using salt or "dry salting" and environmental airing or "dry sweetening" have been developed and are recommended due to their ease of application and low cost (Gómez Allca, 1997).

The transformation of hides into leather and fur can be achieved by means of mineral tanning agents (alum and chrome) or vegetable tanning agents (tannins from the bark of various plants or shrubs). Chrome tanning provides high-quality hides (Alvarez Ascue, 2018; Doria, 2005) but this practice is harmful for the environment due to the associated high level of pollution. Tanning with vegetable tannins is therefore being evaluated to reduce negative environmental impacts while maintaining high-quality products (Alvarez Ascue, 2018).

A potential use of alpaca and llama hides is to produce feed (gelatine and flour) and toys for dogs (Tolentino Garriazo, 2021). The hide thus represents an important by-product of alpacas and llamas, one that is currently underexploited and has the potential to improve the income of small-scale producers.

Bactrian camels and dromedaries

Currently, camel hides are relatively undervalued, especially in countries with the largest camel populations, and often constitute an environmental burden. However, hides are one of the most important by-products of the meat industry. As of 2023, annual slaughter of camels was estimated worldwide at around 3 million animals (FAO, 2025). With each skin representing around 8 percent of an animal's live weight, and a mean age of slaughtering varying between 12 months to 5 years, depending on the country, global camel hide production potential is estimated at 96 000 tonnes. Historically (Hekal, 2014), dromedary skin has been considered to be of poor quality (hard, thick, etc.). The low demand for dromedary hides from tanneries is also linked to the particular shape (presence of the hump) and various anomalies associated with pastoral rearing conditions (high frequency of skin diseases), as well as to slaughtering and skinning conditions (skins in several pieces with many knife cuts compared to a single piece of standard cowhide).

The results of research and studies on the characterization of dromedary hides (Kagunyu, Matiri and Ngari, 2013; Mansouri *et al.*, 2009; Nasr, 2015, 2020) have identified technological properties suitable for the production of protective footwear, men's and women's footwear, and handicrafts such as men's and women's handbags, and travel bags. The recent shift towards more intensive milk and meat production for camels, in particular dromedaries, while limited, has resulted in improvement in the quality of raw hides, thanks to antiparasite treatments and new animal identification systems such as ear tags, electronic chips or bolus, which avoid the use of firebrands that cause irreparable damage to the skin. Slaughtering and skinning operations also have a direct impact on hide quality, notably through inappropriate knife cuts. This is particularly true when skins are supplied free of charge or dumped in public rubbish dumps.

In a trial carried out in Tunisia with payment incentives to enhance quality, the number of knife cuts by slaughterhouse staff was significantly reduced, due in part to training and the use of knives with rounded heads (Khorchani, 2021).

More recently, tanneries have developed tanning and finishing processes to produce finished leather that can be used to make ladies' and men's fashion items (Saudi Arabia and the United Arab Emirates). The market for luxury leather products (**Figure 14**) is valued at USD 75.8 billion and is expected to grow to around USD 92.4 billion. In Saudi Arabia, camel leather could contribute an annual income of USD 98.7 million (Khan, 2024). At present, the share of leather from alternative resources such as camels, yak and ostrich represents around 2 percent of the global market. The characteristics of camel leather indicate a potential place in the luxury goods market (Ministry of Culture of Saudi Arabia, 2024); however, dromedary products still lack national and international standards (Faye, 2024).

In 2019, Tunisia was one of only a few countries to establish four specific standards for dromedary hides and skins.

Figure 14. Luxury jacket in camel leather on sale in Abu-Dhabi, United Arab Emirates

2.5. Manure and urine

Camelid manure holds value, particularly as fertilizer for agricultural production. However, in extensive production systems, where camelids are typically reared, manure collection is more often done in the corral (out of the corral the dung is too widespread to be collected). In the Plurinational State of Bolivia, camelid manure is used for fertilizing potato crops. Outside of agriculture, camelid manure can also play an ecological role through fertility transfer – the redistribution of nutrients via manure as animals move across different areas. However, the value of such transfers is limited, as camelids often produce dung piles in pasturelands. In the Plurinational State of Bolivia, again, folk medicine employs the urine of black llamas to treat diabetes, while llama urine is also consumed as a remedy for gastrointestinal problems, but the efficacy of these applications has not been scientifically tested.

Proper management of both manure and urine is critical to minimize environmental impacts and ensure the sustainability of camelid production systems. If not properly handled, these waste products can degrade water and soil quality.

Alpacas and llamas

Alpaca and llama manure is a good fertilizer offering significant benefits in terms of soil recovery in the high Andean pastures. Additionally, llama manure is frequently used to fertilize quinoa fields in the Plurinational State of Bolivia. An adult alpaca can produce 3 kg per day of excreta (urine and faeces), equivalent to 1.1 tonnes per animal per year (Quiñones Ramirez, Trejo Cadillo and Juscamaita Morales, 2016; Rodríguez, 2008). Alpaca faeces (**Figure 15**) have a composition of 24.3 percent dry matter, 91.2 percent organic matter (protein, ethereal extract, crude fibre and nitrogen-free extract) and 68 percent neutral detergent fibre (MINAGRI, 2019). Unfortunately, information on the production and chemical properties of llama manure are not available in the literature. Dried manure of alpacas and llamas is also used as a fuel for cooking in rural areas of the Andes.

Figure 15. Alpaca dung pile mixed with urine accumulated in specific places in a corral

Processes that decompose excreta in a controlled manner without generating environmental contamination, such as composting, liquid fertilizers and biodigesters, also constitute an alternative renewable energy source. The use of biogas and natural fertilizers would increase the sustainability of alpaca production and generate additional income for farmers (Quiñones Ramirez, Trejo Cadillo and Juscamaita Morales, 2016).

© Claudio Vicentini

Bactrian camels and dromedaries

Manure

Very few data are available on the composition of camel dung and interest in fertility transfer (Kheira *et al.*, 2017). According to Seboussi *et al.* (2009), daily faecal excretion in camels reaches around 2 200 g ± 900 g. Given a global population of 41 million, this is equivalent to approximately 90 million tonnes of faeces. This quantity corresponds to 9 000 tonnes of nitrogen, 162 000 tonnes of phosphorus, 171 000 tonnes of potassium, 2.5 million tonnes of magnesium and 4 million tonnes of calcium. If urinary excretion is added – around 6.26 ± 4.15 L/24 h according to Seboussi *et al.* (2009), with a a percentage of nitrogen of 94.4 percent (DM basis) (Latifah *et al.*, 2018) and dry matter equivalent to around 5.4 percent (Dogondaji, Wasagu and Umar, 2023) – the quantity of nitrogen restored to the soil by urine will be around 4.8 million tonnes/year.

Ammoniac released by manure in stables is regarded as a pollutant. Smits and Montety (2009) estimated the volume of released ammoniac in camel dairy farms at 5–6 kg/head, that is 50 percent of the volume released by cow manure. However, when high concentrations occur, for example at intensive camel farms or during specific events, manure collection is sometimes carried out, such as during the Pushkar fair in India (**Figure 16**).

Figure 16. Collection of camel dung during the Pushkhar fair, India

Recently, a local handicraft workshop in India successfully used camel dung in the fabrication of paper (**Figure 17**).

Figure 17. Paper processed from camel dung, India

© Hitesh Rathi

Urine

The utilization of urine, whether consumed or applied topically, has intrigued health scholars and researchers for centuries, primarily because of its reputed preventive and therapeutic benefits for various health conditions (Savica *et al.*, 2011). Historical records on the medical use of camel urine date back to 1020 with Avicenna's *The Canon of Medicine* (Alhaider *et al.*, 2011). The consumption of camel urine, either on its own or mixed with milk, is a well-known practice in folk medicine, particularly in Arabian countries among Bedouin tribes with a strong Muslim heritage (Ali, Baby and Vijayan, 2019; Al-Yousef *et al.*, 2012), where the urine of virgin female camels is highly valued (Abdelzaher *et al.*, 2020).

Over the past three decades, numerous *in vitro* and *in vivo* studies have investigated the biological effects of camel urine. The most frequently studied application is its potential in treating oncological diseases, followed by its antiplatelet, gastroprotective, hepatoprotective, anticlastogenic and antimicrobial effects. Camel urine has demonstrated cytotoxic effects against human and murine cancer cell lines, potential in regulating inflammatory angiogenesis, inhibition of platelet aggregation, protection against hepatic dysfunction, prevention of gastric ulceration and anticlastogenic properties as well as aiding in the treatment of certain infectious diseases (Iglesias Pastrana *et al.*, 2022). Additionally, the bioactive fraction[1] and subfraction PMF-K, both derived from lyophilized camel urine (PM701), have been highlighted for their selective anticancer and antimicrobial properties (Bakhsh *et al.*, 2019; Khorshid, Osman and Abdel-Sattar, 2009; Noor *et al.*, 2015).

Unlike other animal urine, the alkalinity of camel urine (high levels of potassium, magnesium and albuminous protein, and low concentrations of uric acid, sodium and creatine) may be the reason for its comparatively higher usage, historically (Alkhamees and Alsanad, 2017). Additionally, the acknowledged bioactive effects of camel urine are hypothetically attributed to the bioactive compounds present in desert plants consumed by camels (Alkhamees and Alsanad, 2017; Amina, Habiba and Abouddihaj, 2024) and single-domain antibodies in camel blood that clear rapidly through the kidneys (Alhaider *et al.*, 2012). However, these hypotheses need further testing.

[1] Prophet medicine is an Islamic field of medicine based on the hadiths; the Prophet Medicine Fraction, or PMF, relates to the fraction of urine that presents bioactive properties.

Although some reports indicate a lack of genetic toxicity from camel urine consumption (Anwar *et al.*, 2021; Khorshid *et al.*, 2010, 2015), future research should aim to unravel the complex aetiology of camel urine chemical composition and its potential public health implications. This research will promote both safe usage and sustainable conservation of traditional medicines derived from indigenous animal populations, in line with the 2003 UNESCO Convention on the Safeguarding of the Intangible Cultural Heritage.

Bottle of camel urine for sale, Morocco

© Bernard Faye

3 Services

Camelids provide not only a diverse range of products, but also a variety of services. These include the transportation of goods and people, draught power for agricultural activities and, increasingly, their use in tourism. In addition to these direct contributions, camelids offer valuable ecosystem services – such as seed dispersal – playing a significant ecological role. This section focuses on camelids' direct services to the people who raise them. Their ecosystem services are addressed in Volume 4.

3.1. Transport and draught power

Bactrian camels and dromedaries

Dromedaries and Bactrian camels can survive and carry 100–250 kg of goods in ecosystems with limited water and feed resources. Organized in caravans, packing camels have travelled across all deserts from Mauritania to China, from ancient times until the twentieth century (**Figure 18**). While long-distance caravan activities through Asia or the Sahara have decreased or disappeared, short-distance transportation in remote areas of non-perishable goods such as salt, fodder (Brachet, 2004) or other items is still practised, including cross-border smuggling activities (Alary and Faye, 2016). Bactrian camels and dromedaries are also used to transport specific goods within the framework of social activities. One such example is the "camel library" in Kenya, which transports books to remote regions (Atuti, 1999).

Figure 18. A caravan of camels in the Algerian desert

Humans have also taken advantage of the strength and endurance of camels in agricultural work. Dromedaries have been used for ploughing, for example in Ethiopia and Morocco, where they were paired with donkeys or mules, for harrowing, hoeing and for other soil-based work. In Sahelian countries, dromedaries were also used to extract water from wells (*noria*) or for pound digging. In the Sudan, dromedaries worked in mills that extracted sesame oil (**Figure 19**). Draught and loading animals retained their economic importance throughout the twentieth century in some low- and middle-income countries, some of which have taken a renewed interest in their potential (Schwartz, 1986).

Figure 19. Use of camels for (a) ploughing in Morocco, (b) ploughing in Ethiopia, (c) work in sesame oil mills in the Sudan, (d) water extraction in the Niger, (e) carting agricultural goods in India, (f) harrowing firewalls in the Niger and (g) hoeing millet fields in the Niger

© Bernard Faye

The transport and draught power of camels is intrinsic to their usefulness in the desert. Camels have more pulling power than other livestock (Singh, 1999) and have demonstrated extraordinary capabilities to pull loads across desert sandy tracts even under hot and arid atmospheric conditions.

Some studies have been performed to assess the work power of camels, especially in India (Gupta *et al.*, 2010) and the Niger (Vias *et al.*, 2004). The optimum load carrying capacity for Bikaneri, an Indian dromedary breed used for pulling four-wheel carts, was estimated at 2.8 kg per kg body weight (Rai and Khanna, 1994). The animal could cover more than 25 km at almost 5 km/h under temperatures above 40°C. Regarding packing, loading values could surpass 200 kg and even reach 600 kg, attesting to the ability of caravaners to overload animals on occasions, disregarding animal welfare. In contrast, during colonial times, various regulations limited loads to 200 kg or even less (Faye, 2024).

Llamas

Llamas have played a significant role as transport animals in the history of the Andean region, particularly in pre-Columbian South America. Indigenous civilizations, such as the Inca, relied heavily on llamas for their ability to carry goods across the challenging terrain of the Anden highlands. The Incas also used llamas as pack animals for their conquests along the Andes. Neither llamas nor alpacas have been used for draught power in agriculture.

Llama caravans, known as *llamerías*, were vital for transporting food and textiles over long distances. These caravans connected isolated communities from the High Andes with communities on the coast, the Andean valleys and the slopes of the Andes towards the Amazon region. Different food crops produced in the respective agroecological zones were exchanged via barter trade.

Llamas are efficient pack animals and depending on the duration of the journey (several days to months), group sizes could range from 10 to 100 llamas (Iñiguez and Alem, 1996). During the journey, the animals fed on natural pasture and wild grasses, alleviating the need to carry food for the animals (Camino and Sumar, 1992). In general, castrated llama males were used for transport. Males were castrated at the age of 3 years and were used as pack animals for about 6–8 years (Iñiguez and Alem, 1996). The carrying capacity per animal amounted to 15–17 percent of its live weight, corresponding to 20–25 kg (Gauly, Vaughan and Cebra, 2011). Llamas can walk 8–10 hours per day, covering about 20 km.

Mining began to boom with the arrival of the Spaniards. Though not as strong as horses or donkeys, llamas proved indispensable on rugged, narrow mountain paths (Gauly, Vaughan and Cebra, 2011). Mercury, important for the silver mines, was transported by llama caravans from Huancavelica in present-day Peru to Potosi, now in the Plurinational State of Bolivia, over about 2 000 km.

The use of llamas as transport has lost importance over the decades, as better infrastructure now allows access with motor vehicles. Still, they remain important for transporting goods within farms or for shorter trips.

Llama used for transport, Peru

3.2. Tourism

Bactrian camels and dromedaries

Camels are widely used in tourism – for visits to the pyramids of Giza in Egypt (Wynne-Hughes, 2021), the Sahara Desert in Morocco (Amsidder *et al.*, 2024), Petra in Jordan (Chatelard, 2005) and the Great Wall of China (Zhou and Shu, 1995), among other notable destinations. Whether camel owners rent their camels for additional income or operate dedicated entrepreneurial outfits, camels can generate revenue while providing visitors with insights into some of the world's richest cultures – a service vital to sustainable and responsible tourism.

Overnight or multiday trekking can give visitors an opportunity to experience nomadic life. Even simple farm visits which feature short rides can offer value to both visitors and camel owners. In addition, value-added services help to create a dynamic business model. Items such as camel-hair textiles, camel milk and camel-milk products sold onsite can also create revenue for camel owners. In addition, camel-related cultural artifacts can be marketed to guests.

Tourists riding camels at the Great Pyramid of Giza, Egypt

Old caravan routes are ready-made for camel trekking and combine both history and culture (Shunnaq and Shunnaq, 2012). Trade in gold and salt form part of the history of the Sahara, and camel outfits in Morocco allow guests to relive a part of this history amid the endless dunes. Meanwhile, camel safaris in the Sinai of Egypt immerse visitors in Bedouin culture.

Camel-based tourism has also recently taken root in places that do not traditionally have camels, such as Australia, Europe, Mexico, Scandinavia, Thailand, the United States and even Jamaica.

Llamas

In Andean countries, some initiatives are working to revive the traditional use of llamas as pack animals, viewing this as an opportunity for ecotourism. In Europe and North America, there is also growing interest in using llamas for trekking tours with tourists. In this way, llamas are contributing to sustainable tourism as well as the economic livelihoods of their owners (Gauly, Vaughan and Cebra, 2011).

4 Markets and trade

Camelid meat, milk and fibre are sold across local, national and international markets, involving a variety of market structures and actors. Generally, only fibre and dromedary milk reach international markets, while other products are primarily traded locally and regionally. The marketing and trade of camelid products faces several challenges, including demand and price volatility, as well as the need to meet animal welfare standards.

4.1. Meat and meat products

Alpacas and llamas

This section provides information on the value chains of llama and alpaca meat in Peru and the Plurinational State of Bolivia. Production plays only a minor role in the neighbouring countries of Argentina, Chile and Ecuador, due to the small number of animals. Llama and alpaca meat is used either for personal consumption or sold on local markets, often through informal channels. Accordingly, little reliable data are available on the contribution of alpaca and llama meat to the local economy (Raggi, 2025).

The high incidence in South American camelids of sarcocystosis, a parasitic disease caused by the Sarcocystis genus, has resulted in low acceptance of South American camelid meat among consumers. This reluctance is exacerbated by the low hygienic standards of informal slaughterhouses commonly used by most alpaca and llama farms, who are unable to access certified establishments due to their remote location. Llama and alpaca meat is also sold at comparably higher prices compared to more affordable chicken meat (Raggi, 2025).

Alpaca and llama meat in Peru

The production of alpaca and llama meat in Peru has remained stable over recent years (**Table 10**), with annual consumption estimated at about 0.39 kg and 0.12 kg/person/year for alpaca and llama meat, respectively. However, there are large variations with the highest consumption rates found in rural areas and the Andean highlands (MIDAGRI, 2022).

Table 10. Production of alpaca and llama meat in Peru, 2019–2022

		2019	2020	2021	2022
Alpaca	Slaughtered animals (No. animals)	473 283	464 229	469 624	476 210
	Production of meat (tonnes)	12 579	12 362	12 581	12 753
	Yield (kg/animal)	27	27	27	27
	Price (Peruvian Soles/kg)	7.50	10.00	12.00	12.00
Llama	Slaughtered animals (No. animals)	115 790	113 685	117 682	118 241
	Production of meat (tonnes)	3 847	3 818	3 940	3 971
	Yield (kg/animal)	33	33	33	33
	Price (Peruvian Soles/kg)	7.50	10.00	12.00	12.00

Source: **DGDG (General Directorate of Livestock Development).** 2024. Perspectivas de políticas para el desarrollo de la cadena de carne de camélidos [Policy perspectives for the development of the camelid meat value chain]. In: *II Seminario Nacional Carne de Camelidos*, DESCOSUR, Arequipa, Peru. www.descosur.org.pe/wpcontent/uploads/2024/11/II-SEMINARIO-CARNE-DE-CAMELIDOS-1.pdf

Llama meat in the Plurinational State of Bolivia

In the Plurinational State of Bolivia, the majority of camelid meat production comes from llamas, as their numbers are significantly larger than that of alpacas. Llama meat consumption is confined primarily to the regions where llamas are raised, namely La Paz, Oruro, Potosí and Cochabamba. It is limited mostly to self-consumption by producers, who rely on the meat as a key source of animal protein, people who migrate to urban areas yet adhere to "customary traditions", and members of the middle class who appreciate its nutritional benefits.

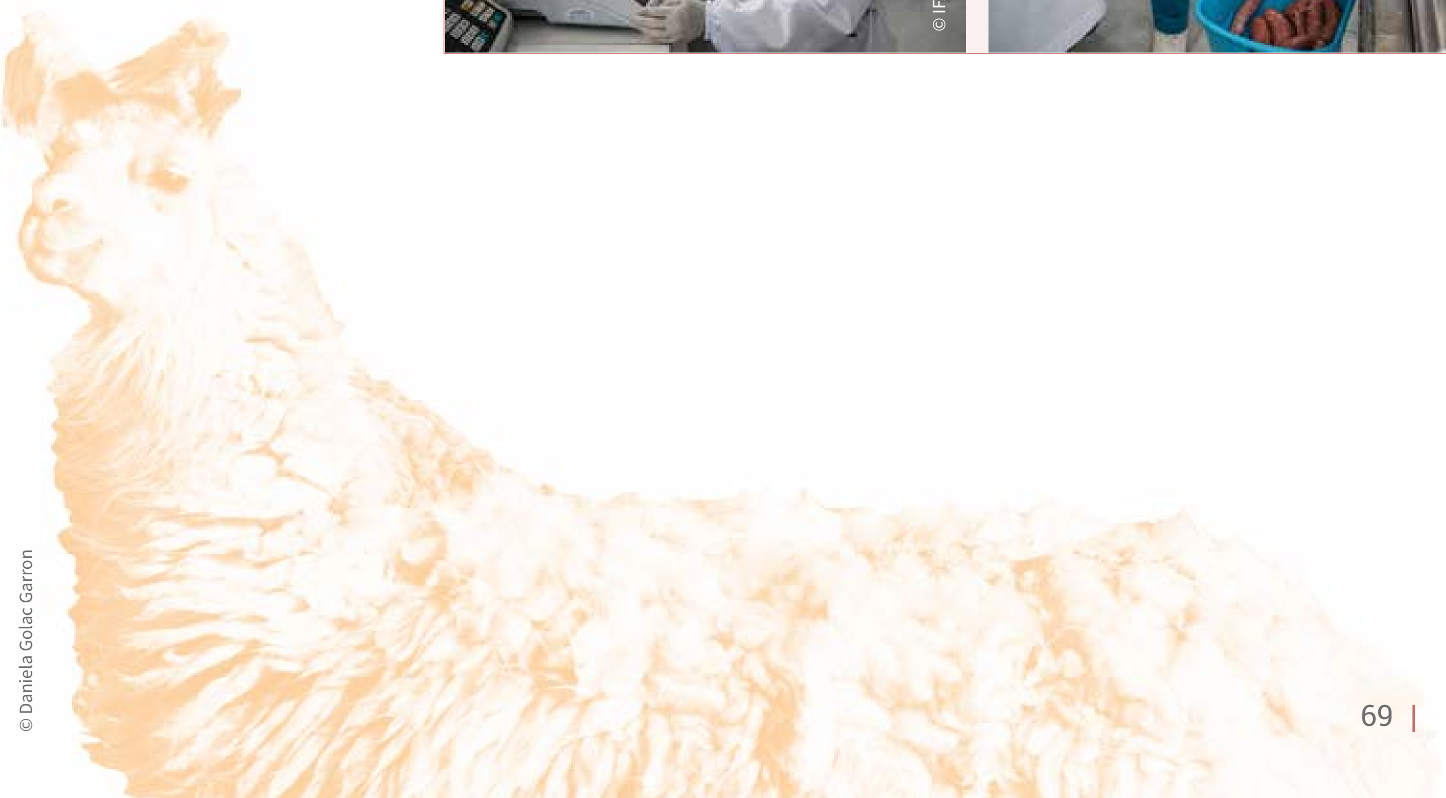
According to the Programa Empoderar (2018), per capita consumption of llama meat in the Plurinational State of Bolivia amounts to 0.57 kg per year. The cities with the highest consumption rates are El Alto (1.06 kg/year), followed by Oruro (1.03 kg), Potosí (0.56 kg), Santa Cruz (0.40 kg), Cochabamba (0.38 kg), La Paz (0.34 kg) and Sucre (0.22 kg per year).

Estimated yearly production of llama meat in the Plurinational State of Bolivia is approximately 16 660 tonnes (Programa Pro-camélidos, 2024) of which 19 percent is destined for self-consumption and 81 percent is sold as fresh meat, largely for processing into charqui and cold meats. The main producer of llama meat is the department of Oruro (50.9 percent), followed by Potosí (24.0 percent), La Paz (20.4 percent) and Cochabamba (3.1 percent).

Both formal and informal marketing channels cater to national and regional markets for llama meat. Producers typically sell live animals aged between 2 years and 7 years to *matanceros* (slaughterers). Another distribution route involves *acopiadores* (intermediaries), who generally buy younger animals, fatten them and resell them at a higher weight, and sell older animals directly to slaughterhouses.

Llama meat-processing units in the Plurinational State of Bolivia consist mostly of associations that produce charqui and other llama meat products, including chorizos, sausages, salami and canned picadillo. These associations supply government-run food programmes or supermarkets, trade fairs, camelid fairs and restaurants (Programa Pro-Camélidos, 2024). Over the last decade, the number of restaurants offering traditional dishes such as *charquekan orureño*, which feature llama charqui, has increased.

Processing of charqui and llama sausages at the *Asociación de Productores Agroganaderos de Turco* (APAT) in the Turco Municipality of Sajama Province in the department of Oruro, Plurinational State of Bolivia



Guanacos

The Argentinian government promotes guanaco meat production and exports, yet no public reports are available on international sales, harvest numbers or population surveys. The scientific community has advocated for the implementation of rigorous control protocols and traceability mechanisms in harvesting models, especially given the high incidence of sarcocystosis (Carmanchahi *et al.*, 2022a). At the local level, commercialization is limited, and guanaco meat is not commonly found in conventional markets, with sellers primarily targeting specific niches, such as high-end restaurants that offer exotic and locally sourced products.

Guanaco meat harvesting in Chile is conducted mainly by two companies in Tierra del Fuego (Soto Volkart and Molina Uriarte, 2016). Due to the high incidence of sarcocystosis (89.2 percent of meat is affected) and significant production costs, one company ceased production in 2016 (SAG, 2016), but submitted a new request for extraction quotes in 2019 (Soto Volkart and Molina Uriarte, 2016).

In order to enhance the sustainable commercialization of guanaco meat, improved traceability, detailed population studies and a clear marketing strategy are necessary to balance species conservation with local economic benefits.

In Chile, only 5.6 percent of hides are traded, as the market demands high-quality, sustainably sourced and certified products (Martegani, 2017). Interest in developing the guanaco hide industry in Chile remains low due to tanning difficulties; however, recent analyses show that Argentinian guanaco leather is of an acceptable quality for footwear manufacturing (Martegani, 2017).

Bactrian camels and dromedaries

Nowadays, the camel meat trade includes the local trade of carcasses, the international trade of frozen meat and processed products, and the regional trade of live animals for slaughter. Locally, the camel meat value chain generally involves a farmer, a camel dealer close to the farm (collection market), another camel dealer (grouping market) and a wholesaler and/or retailer butcher. Camels intended for local consumption are slaughtered either in official abattoirs (controlled slaughtering) or slaughtering areas/butchers (not necessarily controlled) or, less commonly, outside of the formal sector. The camel carcasses are then purchased by wholesalers and retailers, and ultimately sold as portions in small shops or restaurants. Not all of these stakeholders are necessarily specialized in the camel trade but may integrate camel meat into the chain between producers and butchers.

Live camels for export and import play an important role in regional markets (Faye *et al.*, 2013). The main flows are from:

- Sahelian countries (Chad, Mauritania, Mali, the Niger) to North Africa (mainly Morocco, Algeria, Libya), and following political insecurity in the Sahel, to coastal countries (mainly Guinea, Côte d'Ivoire, Nigeria and Senegal); and
- the Horn of Africa (Djibouti, Ethiopia, Kenya, Somalia and the Sudan) to Egypt and the Arabian peninsula (Faye, 2019).

This trade appeared in the nineteenth century when the British authorities in Somaliland began exporting live camels to supply the British military garrison of Aden in Yemen (Djama, 1999).

The regional trade in camels is partly informal, with exporters often seeking to evade taxes – some of which are unlawfully imposed at border crossings. Accordingly, official data on camel exports may not match the volume of slaughtered animals in importing countries due to significant gaps in information (Alary and Faye, 2016).

Dromedary camel market in Nouakchott, Mauritania

© Zied Ben Romdhane/Magnum photos for FAO

Exported camels are intended mainly for slaughter, with a few animals traded for breeding purposes in the milk-producing or racing sectors. Trading racing camels is common between countries of the Gulf States, where camel races are very popular.

In Asia, little data are available on the camel meat market, and the live camel market is not documented. Türkiye, for example, can import camels from neighbouring countries (the Islamic Republic of Iran, the Syrian Arab Republic), but this is usually done to obtain wrestling camels, rather than animals for slaughter. Turkmenistan, the country of origin of the highly productive Aruana dromedary breed, has restricted exports to Kazakhstan, where this breed is used for crossbreeding with Bactrian camels.

In general, camel meat value chains in Central Asia are not well organized, and are limited to local consumption in steppe areas, rarely reaching urban areas. Few meat-processing enterprises offer camel products (Shoman *et al.*, 2018).

In Australia, a significant population of feral camels is causing environmental problems in arid lands. One proposal to address this issue, and decrease pressure on these lands, involves capturing camels and exporting the frozen carcasses to China and the Near East (Virtue *et al.*, 2016).

Based on the only available official data (FAO, 2025), since 2017, global trade of camel meat has trended upwards, camel meat exports having almost doubled from an average of 1 000 tonnes per year to 1800 tonnes in 2023. However, the COVID-19 pandemic and political instability in the Sahel region reversed this trend, bringing trade volumes back to 2017 levels. Despite these challenges, the camel meat trade was valued at USD 7.4 million in 2023. Australia dominates the market, accounting for 60 percent of global exports by value, with Pakistan as the only significant competitor at 36 percent. All other exporting countries contribute 1 percent or less. On the import side, the United States leads, accounting for half of global camel meat purchases, followed by Morocco at 39 percent. Other importers include Belgium, Canada and Germany. It must be noted that these data concern meat carcasses, not living animals for slaughter abroad, as is the case in most importing countries (Egypt, Saudi Arabia, the United Arab Emirates).

© Muhammad Fathun

While foreign trade of camel meat is poised for expansion, driven largely by growing concerns over intensive production systems in the context of a fast-growing camel population, several challenges could impede this growth. Foremost among these is the fact that the camel meat value chain for the most part currently operates within informal or non-corporate market channels. As food safety regulations become increasingly stringent, this industry will need to transition to formal, corporate channels. This is already occurring, notably in the Near East and Central Asia, necessitating significant investments and the adoption of good practices. Another obstacle is the underdeveloped regulatory framework, which has not yet been fully refined to support market growth. It is worth noting that the Harmonized System for international trade has a specific code for camel meat, which facilitates market analysis, but that this advantage is not extended to camel dairy or other camel products, posing a significant challenge for those trying to navigate and develop these markets (Faye *et al.*, 2013).

4.2. Milk and milk products

Contrary to camel meat, milk from Bactrian camels and dromedaries was largely unavailable on the market until the end of the twentieth century. Central Asia during the Soviet era constituted an exception here, with newly established collective structures (*kolkhozes* and *sovkhozes*) supplying the urban market with fermented camel milk known as *shubat* (Konuspayeva and Faye, 2020). Elsewhere, camel milk was regarded as a gift for guests and members of the wider family, as well as for destitute people. Indeed, consideration of camel milk as a gift by camel pastoralists was regarded as a chief obstacle to the collection of camel milk among nomads, as noted by Nancy Abeiderrahmane, who founded one of the first industrial camel dairies, or “Tiviski”, in Mauritania in 1989 (Abeiderrahmane, 1997, 2013). Less than 20 years later, it was possible to find processed camel milk (mainly pasteurized) in supermarkets of key cities in the Near East, as well as in Central Asia and North Africa. Within a few years, camel milk had reached national markets, and with the development of a camel milk powder sector, it acquired a presence on the international market, selling via online platforms (Konuspayeva, Faye and Duteurtre, 2022).

This trajectory implied a considerable shift in perception, with camel milk moving from a gift economy to a market economy (Faye and Corniaux, 2024). However, self-consumption of camel milk remains very important, accounting for around 62 percent of camel milk produced in Saudi Arabia (Faye, Madani and El-Rouili, 2014) and even more in Sahelian countries – reaching 75 percent in Chad (Koussou, Mahamat and Grimaud, 2012). Of the 4.1 million tonnes of camel milk officially produced worldwide (FAO, 2025), only a small proportion reaches the market.

Machine milking of Bactrian camels, Mongolia

© FAO

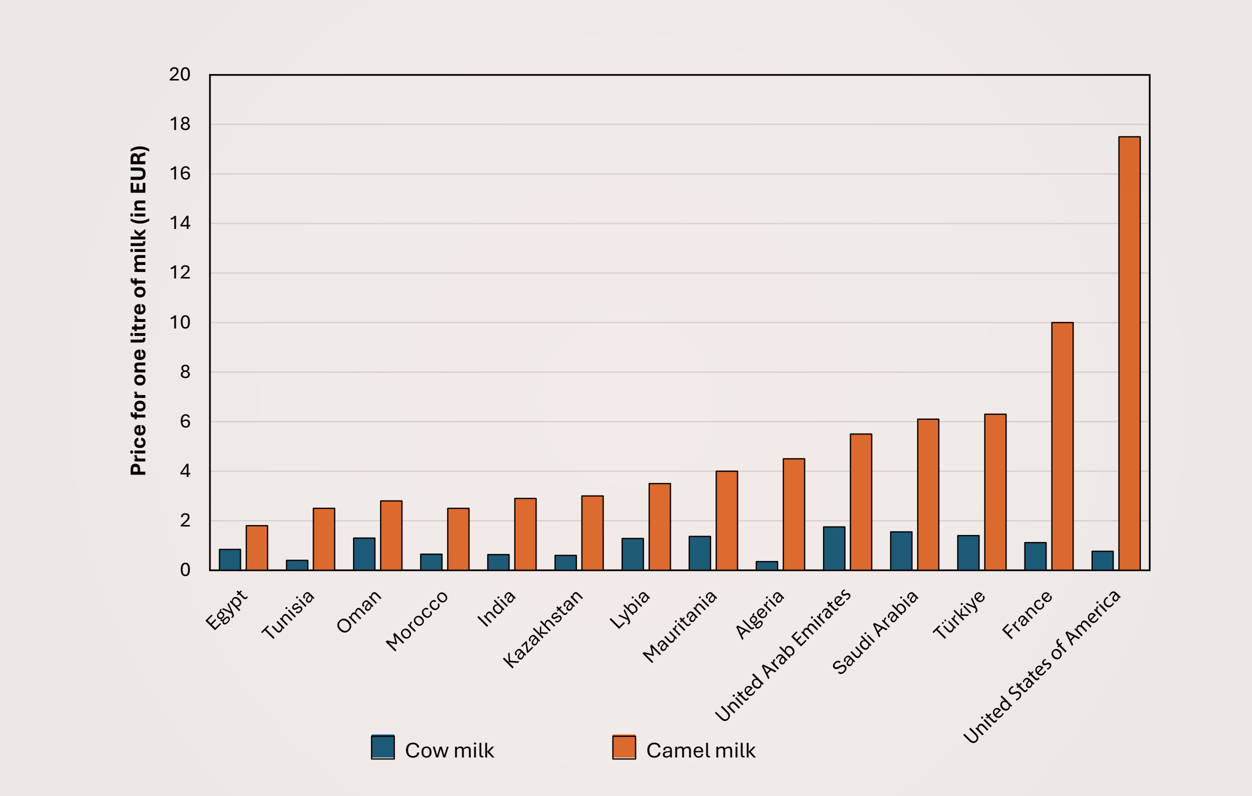
National markets

At the national level, the camel milk trade generally consists of four main subsectors:

- the *out-market subsector*, where camel milk remains part of the "gift economy" (self-consumption, free exchange) and accounts for the highest proportion of this milk, especially in Africa;
- the *informal subsector*, where raw (or sometimes fermented) camel milk is sold directly by producers to consumers or through informal carrier-collectors without quality control;
- the *formal subsector*, where camel milk is procured by collecting centres with quality control measures in place, before being delivered to processing plants, and then sold in specific shops or supermarkets at the local or national level; and
- the *integrated industrial subsector*, where milk-processing plants are integrated into big camel farms providing camel milk to national (often through their own network of shops) or international markets.

Dairy plants may specialize in processing camel milk, or not, but in all cases, the price of camel milk on the market is higher than that of cow milk, varying from double to 20 times more depending on the country, with health claims linked to camel milk often being a factor in commercial pricing (**Figure 20**).

Figure 20 Market price differentials between cow and camel milk (average EUR/L) in some countries



Source: **Faye, B.** 2023. Achievement of Work-Package no. 2. CAMILK PRIMA program: Boost the production, processing and consumption of camel milk in the Mediterranean basin. El-Oued, Algeria.

An important element supporting the formal camel milk subsector at the national level is a network of collecting centres, as producers are often widely distributed across the territory. For instance, milk collection points established in 2017 by a private company in the Dhofar region of Oman underpinned the establishment of a camel milk-processing unit, boosting production capacity (Khatun, Ahmed and Hasan, 2018). Similar observations can be made regarding the development of a formal camel milk subsector in Mauritania, with the creation of collecting centres in the Rosso region on the border with Senegal (Mohammed, 2003).

Going camel dairy. A climate-smart choice for Oman

In Oman, camels have long been bred for racing, a tradition deeply rooted in the nation's culture. However, in 2016, the country's Sustainable Agriculture and Rural Development Strategy towards 2040 proposed the harnessing of camels for dairy production. This strategic move aimed to capitalize on the unique potential of camels in the face of changing environmental conditions. One year later, the vision materialized with the establishment of a camel milk-processing unit in Salalah, boasting a capacity of 5 tonnes of milk per day. This marked the birth of the Al Murooj Dairy Company, a venture valued at USD 26 million, which blended centuries-old tradition with modern technology. Al Murooj has since set up milk collection points across Dhofar and other regions in Oman, ensuring a steady supply of fresh camel milk. Today, Al Murooj is a leader in the pasteurized camel milk market in the country, with plans to diversify its product line to meet the growing demands of both domestic and regional consumers.

The decision to invest in camel dairy has proven to be an opportune commercial move by Omani policymakers as well as also a practical response to the country's environmental realities. Given the increasing temperatures and limited water and land resources, camels have emerged as the ideal livestock for sustainable dairy production, placing them at the forefront of Oman's agricultural future. In addition, traditional camel dairy markets are undergoing considerable transformation, expanding into the global market to meet growing demand from consumers, who are attracted to the unique qualities of camel dairy for human health or are simply curious to try something new. The industry is responding to this demand but also innovating new processing technologies to extend the shelf-life of camel dairy products, from a few weeks to as long as 6–24 months. This offer includes a diverse range of products, from drinking milk to ice cream, milk powders and gourmet offerings like cheeses, creams and jams.

These ambitions necessitate a substantial upgrade in raw milk quality, driving the need for an enhanced value chain that incorporates rigorous food safety protocols. Such advancements require considerable investment, primarily from the private sector. Additionally, there is a growing need to rethink the selection of animal drugs for camels and to review regulations on antibiotic residues, as withdrawal periods in camelids are sometimes longer than in cattle (Khatun, Ahmed and Hasan, 2018).

International markets

Small-scale dairy plants that process camel milk have been established in Chad, Kenya, Mali and the Niger, while industrial dairy plants are operational in Central Asia, China and the Gulf countries. At present, only the Emirates Industry for Camel Milk & Products (EICMP) in Dubai has obtained an EU agreement for exporting milk to Europe, but other processing units in Australia, India, Kazakhstan and Kenya are able to supply a regional market by exporting to neighbouring countries. Small- or medium-scale dairy plants offering diversified products (pasteurized or fermented milk, cheese and ice cream, aromatized milk and milk powder) have been established in China, Europe (France and the Kingdom of the Netherlands) and the United States, where they contribute to supplying local and national markets and, through online platforms, the international market. The number of stakeholders globally is, however, limited.

According to the *Global Camel Milk Powder Professional Survey Report 2024* (Absolute Reports, 2024), the annual growth rate of the international market was estimated at 3.9 percent between 2011 and 2018. The same report estimated that the market could grow at an annual rate of 8 percent over the period 2019–2024. Internationally, growth is driven by the Chinese market, as in many other agricultural sectors. The same report projected that the Chinese camel milk powder market could potentially reach USD 189.36 million by 2027, growing at a rate of 8.4 percent from 2020 onwards. Europe, however, is not left behind. According to the same source, the value of the camel milk powder market would reach USD 881.36 million in 2027 worldwide (Konuspayeva, Faye and Duteurtre, 2022).

In Central Asia and the Near East, China remains the major market for camel dairy products, with an emphasis on milk powder. Independent experts estimate that this market accounts for around 50 tonnes per year.
The key to entering this market lies in adhering to strict food safety and quality standards, creating competition among major regional players, particularly from Kazakhstan and the United Arab Emirates. So far, only companies from Central Asia, specifically Kazakhstan and Mongolia, have successfully entered the Chinese market. Companies, mainly small- and medium-sized enterprises, engage in camel dairy development offering premium gourmet products online, in-store or through agrotourism experiences.

4.3. Fibre

Fibre from camels (dromedaries and Bactrian camels) and South American camelids (alpaca, llama, guanaco and vicuña) shares many valued textile properties including softness, strength and variety of natural colours. Due to these properties and the low volume harvested annually, compared to wool, cotton and synthetic fibres, they form part of the group of luxury animal fibres together with cashmere, mohair, yak and others. In 2023, animal fibre accounted for 1.0 percent of the global fibre market (about 1.3 million tonnes), with wool and silk making up the majority (90 percent and 6 percent, respectively) (Textile Exchange, 2024).

Alpacas, llamas, guanacos and vicuñas

Alpacas and llamas

This section provides a detailed overview of the value chains for alpaca fibre in Peru and for both llama and alpaca fibre in the Plurinational State of Bolivia, the textile industry contributing significantly to the economies of both countries. In neighbouring countries such as Argentina, Chile and Ecuador, fibre production plays a minor role due to the smaller animals populations, where the fibre is typically processed and sold locally in the form of handicrafts. In 2023, alpaca and llama fibre amounted to about 6 200 and 2 800 tonnes worldwide, respectively (Textile Exchange, 2024).

Alpaca fibre in Peru

Peru, with the largest alpaca population in the world, has a well-established textile industry. The many and different actors involved include producers, intermediaries, textile producers and clothing companies. More than 150 000 families are integrated into the various stages of the value chain undertaking tasks including alpaca rearing, fibre collection and processing, and selling of the final products (IAA, 2023).

In Peru, most producers operate small-scale farms and own on average about 50 animals (MIDAGRI, 2017). They make use of different marketing channels, depending on the farm's location and size and their membership (or not) of a producers' association or cooperative. They sell the raw material from their animals to intermediaries, who travel between remote areas where most farms are located and offer typically low prices. In some cases, these intermediaries sell the fibre to larger intermediaries, often at local markets.

The next set of actors in the value chain is brokers, who are financed by wholesalers. Financially better off, and in possession of storage facilities, this group is able to sell the purchased fibre when prices are high. Wholesalers are the final link in the unprocessed fibre supply chain. They collect the fibre and store it in warehouses in smaller cities in the Andean region. Financially supported by major processing companies, they transport the fibre to the city of Arequipa, where the textile industry is concentrated, accounting for at least 90 percent of Peru's total alpaca fibre production. Of the remaining fibre, a small portion is exported to the Plurinational State of Bolivia and the remaining is directed to artisan workshops where yarns are handmade and used by artisans to produce finished goods (INIA, 2020).

Since many actors are involved in the value chain and all want a share of the profits, the amounts realized by farmers are often very low. Since the price paid for the raw fibre is dictated mostly by weight and not quality, contamination of the fibre with stones and soil is a common practice to increase the weight. Some alpaca farmers have formed organizations to avoid the long and often non-transparent chain of intermediaries. These organizations traditionally take the form of non-profit civil associations, although recent years have seen the emergence of special producers' cooperatives. In either case, these groups seek support from public entities (municipal or central government programmes) to organize and run fibre collection centres, which are set up temporarily during shearing periods (November/December and March). The collection centres offer higher prices than the intermediaries, use proper scales and pay according to quality (INIA, 2020).

Growing concerns among consumers about animal welfare, land management and social welfare at the farm level have led to the development of Responsible Alpaca Standard (RAS) certification (Textile Exchange, 2021). In 2023, 7 percent of alpaca fibre produced worldwide was RAS certified (Textile Exchange, 2024).

The largest alpaca textile companies are Michell and the Inca Group (de Pereny, Ramlogan and Miozzo, 2020). Both are located in Arequipa and have more than 60 years' experience in the fibre market. The textile industry sells mainly semi-processed products in the form of "tops" – strands of clean, combed and scoured fibre (**Figure 21**) – and yarn, as well as consumer products like fabrics, garments and home textiles.

Figure 21. Alpaca fibre top

In 2023, the main alpaca textile products exported were tops, yarns and garments, accounting for approximately 43 percent, 24 percent and 22 percent of export value, respectively (PROMPERÚ, 2024). The exported products, encompassing raw fibre, garments and home textiles, have distinctive international markets. The main market for alpaca raw fibre and tops is China, where the Chinese textile industry processes the raw material into consumer products. The main destination markets for yarn are Italy, Norway, Sweden and the United States, the latter country also representing the principal market for fabrics and garments.

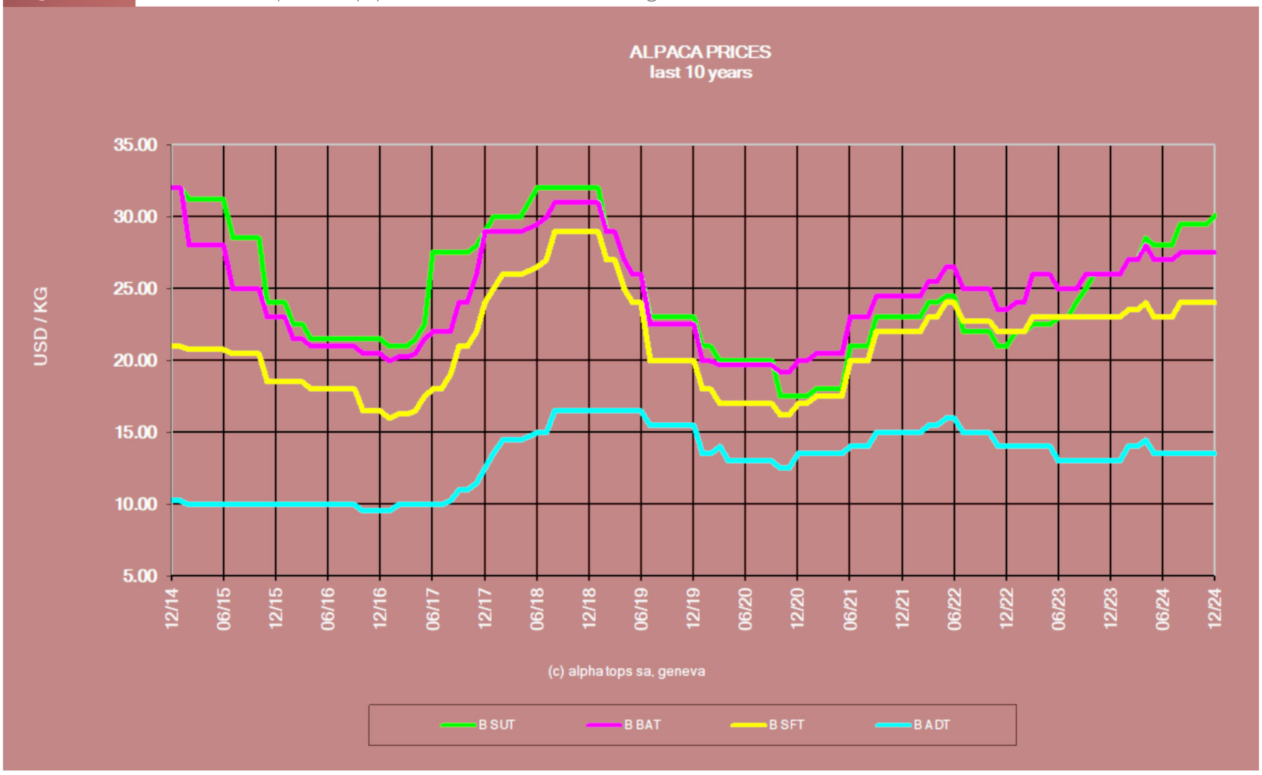
The value of alpaca product exports trended upwards between 2019 and 2023, with the exception of 2020 due to the COVID-19 pandemic (**Table 11**). During 2023, export value for alpaca products from Peru amounted to USD 214 million, increasing by 14.5 percent compared to the previous year (PROMPERÚ, 2024). However, the price of alpaca products is also highly volatile, as can be seen for tops (**Figure 22**), as demand depends on fashion trends.

Table 11. Evolution of alpaca product exports (2018–2023) from Peru (USD millions)

Products	Year				
	2019	2020	2021	2022	2023
Fibre	6	2	6	7	9
Tops	57	36	73	70	92
Yarns	40	32	48	42	51
Fabrics	4	3	3	4	4
Alpaca garments	43	29	39	50	46
Home textiles	9	8	15	13	12
Total	**159**	**110**	**184**	**186**	**214**

Source: Adapted from **PROMPERÚ (Trade, Tourism and Investment Commission of Peru).** 2024. Exportaciones 2023. [Exports 2023]. In *PROMPERÚ*. Lima. [Cited 29 April 2025]. https://hdl.handle.net/20.500.14152/6597

Figure 22. Trends in alpaca top prices, 2014–2024 (USD/kg)



Notes: B SUT: Suri; B BAT: Baby Huacaya; BSFT: Super Fine; B ADT: Adult Huacaya (coarse).

Source: **Alpha Tops.** 2024. Alpaca – Alpha Tops for alpaca, cashmere, mohair – scoured, web, tops and yarns. In: *Alpha Tops*. [Cited 11 November 2025]. www.alphatops.com/market/alpaca

Alpaca and llama fibre in the Plurinational State of Bolivia

In the Plurinational State of Bolivia, llama and alpaca fibre is produced, processed and sold on national and international markets either in the form of semi-processed products (yarn, tops) or as manufactured textiles (gloves, socks, hats, scarves, blankets, etc.).

At present, the supply of llama fibre in the Plurinational State of Bolivia amounts to approximately 415 tonnes per year. According to estimates, 7 percent comes from sheared live llamas; the remaining 93 percent is sheared from the hides of slaughtered animals (Quispe, 2024). Regionally, the largest producer of llama fibre is the department of Oruro, followed by Potosí, La Paz and Cochabamba.

Actors participating in fibre value chains in the Plurinational State of Bolivia include farmers, intermediaries, large textile companies and a variety of smaller enterprises of different types. At the start of the value chain are numerous, poor, small-scale producers in the Andean region. The negotiating power of these producers is weak, resulting in very low payments. A network of intermediaries organizes the collection of the raw fibre and sells it onto the textile companies. Farmers traditionally sell their fibre at communal and provincial fairs (Programa Pro-camélidos, 2019).

The camelid fibre textile industry in the Plurinational State of Bolivia is run by three main companies: YACANA, which is state owned; Consorcio de Fortalecimiento Integral de Productos de Camélidos (COFIPCA S.A.), formerly known as COPROCA S.A.; and ALTIFIBRES. These vertically integrated companies transform and commercialize semi-processed and final materials (tops, yarn and knitted and woven fabrics). In addition to these three companies, a small but diverse group of small, medium and large companies with different legal frameworks – family-owned or operated by associations – produce a variety of products from alpaca or llama fibre (Programa Pro-camélidos, 2024).

The high margins of handmade camelid garments sold abroad have led some governmental and non-governmental organizations to encourage the formation of urban-based associations, with a view to scaling up production, conducting quality control of garments, and facilitating commercialization and positioning in niche foreign markets. On average, these associations have more than 40 members and produce from 150 to 300 garments a month, including jumpers, blankets, waistcoats, gloves, stockings and leg warmers. The raw material they use combines handmade yarns dyed with natural vegetables and industrial yarns. Their main markets are the United States and some European and Asian countries (Programa Pro-camélidos, 2024).

Rural craft associations also have their origins in public and private interventions, which have encouraged a shift from rural domestic crafts to a more market-based approach. The Pro-camélidos Programme of the Ministry of Rural Development and Lands has supplied 52 rural associations with necessary infrastructure, equipment and raw materials. Ten of these associations in the department of Potosí produce llama yarn garments, which are marketed to tourists in the cities of Potosí and Uyuni (Programa Pro-camélidos, 2024). In addition, many informal family-run businesses source raw material locally, or spin the yarn themselves, selling knitted fabrics and other garments on nearby markets at a low price.

According to the Chamber of Exporters, Logistics and Investment Promotion of La Paz (CAMEX, 2024), exports of llama and alpaca products experienced a notable drop between 2018 and December 2023 (**Table 12**). In 2018, exports reached USD 12 985 816.33 (766.90 tonnes) but dropped to USD 4 853 104.22 (200.58 tonnes) in 2023. Although a trend towards recovery is perceptible from 2021 onwards, the stronger levels of the base year have not yet been reached.

Table 12. Bolivian exports of products related to camelid textiles (llama and alpaca), 2018–2023 (values in USD million)

Products	Year					
	2018	2019	2020	2021	2022	2023
Raw materials and inputs (yarn, tops and washed fibre)	10	7	2	3	2.5	4
Clothing (jumpers, waistcoats, dresses, coats, etc.)	2	2	1	1	0.6	0.4
Manufactured textile articles (gloves, socks, hats, scarves, blankets, etc.)	0.6	0.5	0.3	0.4	0.2	0.1
Total	**12.6**	**9.5**	**3.3**	**4.4**	**3.3**	**4.5**

Source: **CAMEX (Chamber of Exporters, Logistics and Investment Promotion of La Paz).** 2024. Análisis estadístico del sector camélido [Statistical Analysis of the Camelid Sector]. La Paz, CAMEX. https://camexbolivia.com/wp-content/uploads/2024/03/COMITE-DE-TEXTILES_Analisis-Estadistico-1.pdf

© FAO/Max Valencia

In 2023, the principal destinations for llama and alpaca raw material and textile exports were Italy (71 percent), China (21 percent) and France (3 percent), with other countries accounting for the remaining 5 percent. In the same year, llama and alpaca fibre clothing were exported to the United States (29 percent), Denmark (28 percent), France (11 percent), Germany (9 percent) and Italy (5 percent), with other countries amounting to 18 percent. Finally, the main destination countries for llama and alpaca textile accessories and articles were Denmark and the United States (both 22 percent), Japan (13 percent), Germany (11 percent) and Peru (9 percent), with other countries representing 23 percent (CAMEX, 2024).

Yarn of alpaca fibre

Guanacos and vicuñas

Value chain

The value chain for vicuña and guanaco fibre stretches from remote communities in the Andes of the Plurinational State of Bolivia and Peru, or ranches in the Argentinian Patagonia, via traders, processors and import and export authorities, all the way to designers, retailers and, finally, the end consumer. The value of the fibre increases with each level of processing. At the lower end of the spectrum is raw fibre, obtained immediately after shearing the animals, with no added value. At the other end is the production of industrial textiles aimed at the very wealthy. *Haute couture* designers, tailors, exclusive retailers and showrooms of leading luxury brands all process and sell vicuña fabrics.

The value chain consists of several key stages: raw fibre, washed fibre, dehaired fibre, top production and finally spinning – leading up to the design and manufacture of final products. While the initial stages of the value chain occur in Andean countries, the majority of the final processing takes place in Europe. Most value-adding activities for vicuña fibre are concentrated in Italy, with raw fibre comprising the largest volume of vicuña exports from Andean countries.

Primary production takes place in Andean countries. The fibre is then exported in various forms – greasy, pre-dehaired, dehaired or washed. For instance, in 2022, 47 percent of fibre exported from Peru was pre-dehaired, and 13.3 percent was dehaired (Flores, 2024).

In Argentina, guanaco fibre is produced by local cooperatives or individual farmers. The fibre is sold to one of two trading companies, which also source sheep wool from the same producers, benefiting from well-established relationships. These companies export both vicuña and guanaco fibre to Italy.

For vicuña fibre sales, the Plurinational State of Bolivia handles block transactions through the country's Community Association for Commercialization of Vicuña Fibre (ACOFIV). In Argentina, the communities that form the Andean Managing Communities of Vicuña (*Comunidades Andinas Manejadoras de Vicuñas*, CAMVI) also negotiate sales collectively to strengthen their bargaining power. In Peru, since the dissolution of the National Vicuña Society (*Sociedad Nacional de Criadores de Vicuna del Peru*), communities either sell their fibre through regional associations or individually.

At the garment-making stage, companies from Belgium, Germany and the United Kingdom, as well as a few from Australia, China, Japan and North America, enter the market for vicuña products. These companies purchase fabrics from Italian or British manufacturers, design styles and produce garments.

A small percentage of fibre is dehaired, spun and handwoven into handicrafts by local artisans. In the Catamarca and Jujuy provinces of Argentina, it is possible to purchase handmade ponchos and scarves crafted by local artisans using certified fibre. This practice not only supports the revival of ancestral weaving techniques but also provides an alternative source of income for local communities through the sustainable local use of vicuña fibre.

Fibre market

The vicuña and guanaco fibre market is an oligopsony with a few large buyers and many sellers (Lichtenstein, 2010). This market places control of the terms of trade and a significant portion of the profits in the hands of the buyers (Ribot and Peluso, 2003). It is theorized that this approach pushes down the price of the good, which seems to be the case. Although the four producer countries for vicuña (and one for guanaco) are technically in a position to establish sales prices, taking into consideration the small volume of fibre marketed in the world, in practice prices are imposed by intermediary or textile companies.

There is no formal market for vicuña or guanaco fibre, and no established set of "reference prices" as is the case for merino wool or cashmere (Lichtenstein, 2010). Historically, vicuña fibre prices have been influenced by factors such as market demand, the bargaining power of involved parties, cash flow issues, the volume of fibre in stock, the number of commercialization channels, and, in some cases, corruption in bidding processes (Lichtenstein, 2010). The volume of production is also crucial, as producers with smaller quantities often have no choice but to sell their fibre to middlemen at lower prices. Additionally, the remoteness of producers from final markets complicates negotiations.

In the case of guanaco, given that ranchers produce and sell the fibre individually, the small volume produced leaves them with no option but to sell the fibre to intermediaries for relatively low prices. Producers are unable to access international buyers, who consist of a small number of Italian companies with established relationships with traders (Carmanchahi *et al.*, 2022a).

Although guanaco fibre has long been exported to Europe, it is not as highly valued as vicuña, which is considered a symbol of status (Kasterine and Lichtenstein, 2018). According to fibre experts these two fibres possess similar physical attributes, colour and thickness, making them difficult to distinguish even with a microscope (Marino, personal communication, 2018). The potential for fibre mixing and the fact that the price of guanaco fibre is lower than that of vicuña fibre has probably led to some substitution in the industry (Carmanchahi *et al.*, 2022a). The lack of differentiation of guanaco fibre and inadequate market positioning, coupled with the inability of producers to capture value due to their weak price negotiating position, has led to price erosion and undermined producers' profitability as well as their interest in managing guanacos.

Fibre produced per country in 2012 and 2022–2023

Following the suspension of annual meetings of the Vicuña Convention in 2018, member countries have ceased submitting annual reports on fibre production, exports and vicuña conservation and management. This lack of reporting has fragmented data, making it difficult to access comprehensive information on fibre production and exports (**Table 13**), significantly impacting the traceability of fibre. In Argentina, for example, the country's federal structure means that each province maintains its own data; however, no national reports have been compiled in the absence of the Vicuña Convention Ordinary Meetings. Fortunately, the annual meetings of the Vicuña Convention resumed in April 2025.

Peru is the largest exporter of vicuña fibre, followed by the Plurinational State of Bolivia and Argentina. Fibre production in vicuñas is constrained by the species' biological characteristics – such as low fibre yield per animal, the need for biannual shearing and the unpredictability of the number of animals captured – as well as by conservation regulations, ecological limitations and the high organizational costs of sustainable harvesting. These combined factors restrict the overall volume and consistency of fibre supply. Bureaucratic delays sometimes result in fibre being exported one or more years after production.

The production of vicuña fibre in Andean countries has experienced an upward trend over the last decade or more (**Table 13**), likely due to growth in the vicuña population, the higher percentage of captured animals and the involvement of more communities and new stakeholders in species. management. In the case of Argentina, there has been a significant rise in fibre production by private companies. In 2022, fibre produced in Catamarca came from private enterprises (70.76 percent) and community captures (29.34 percent) (Ministry of the Environment, Government of Catamarca 2022). Similarly, in Peru, the number of managed vicuñas has also grown substantially.

Table 13. Production and exports of vicuña fibre from Argentina, the Plurinational State of Bolivia and Peru

	Production 2012 (kg)	Export 2012 (kg)	Production 2022 (kg)	Export 2022 (kg)	Production 2023 (kg)	Export 2023 (kg)
Argentina	672	779	2 854	1 025	2 162	2 487
Bolivia (Plurinational State of)	943	1 159	3 315	3 315	1 250	1 250
Peru	6 748	5 757	11 031	9 126	12 578	8 792

Source: Adapted from country reports to the Vicuña Convention.

Guanaco fibre is only exported from Argentina. Because of the absence of an open and transparent market for its fibre, production is much smaller than that of vicuña. Between 2021 and 2023, Argentina exported only 559.3 kg of guanaco fibre.

Demand and certification

Vicuña fibre is often referred to as "the fibre of the Gods" (Lichtenstein and Vilá, 2003), and as such, has an unparalleled status among luxurious, rare and expensive wools. The fibre epitomizes fine, artisanal craftsmanship and lightness, and has become a symbol of the highest quality in tailoring. Although guanaco fibre is not as internationally renowned as vicuña, it is still considered one of the finest luxury and specialty fibres, valued for its rarity and soft texture.

Yarn made of guanaco fibre

The fashion industry is currently undergoing a paradigm shift, increasingly promoting the use of higher-quality natural materials, environmentally responsible production, ethical management practices and respect for animal rights. This shift also emphasizes the generation of quality employment throughout the entire production chain, from raw material sourcing to product design. In this context, fibre obtained from wild South American camelids, managed with high animal welfare standards and following good practice protocols, aligns with this consumption model. Such practices could increase the value of guanaco fibre as an environmentally sustainable material that benefits local communities. For vicuña management, producing certified fibre could further enhance animal welfare standards. Wild-sourced and sustainably harvested vicuña and guanaco fibres could potentially earn certifications like the Global Organic Textile Standard or Wildlife Friendly, thereby increasing their market value.

Bactrian camels and dromedaries

Few data are available regarding camel wool market. The wool of dromedaries is of low quality, and is not deemed valuable. In North Africa, Mauritania and India, camel wool (known as *ouber*) is collected by small-scale cooperatives to make traditional clothes or carpets, a process that is managed mainly by women and that targets the national tourist sector (Rabehi *et al.*, 2023).

Conversely, wool from Bactrian camels is highly valued and integrated into international markets aimed principally at the fashion industry in China, Europe and the United States (Lakshmanan, Jose and Chakraborty, 2016). In China, Mongolia and, more recently, Kazakhstan (Alibayev *et al.*, 2020), this sector is developing due to improvements in the quality of collected wool, processing in modern and innovating spinning mills, and modernization of the proposed final products, which consist mainly of clothes and blankets (Pacheco-Lopez, 2011). Other countries such as Afghanistan, the Islamic Republic of Iran and the Russian Federation have begun to initiate trade in this sector.

The processing of wool fibres in producing countries enables those countries to retain the added value. However, in Kazakhstan and Mongolia, for example, important price differentials have led to raw material being smuggled to Chinese factories. In response, and with the support of the European Union, the Mongolian government has established “Gobi Desert camel wool” as a “Geographical Indication”, thereby guaranteeing the wool’s origin.
This certification requires that all processing steps are undertaken in Mongolia. Registered producers can apply the Geographical Indication logo as well as their own trademarks. Estimated at more than 1 067 tonnes in 2010 (Nansalmaa, Otgonjargal and Altantuya, 2013), production in Mongolia may now surpass 1 600 tonnes of which more than 80 percent is exported. Globally, between 4 500 and 5 000 tonnes of Bactrian wool are available on the market (Veit, 2022).

Camel hide is also poorly valorized in many countries (Mwinyihija and Mekonnen, 2016). The prevalence of skin diseases, the poor conditions of collection and storage, the low quality of processing and the lack of tanneries are among the main constraints in this sector. However, local and regional trade in camel hide exists, even if it is weakly documented. In Africa, the camel skin trade consists of three main subsectors: (i) local processing in traditional or modern tanneries to supply the touristic sector with medium- or high-quality final products (e.g. in Morocco or Tunisia); (ii) production for regional or international markets aimed at supplying processors mainly in Europe (Italy), China or South Asia (India, Pakistan) with high-quality raw material (Wanyoike *et al.*, 2018); and (iii) export of raw skin to coastal countries (Ghana, Nigeria) where camel skin is used as food. In Asia, modern tanneries have been established to add significant value to camel skins for the luxury sector in the United Arab Emirates, among others.

© Tuvshinbayar Tumur

References

Abdallah, H.R. & Faye, B. 2013. Typology of camel farming system in Saudi Arabia. *Emirates Journal of Food and Agriculture*, 25(4): 250. https://doi.org/10.9755/ejfa.v25i4.15491

Abdeen, E-S.M., El-Shafei, S.M.S. & Khalifa, S.A. 2019. Manufacture of processed cheese spread from camel cheese based: Evaluation of cheese characteristics. *American Journal of Food Science and Nutrition Research*, 5(4): 76–86.

Abdelgadir, W.S., Ahmed, T.K. & Dirar, H.A. 1998. The traditional fermented milk products of the Sudan. *International Journal of Food Microbiology*, 44(1): 1–13. https://doi.org/10.1016/S0168-1605(98)00090-7

Abdelhadi, O., Babiker, S., Faye, B. & Kijora, C. 2011. Effect of ageing time on chemical composition and quality of the desert camel meat (*Camelus dromedarius*). In: *Development on the margin – Tropentag 2011*. International Research on Food Security, Natural Resource Management and Rural Development, Bonn, Germany, 5 October 2011. www.tropentag.de

Abdelhadi, O.M.A., Babiker, S.A., Picard, B., Jurie, C., Jailler, R., Hocquette, J.F. & Faye, B. 2012. Effect of season on contractile and metabolic properties of desert camel muscle (*Camelus dromedarius*). *Meat Science*, 90(1): 139–144. https://doi.org/10.1016/j.meatsci.2011.06.012

Abdelzaher, H., Alsuhaymi, M., Alshammari, F., Alshammari, S. & Alshammari, Z. 2020. Evaluation of the effectiveness of virgin camel's urine as antifungal agents. *Journal of Bacteriology & Mycology: Open Access*, 8(4): 124–128. https://doi.org/10.15406/jbmoa.2020.08.00284

Abeiderrahmane, N.J. 1997. Camel milk and modern industry. *Journal of Camel Practice and Research*, 4(2): 223–228.

Abeiderrahmane, N.J. 2013. *Camel cheese – seemed like a good idea*. Nouakchott, Mauritania, Nancy Jones Abeiderrahmane. https://africabib.org/rec.php?RID=396440258&DB=w

Absolute Reports. 2024. *Global camel milk powder professional survey report 2024, forecast to 2029.* Maharashtra, India. www.absolutereports.com/global-camel-milk-powder-professional-survey-report-2024-forecast-to-2029-28080728

Ahmed, A.S.M. & El-Zubeir, I. 2015. Microbiological and sensory properties of low fat ice cream from camel milk using natural additives. *Annals of Food Science and Technology*, 16: 236–244.

Akbar, K.M., Alhajeri, B.H. & Alhaddad, H. 2024. Fiber characteristics of the dromedary camel in the Arabian Peninsula. *Small Ruminant Research*, 235: 107276. https://doi.org/10.1016/j.smallrumres.2024.107276

Akhmetsadykova, S., Baubekova, A., Konuspayeva, G., Akhmetsadykov, N., Faye, B. & Loiseau, G. 2015. Lactic acid bacteria biodiversity in raw and fermented camel milk. *African Journal of Food Science and Technology*, 6(3): 84–88. http:/dx.doi.org/10.14303/ajfst.2015.026

Alary, V. & Faye, B. 2016. The camel chains in East Africa: Importance of gaps between the data and the apparent reality. *Journal of Camelid Science*, 9: 1–22.

Algruin, K. & Konuspayeva, G. 2015. Making leben with camel milk. In: G. Konuspayeva, ed. *Proceedings of the 4th Conference of ISOCARD, "Silk Road Camel: The Camelids, Main Stakes for Sustainable Development", Almaty, Kazakhstan, 8–12 June 2015*.

Alhaider, A.A., Bayoumy, N., Argo, E., Gader, A.G. & Stead, D.A. 2012. Survey of the camel urinary proteome by shotgun proteomics using a multiple database search strategy. *PROTEOMICS*, 12(22). https://analyticalsciencejournals.onlinelibrary.wiley.com/doi/10.1002/pmic.201100631

Alhaider, A.A., El Gendy, M.A.M., Korashy, H.M. & El-Kadi, A.O.S. 2011. Camel urine inhibits the cytochrome P450 1a1 gene expression through an AhR-dependent mechanism in Hepa 1c1c7 cell line. *Journal of Ethnopharmacology*, 133(1): 184–190. https://doi.org/10.1016/j.jep.2010.09.012

Alhaj, O.A., Altooq, N.J., Alenezi, A.F., Janahi, A.I., Janahi, M.I., Humood, A.M., AlRasheed, M.M. *et al.* 2022. Camel milk composition by breed, season, publication year, and country: A global systematic review, meta-analysis, and meta-regression. *Comprehensive Reviews in Food Science and Food Safety*, 21(3): 2520–2559. https://doi.org/10.1111/1541-4337.12943

Alhaj, O.A., Metwalli, A.M. & Elsayed, A.I. 2011. Heat stability of camel milk proteins after sterilisation process. *Journal of Camel Practice and Research*, 18(2): 277–282.

Ali, A., Baby, B. & Vijayan, R. 2019. *From Desert to Medicine: A Review of Camel Genomics and Therapeutic Products.* Lima, Peru, Universidad Nacional Agraria La Molina. www.frontiersin.org/journals/genetics/articles/10.3389/fgene.2019.00017/full

Ali, I.M. 2023. Perceived effects of selected factors on camel productivity in Mandera County, Kenya. KeMU. Master's thesis. http://repository.kemu.ac.ke/handle/123456789/1617

Alibayev, N., Semenov, V., Baimukanov, A., Ermakhanov, M. & Abuov, G. 2020. Monitoring the development of young camels and wool quality camels of Kazakhstan population. *IOP Conference Series: Earth and Environmental Science*, 604(1): 012026. https://doi.org/10.1088/1755-1315/604/1/012026

Alkhamees, O.A. & Alsanad, S.M. 2017. A review of the therapeutic characteristics of camel urine. *African Journal of Traditional, Complementary and Alternative Medicines*, 14(6): 120–126. https://doi.org/10.21010/ajtcam.v14i6.12

Al-Otai, M., Al-Zore, N. & El-Derm, H. 2013. Camel's milk as a natural source for probiotics. *Research Journal of Microbiology*, 8: 70–80. https://doi.org/10.3923/jm.2013.70.80

Al-Owaimer, A.N. 2000. Effect of dietary halophyte *Salicornia bigelovii Torr* on carcass characteristics, minerals, fatty acids and amino acids profile of camel meat. *Journal of Applied Animal Research*, 18(2): 185–192. https://doi.org/10.1080/09712119.2000.9706342

Alvarez Ascue, P.E. 2018. *Características tecnológicas del cuero para capellada de alpaca Huacaya (Lama pacos) adulta, curtido mediante los métodos Wet-White y Wet-Blue* [Technological characteristics of the leather for uppers made from adult Huacaya alpaca (*Lama pacos*), tanned using the Wet-White and Wet-Blue methods]. Lima, Universidad Nacional Agraria La Molina. https://hdl.handle.net/20.500.12996/3455

Al-Yousef, N., Gaafar, A., Al-Otaibi, B., Al-Jammaz, I., Al-Hussein, K. & Aboussekhra, A. 2012. Camel urine components display anti-cancer properties *in vitro*. *Journal of Ethnopharmacology*, 143(3): 819–825. https://doi.org/10.1016/j.jep.2012.07.042

Amina, R., Habiba, R. & Abouddihaj, B. 2024. Camel urine as a potential source of bioactive molecules showing their efficacy against pathogens: A systematic review. *Saudi Journal of Biological Sciences*, 31(5): 103966. https://doi.org/10.1016/j.sjbs.2024.103966

Ampuero, E. 2006. Beneficio técnico y elaboración de charqui de alpaca [Technical processing and production of alpaca jerky]. Conference presentation at Seminario Internacional: Sistemas de producción e industrialización de camélidos americanos, 2006, Lima.

Amsidder, L., Alary, V., Duteurtre, G. & Mnaouer, I. 2024. The economic contribution of camel-based livestock systems in North-African drylands: The case of East and South Moroccan provinces. *Pastoralism: Research, Policy and Practice*, 14: 13600. https://doi.org/10.3389/past.2024.13600

Anwar, S., Ansari, S.A., Alamri, A., Alamri, A., Alqarni, A., Alghamdi, S., Wagih, M.E. *et al*. 2021. Clastogenic, anti-clastogenic profile and safety assessment of camel urine towards the development of new drug target. *Food and Chemical Toxicology*, 151: 112131. https://doi.org/10.1016/j.fct.2021.112131

Arnold, R.N., Scheller, K.K., Arp, S.C., Williams, S.N. & Schaefer, D.M. 1993. Dietary α-tocopheryl acetate enhances beef quality in holstein and beef breed steers. *Journal of Food Science*, 58(1): 28–33. https://doi.org/10.1111/j.1365-2621.1993.tb03203.x

Asiimwe, R., Ainembabazi, J.H., Egeru, A., Isoto, R., Aleper, D.K., Namaalwa, J. & Diiro, G.M. 2020. The role of camel production on household resilience to droughts in pastoral and agro-pastoral households in Uganda. *Pastoralism*, 10(1): 5. https://doi.org/10.1186/s13570-020-0160-x

Attia, H., Kherouatou, N., Nasri, M. & Khorchani, T. 2000. Characterization of the dromedary milk casein micelle and study of its changes during acidification. *Le Lait*, 80(5): 503–515. https://doi.org/10.1051/lait:2000141

Atuti, R.M. 1999. Camel library service to nomadic pastoralists: The Kenyan scenario. *IFLA Journal*, 25(3): 152–158. https://doi.org/10.1177/034003529902500305

Ayyash, M., Al-Dhaheri, A.S., Al Mahadin, S., Kizhakkayil, J. & Abushelaibi, A. 2018. In vitro investigation of anticancer, antihypertensive, antidiabetic, and antioxidant activities of camel milk fermented with camel milk probiotic: A comparative study with fermented bovine milk. *Journal of Dairy Science*, 101(2): 900–911. https://doi.org/10.3168/jds.2017-13400

Baba, W.N., Rasool, N., Selvamuthukumara, M. & Maqsood, S. 2021. A review on nutritional composition, health benefits, and technological interventions for improving consumer acceptability of camel meat: an ethnic food of Middle East. *Journal of Ethnic Foods*, 8(1): 18. https://doi.org/10.1186/s42779-021-00089-1

Babiker, S.A. & Yousif, O.Kh. 1990. Chemical composition and quality of camel meat. *Meat Science*, 27(4): 283–287. https://doi.org/10.1016/0309-1740(90)90066-F

Bacchi, C.S., Lanari, M.R. & von Thüngen, J. 2010. Non-genetic factors affecting morphometric and fleece traits in guanaco (*Lama guanicoe guanicoe*) populations from Argentinean Patagonia. *Small Ruminant Research*, 88(1): 54–61. https://doi.org/10.1016/j.smallrumres.2009.11.011

Badawy, S., Liu, Y., Guo, M., Liu, Z., Xie, C., Marawan, M.A., Ares, I. *et al.* 2023. Conjugated linoleic acid (CLA) as a functional food: Is it beneficial or not? *Food Research International (Ottawa, Ont.)*, 172: 113158. https://doi.org/10.1016/j.foodres.2023.113158

Bakhsh, R.S., Noor, S.O., Khorshid, F.A.R., Alsulaimany, F.A., Alzahrani, A., Najjar, A.A. & Al-Hejin, A. 2019. The antibacterial activity of a fraction extracted from camel urine against mycobacterium tuberculosis isolated from tuberculosis patients in Jeddah City. *Advances in Environmental Biology*, 13(4): 1–6. https://doi.org/10.22587/aeb.2019.13.4.1

Baubekova, A., Akhmetsadykova, S., Konuspayeva, G., Akhmetsadykov, N., Faye, B. & Loiseau, G. 2015. Biodiversity study of the yeast in fresh and fermented camel and mare's milk by denaturing gradient gel electrophoresis. *Journal of Camel Practice and Research*, 22(1): 91–95. https://doi.org/10.5958/2277-8934.2015.00014.4

Bekhit, A.E. & Farouk, M.M. 2013. Nutritive and health value of camel meat. In: I. Kadim, O. Maghoub, B. Faye & M. Farouk, eds. *Camel meat and meat products.* pp. 205–223. CABI Books. https://doi.org/10.1079/9781780641010.0205

Ben Semaoune, Y., Senoussi, A. & Faye, B. 2019. Typologie structurale des élevages camelins au Sahara septentrional Algérien – cas de la willaya de Ghardaïa [Structural typology of camel farms in the northern Algerian Sahara – case of the wilaya of Ghardaïa]. *Livestock Research for Rural Development*, 31(2). www.lrrd.org/lrrd31/2/semao31024.html

Berhe, T., Ipsen, R., Seifu, E., Kurtu, M.Y., Fugl, A. & Hansen, E.B. 2019. Metagenomic analysis of bacterial community composition in Dhanaan: Ethiopian traditional fermented camel milk. *FEMS Microbiology Letters*, 366(11): fnz128. https://doi.org/10.1093/femsle/fnz128

Berhe, T., Seifu, E. & Kurtu, M.Y. 2013. Physicochemical properties of butter made from camel milk. *International Dairy Journal*, 31(2): 51–54. https://doi.org/10.1016/j.idairyj.2013.02.008

Bernabé Soles, P.E. 2015. *Comparación de las características textiles de las fibras de la llama Ch'aku (Lama glama) y la alpaca Huacaya (Vicugna pacos) den Centro de Investigación y Desarrollo de Camélidos Sudamericanos – Lachocc* [Comparison of the textile characteristics of the fibres of the Ch'aku llama (*Lama glama*) and the Huacaya alpaca (*Vicugna pacos*) at the South American Camelid Research and Development Centre – Lachocc]. Trujillo, Peru, Universidad Nacional de Trujillo. Thesis.

Berolatti Obando, G., Ruiz Mejía, L., Cabrera Bustamante, F.A., Aliaga Gutiérrez, J., Quispe Bonilla, M.D. & Quispe Peña, E.C. 2021. Evaluación de la medulación de fibras de lanas y fibras especiales de algunas especies de animales [Evaluation of the medullation of wool fibres and special fibres from some animal species]. *Revista de Investigaciones Veterinarias del Perú*, 32(5): e17639. https://doi.org/10.15381/rivep.v32i5.17639

Bilal, Z., Akhmetsadykova, S., Baubekova, A., Tormo, H., Faye, B. & Konuspayeva, G. 2024a. The main features and microbiota diversity of fermented camel milk. *Foods*, 13(13): 1985. https://doi.org/10.3390/foods13131985

Bilal, Z., Kondybayev, A., Ospanova, A., Tormo, H., Akhmetsadykova, S., Amutova, F., Faye, B. & Konuspayeva, G. 2024b. Volatile organic compounds of camel milk and shubat across Kazakhstan's regions, seasons, and breeds. *Heliyon*, 10(15): e35365. https://doi.org/10.1016/j.heliyon.2024.e35365

Biya, M.B., Chrif Ahmed, M.S., Dieye, C.Y., Diop, A.K.M., Mohamed, R.B., Salem, M.M., Sidatt, M. *et al.* 2021. Typologie descriptive des systèmes d'élevage camelin en Mauritanie [Descriptive typology of camel farming systems in Mauritania]. *Livestock Research for Rural Development*, 33(3). www.lrrd.org/lrrd33/3/bjfaye3344.html

Bonavia, D. 2008. *The South American Camelids*. Vol. 64. Los Angeles, CA, Cotsen Institute of Archaeology Press at UCLA. https://doi.org/10.2307/j.ctvhhhg7z

Boughey, I., Hall, E. & Bush, R. 2024. Australian alpaca demographics and management: A National Survey. *Animals*, 14(19): 2861. https://doi.org/10.3390/ani14192861

Boulay, S. 2008. Alimentation, diététique et relations sociales au Sahara L'exemple des pasteurs nomades maures de Mauritanie [Food, diet and social relations in the Sahara: The example of nomadic Moorish pastoralists in Mauritania]. *OCHA (Observatoire Cniel des Habitudes Alimentaires)*. www.lemangeur-ocha.com/wp-content/uploads/2012/04/S-Boulay-alimentation-sahara.pdf

Brachet, J. 2004. Le négoce caravanier au Sahara central : histoire, évolution des pratiques et enjeux chez les Touaregs Kel Aïr (Niger) [Caravan trade in the central Sahara: History, evolution of practices and challenges among the Kel Aïr Tuareg (Niger)]. *Les Cahiers d'Outre-Mer. Revue de géographie de Bordeaux*, 57(226–227): 117–136. https://doi.org/10.4000/com.512

Bryant, F.C., Florez, A. & Pfister, J. 1989. Sheep and alpaca productivity on high Andean rangelands in Peru. *Journal of Animal Science*, 67: 3078–3095.

Bustinza Choque, A.V. 2001. *La Alpaca: Crianza, Manejo y Mejoramiento* [The Alpaca: Breeding, Management and Improvement]. Huarez, Peru, UNASAM. https://biblioteca.unasam.edu.pe/cgi-bin/koha/opac-detail.pl?biblionumber=282&shelfbrowse_itemnumber=476

Butler, G., Ali, A.M., Oladokun, S., Wang, J. & Davis, H. 2021. Forage-fed cattle point the way forward for beef? *Future Foods*, 3: 100012. https://doi.org/10.1016/j.fufo.2021.100012

Caballero Armas, W. & Flores Mere, A. 2004. *La Sierra: Primera prioridad para salir del subdesarrollo agrario* [The Sierra: First priority to overcome agricultural underdevelopment]. Lima, Concytec. www.librosperuanos.com/libros/detalle/7458/La-Sierra-Primera-prioridad-para-salir-del-subdesarrollo-agrario

CAMEX (Chamber of Exporters, Logistics and Investment Promotion of La Paz). 2024. *Análisis estadístico del sector camélido* [Statistical Analysis of the Camelid Sector]. La Paz, CAMEX. https://camexbolivia.com/wp-content/uploads/2024/03/COMITE-DE-TEXTILES_Analisis-Estadistico-1.pdf

Camino, A. & Sumar, J. 1992. The Andean camelids, llama and alpaca; the potentials and prerequisites for introducing these animals into other mountain environments. *ICIMOD Mountain Farming Systems Discussion Paper*, 33. Kathmandu. https://doi.org/10.53055/ICIMOD.135

Candio, J., Tolentino, J. & Trejo, W. 2024. Características tecnológicas del cuero de llama mediante el método Wet-Blue [Technological characteristics of llama leather using the Wet-Blue method]. In: *III Seminario Internacional en Producción Sostenible en Camélidos Sudamericanos: Asegurando la Biodiversidad* (p. 181). Lima. www.cip.org.pe/publicaciones/2025/enero/portal/libro-iii-sem-prod-camelidos-sudamericanos-edicion-digital.pdf

Carmanchahi, P., Lichtenstein, G., Gregorio, P.F., Panebianco, A., Marozzi, A., Leggieri, L., Peña, F. & Ovejero, R. 2022a. Guanaco sustainable management as a conservation and rural development strategy. In: P. Carmanchahi & G. Lichtenstein, eds. *Guanacos and people in Patagonia: A social-ecological approach to a relationship of conflicts and opportunities.* pp. 147–190. Natural and Social Sciences of Patagonia (NSSP). Berlin, Springer International Publishing. https://doi.org/10.1007/978-3-031-06656-6_7

Carmanchahi, P., Rago, V., Gregorio, P., Panebianco, A. & Marozzi, A. 2022b. Actualización de los criterios de bienestar animal para el aprovechamiento sustentable de la fibra de guanacos silvestres [Update of animal welfare criteria for the sustainable use of wild guanaco fibre]. *GECS News*, 9: 9–20.

Chatelard, G. 2005. Desert tourism as a substitute for pastoralism? Tuareg in Algeria and Bedouin in Jordan. In: D. Chatty, ed. *Nomadic Societies in the Middle East and North Africa: Entering the 21st Century.* pp. 710–736. Leiden, the Kingdom of the Netherlands, Brill. https://hal.science/hal-00338450

Contreras, A. 2010. Estructura y características físicas de la fibra de Alpaca Huacaya (Vicugna pacos) de color blanco [Structure and physical characteristics of the white Huacaya Alpaca (*Vicugna pacos*) fibre]. Huancavelica, Peru, Universidad Nacional de Huancavelica. Thesis.

Davis, H., Magistrali, A., Butler, G. & Stergiadis, S. 2022. Nutritional benefits from fatty acids in organic and grass-fed beef. *Foods*, 11(5): 646. https://doi.org/10.3390/foods11050646

Dawood, A.A. & Alkanhal, M.A. 1995. Nutrient composition of Najdi-camel meat. *Meat Science*, 39(1): 71–78. https://doi.org/10.1016/0309-1740(95)80008-5

Djama, M. 1999. *Producteurs pastoraux et commerce international : l'évolution des rapports marchands en pays Nord-Somali* [Pastoral producers and international trade: The evolution of trade relations in Northern Somalia]. In: A. Bourgeot, ed. *Horizons nomades en Afrique sahélienne : sociétés, développement et démocratie*. Colloque international sur les sociétés pastorales en Afrique sahélienne, Agadez, Niger, 3 November 1997 – 7 November 1997, Université de Niamey, CNRS, EHESS. Paris, Karthala. https://agritrop.cirad.fr/392056/

Dogondaji, R.A., Wasagu, R.S.U. & Umar, S. 2023. Analyses of proximate composition of raw urine of some female camels (*Camelus dromedarius*) in Sokoto, Nigeria. *PSM Biological Research*, 8(3): 86–91.

Doria, G. 2005. *Características tecnológicas de la napa de piel de alpaca (Lama pacos)* [Technological characteristics of alpaca (*Lama pacos*)]. Lima, Universidad Nacional Agraria La Molina.

Dowelmadina, I.M.M., Zubeir, I.E.M.E.I., Arabi, O.H.M.H. & Abaker, A.D. 2015. Performance of she camels under traditional nomadic and semi-intensive management in Sudan. *Livestock Research for Rural Development*, 27(6). www.lrrd.org/lrrd27/6/dowe27107.htm

Elagamy, E.I. 2000. Effect of heat treatment on camel milk proteins with respect to antimicrobial factors: A comparison with cows' and buffalo milk proteins. *Food Chemistry*, 68(2): 227–232. https://doi.org/10.1016/S0308-8146(99)00199-5

El-Gendy, M.H. 2018. Impact of manufacturing processes on the industry soft cheese from camel milk. *Journal of Biological Chemistry and Environmental Sciences*, 13: 491–510.

Elkot, W.F., Al-Farga, A., Malek, G., Bakr, A., Zaidalkilani, A.T., Alnuzaili, E.S., Eljeam, H.A.A. *et al.* 2024. Effect of using camel milk on quality characteristics, free amino acid content and biogenic amine formation in Domiati cheese. *International Journal of Dairy Technology*, 77(3): 713–723. https://doi.org/10.1111/1471-0307.13088

FAO. 2025. Crops and livestock products. In: *FAOSTAT*. Rome. [Cited 24 March 2025]. www.fao.org/faostat/en/#data/QCL

Faye, B. 2016. Des dromadaires et des hommes au Moyen-Orient [Camels and humans in the Middle East]. *Anthropology of the Middle East*, 11(1): 51–65. https://doi.org/10.3167/ame.2016.110106

Faye, B. 2018. What future for camel pastoralism in the world? In: A. Sghiri & F. Kichou, eds. Presentation at the 5th Conference ISOCARD Recent Advances in Camelids Biology, Health and Production, 12–15 November 2018, Laâyoune, Morocco.

Faye, B. 2019. TADs in the dromedary. In: M. Kardjadj, A. Diallo & R. Lancelot, eds. *Transboundary animal diseases in Sahelian Africa and connected regions.* pp. 91–103. Cham, Switzerland, Springer International Publishing. https://doi.org/10.1007/978-3-030-25385-1_6

Faye, B. 2024. The camels: From domestication to the twenty-first century. In: B. Padalino & B. Faye, eds. *Dromedary camel behavior and welfare: Camel friendly management practices.* pp. 1–15. Cham, Switzerland, Springer International Publishing. https://doi.org/10.1007/978-3-031-48600-5_1

Faye, B., Chaibou, M. & Vias, G. 2012. Integrated impact of climate change and socioeconomic development on the evolution of camel farming systems. *International Journal of Environment and Climate Change*, 2: 227–244. https://doi.org/10.9734/BJECC/2012/1548

Faye, B. & Corniaux, C. 2024. Le lait de chamelle au risque de l'économie politique : de l'économie du don à l'économie marchande [Camel milk at the risk of political economy: From a gift economy to a market economy]. *Revue d'élevage et de médecine vétérinaire des pays tropicaux, 77*: 1–7. https://doi.org/10.19182/remvt.37263

Faye, B., Kadim, I.T., Maghoub, O., Faye, B. & Farouk, M.M. 2013. Camel meat in the world. In: I.T. Kadim, O. Mahgoub & M.M. Farouk, eds. *Camel meat and meat products.* pp. 7–16. CABI Books. https://doi.org/10.1079/9781780641010.0007

Faye, B., Konuspayeva, G., Messad, S. & Loiseau, G. 2008. Discriminant milk components of Bactrian camel (*Camelus bactrianus*), dromedary (*Camelus dromedarius*) and hybrids. *Dairy Science & Technology*, 88(6): 607–617. https://doi.org/10.1051/dst:2008008

Faye, B. & Konuspayeva, G. 2016. The new challenges for marketing camel dairy products and the consequences on genetic selection. Presentation at the Regional Conference for Animal Genetic Resources Conservation: Towards Sustainable Utilization, 23–24 February 2016, Muscat, Oman. www.semanticscholar.org/paper/The-new-challenges-for-marketing-camel-dairy-and-on-Konuspayeva/da56a16a5582213192745e317ce5aabe69a71a43

Faye, B. & Konuspayeva, G. 2024. Camel milk composition and future market potential. *CABI Reviews*, 19(1). https://doi.org/10.1079/cabireviews.2024.0021

Faye, B., Madani, H. & El-Rouili, A.H. 2014. Camel milk value chain in Northern Saudi Arabia. *Emirates Journal of Food and Agriculture*, 26(4): 359–365. https://doi.org/10.9755/ejfa.v26i4.17278

Fernandez-Baca, S. 2005. *Situación actual de camélidos sudamericanos en Perú – Proyecto de Cooperación técnica en apoyo a la crianza y aprovechamiento de los Camélidos Sudamericanos en la Región Andina* [Current situation of South American camelids in Peru – Technical Cooperation Project in support of the breeding and use of South American Camelids in the Andean Region]. TCP/RLA/2914. Rome, FAO. http://tarwi.lamolina.edu.pe/~emellisho/zootecnia_archivos/situacion%20alpcas%20peru.pdf

Flores, E.R. 1991. Manejo y utilización de pastizales [Management and use of pastures]. In: S. Fernández-Baca, ed. *Avances y perspectivas del conocimiento de los camelidos sudamericanos* (pp. 191–212). Santiago, FAO Regional Office for Latin America and the Caribbean.

Flores, E.R. 2024. Gestión y conservación productiva de la vicuña en el Perú [Productive management and conservation of vicuña in Peru]. Presentation at V Foro Nacional de la Vicuña, Puno, Peru, 20–22 November 2024. https://cms.agritacna.gob.pe/uploads/directions/documents/foro/2024/1935db4f-050c-4d68-bd4f-9433102ba14c.pdf

Flores, E.R. & Gutierrez, G. 1995. Ingestive mastication and forage fragmentation in sheep, alpacas and llamas. In: *Proceedings of the Fifth International Rangeland Congress – Salt Lake City, Utah, USA, 23–28 July.* http://hdl.handle.net/10919/66652

Frank, E.N., Hick, M.V.H., Castillo, M.F. & Prieto, A. 2014. Fibre-based components determining handle/skin comfort in fabrics made from dehaired and non dehaired llama fibre. *International Journal of Applied Science and Technology*, 4(3): 51–66.

Frank, E.N., Hick, M.V.H., Lamas, H.E., Gauna, C.D. & Molina, M.G. 2006. Effects of age-class, shearing interval, fleece and color types on fiber quality and production in Argentine Llamas. *Small Ruminant Research*, 61(2): 141–152. https://doi.org/10.1016/j.smallrumres.2005.07.005

Frank, E.N, Prieto, A., Castillo, M., Frondizi, D.S., Mamani-Cato, R. & Hick, M. 2021. The prickle effect comes from fabrics made of South American camelid (alpaca and llama) fibres. Mechanical and/or genetic solutions: A review. *European Journal of Applied Sciences*, 9(3): 46–57. https://doi.org/10.14738/aivp.93.10130

Gagaoua, M. & Boudechicha, H-R. 2018. Ethnic meat products of the North African and Mediterranean countries: An overview. *Journal of Ethnic Foods*, 5(2): 83–98. https://doi.org/10.1016/j.jef.2018.02.004

Gandarillas Espezua, D.G., Quispe, A.E.Q., Iquise, A.P., Hualla, E.A.T., Bobadilla, R.M.R. & Coaquira, J.E.Q. 2022. Características textiles de la fibra de alpacas Huacaya en comunidades altoandinas de la región Tacna, Perú [Textile characteristics of Huacaya alpaca fibre in high Andean communities of the Tacna region, Peru]. *Revista de Investigaciones Veterinarias del Perú*, 33(5). https://doi.org/10.15381/rivep.v33i5.23791

Gaucheron, F. 2011. *Diversité des laits et des produits laitiers dans le monde* [Diversity of milk and dairy products in the world]. Presentation at the *Colloque Cultures des laits du Monde Observatoire CNIEL des habitudes alimentaires*. Paris, 2011. https://hal.science/hal-01454303

Gauly, M., Vaughan, J. & Cebra, C. 2011. *Neuweltkameliden: Haltung, Zucht, Erkrankungen* [New World camelids: Husbandry, breeding, diseases]. Third edition. Stuttgart, Germany, Enke Verlag.

Genene, A., Hansen, E.B., Eshetu, M., Hailu, Y. & Ipsen, R. 2019. Effect of heat treatment on denaturation of whey protein and resultant rennetability of camel milk. *LWT - Food Science and Technology*, 101: 404–409. https://doi.org/10.1016/j.lwt.2018.11.047

Gómez Allca, C. 1997. *Preservación y Conservación de Pieles de Camélidos* [Preservation and conservation of camelid hides]. Lima, Instituto Nacional de Investigación Agraria. https://repositorio.inia.gob.pe/handle/20.500.12955/977

Gropper, S.S., Smith, J.L. & Carr, T.P. 2021. *Advanced nutrition and human metabolism*. 8th edition. Australia, Cengage. www.cengage.uk/c/advanced-nutrition-and-human-metabolism-8e-gropper-carr-smith/9780357449813/

Guo, L., Xu, W., Li, C., Guo, Y. & Chagan, I. 2021. Comparative study of physicochemical composition and microbial community of Khoormog, Chigee, and Airag, traditionally fermented dairy products from Xilin Gol in China. *Food Science & Nutrition*, 9(3): 1564–1573. https://doi.org/10.1002/fsn3.2131

Gupta, L., Tiwari, G.S., Garg, R. & Mudgal, V. 2010. Effect of draught on speed, power output and physiological responses of camels (*Camelus dromedarius*). *Journal of Camel Practice and Research*, 17(2): 185–188.

Gutierrez, G.A., Gutiérrez, J.P., Huanca, T. & Wurzinger, M. 2018. Challenges and opportunities of genetic improvement in alpacas and llamas in Peru. Presentation at the 11th World Congress on Genetics Applied to Livestock Production, Auckland, New Zealand, 11–16 February 2018. www.openagrar.de/receive/openagrar_mods_00079495

Gutiérrez, J.P., Goyache, F., Burgos, A. & Cervantes, I. 2009. Genetic analysis of six production traits in Peruvian alpacas. *Livestock Science*, 123(2): 193–197. https://doi.org/10.1016/j.livsci.2008.11.006

Habtegebriel, H., Wawire, M. & Sila, D. 2018. The effect of pretreatment (spray drying) on the yield and selected nutritional components of whole camel milk powder. *Journal of Food Science*, 83(12): 2983–2991. https://doi.org/10.1111/1750-3841.14361

Hailu, Y., Hansen, E.B., Seifu, E., Eshetu, M. & Ipsen, R. 2016. Factors influencing the gelation and rennetability of camel milk using camel chymosin. *International Dairy Journal*, 60: 62–69. https://doi.org/10.1016/j.idairyj.2016.01.013

Hashim, I.B., Khalil, A.H. & Habib, H. 2009. Quality and acceptability of a set-type yogurt made from camel milk. *Journal of Dairy Science*, 92(3): 857–862. https://doi.org/10.3168/jds.2008-1408

Hattem, H.E., Manal, A.N., Hanna, S.S. & Elham, A.A. 2011. A study on the effect of thermal treatment on composition and some properties of camel milk. *Journal of Brewing and Distilling*, 2(4): 51–55. https://doi.org/10.5897/JBD.9000001

Hekal, S.A. 2014. Histological study of the skin and leather characteristics in two types of Arabian camels (*Camelus dromedarius*). *Journal of American Science*, 10(9): 41–48. www.dx.doi.org/10.7537/marsjas100914.06

Herrmann, K. & Fisher, A. 2004. Dressing of the camel carcass. In: Z. Farah & A. Fischer, eds. *Milk and meat from the camel: Handbook on products and processing* (pp. 109–135). Zollikon, Switzerland, VDF Hochschulverlag AG.

Huanca, T., Naveros, M., Ccopa, J., Nina, A. & Mamani, R. 2018. Problemática y alternativas para mitigar los efectos del cambio climático en la zona alto andina [Problems and alternatives to mitigate the effects of climate change in the high Andean zone]. In: *Libro de Resumenes de XLI Reunion Cientifica de la Asociacion Peruana de Produccion Animal, Lima. Peru.* https://appaperu.blogspot.com

Hunter, L., Smuts, L. & Botha, A.F. 2013. Characterizing visually objectionable and nonobjectionable medullated fibers in mohair. *Journal of Natural Fibers*, 10(2): 112–135. https://doi.org/10.1080/15440478.2013.763483

Hunter, L. 2020. Mohair, cashmere and other animal hair fibres. In: R.M. Kozłowski & M. Mackiewicz-Talarczyk, eds. *Handbook of natural fibres (Second Edition)* (pp. 279–383). Woodhead Publishing Series in Textiles. Delhi, Woodhead Publishing. https://doi.org/10.1016/B978-0-12-818398-4.00012-8

IAA (International Alpaca Association). 2023. Natural Fibre Connect 2023. In: *Asociación Internacional de la Alpaca*. Arequipa, Peru. [Cited 13 May 2025]. https://aia.org.pe/en/natural-fibre-connect-2023-2

Ibrahim, A. & Khalifa, S. 2015. Effect of freeze-drying on camel's milk nutritional properties. *International Food Research Journal*, 22: 1438–1445.

Iglesias Pastrana, C., Delgado Bermejo, J.V., Sgobba, M.N., Navas González, F.J., Guerra, L., Pinto, D.C.G.A., Gil, A.M. *et al.* 2022. Camel (*Camelus* spp.) Urine bioactivity and metabolome: A systematic review of knowledge gaps, advances, and directions for future research. *International Journal of Molecular Sciences*, 23(23): 15024. https://doi.org/10.3390/ijms232315024

INACAL (National Quality Institute). 2022. Fibra de alpaca clasificada. Definiciones, clasificación por grupos de calidades, requisitos y rotulado. 3ª Edición [Graded alpaca fibre. Definitions, classification by quality groups, requirements and labelling. 3rd edition]. In: *INACAL.* San Isidro, Peru. [Cited 3 May 2025]. www.inacal.gob.pe/cid/categoria/normas-tecnicas-peruanas

INIA (National Institute of Agricultural Innovation). 2020. *Sistematización de la experiencia de los subproyectos de camélidos sudamericanos financiados por el programa nacional de innovación agraria* [Systematization of the experience of the South American camelid sub-projects financed by the National Agricultural Innovation Programme]. Lima. https://repositorio.inia.gob.pe/server/api/core/bitstreams/7f4c5ccf-f041-49e2-8adf-791c960fe581/content

Iñiguez, L. & Alem, R. 1996. La funcion de los camelidos como medio de transporte e intercambio en la region andina de Bolivia [The role of camelids as a means of transport and exchange in the Andean region of Bolivia]. *World Animal Review*. www.semanticscholar.org/paper/La-funcion-de-los-camelidos-como-medio-de-e-en-la-I%C3%B1iguez-Alem/c2ed1b027234c80309d6a7f2768d94eada7e1fa0

INSA (Agricultural Insurance Institute). 2023. *Estudio del producto de seguro pecuario colectivo para ganado Camélido* [Study of collective livestock insurance products for camelid livestock]. La Paz, Ministry of Rural Development and Lands. www.studocu.com/bo/document/universidad-mayor-de-san-andres/preparacion-y-evaluacion-de-proyectos-i/estudio-del-producto-de-seguro-pecuario-colectivo-para-ganado-camelido-insa-2023/137033497

Ismaili, M.A., Hamama, A., Saidi, B., Zahar, M. & Meryem, A. 2017. Chemical composition, microbial profile and identification of lactic acid bacteria of Moroccan Fermented camel milk lfrik. *Current Research in Nutrition and Food Science Journal*, 5(3): 383–390.

Jabbari, M., Eini-Zinab, H., Safaei, E., Poursoleiman, F., Amini, B., Babashahi, M., Barati, M. & Hekmatdoost, A. 2023. Determination of the level of evidence for the association between different food groups/items and dietary fiber intake and the risk of cardiovascular diseases and hypertension: An umbrella review. *Nutrition Research*, 111: 1–13. https://doi.org/10.1016/j.nutres.2022.12.011

Joly, F., Tulganyam, S. & Hubert, B. 2019. Subsistence or market economy? Assessment of a pastoral system of Mongolia twenty years after the fall of socialism. *Nomadic Peoples*, 23(1): 106–142.

Kadim, I. & Mahgoub, O. 2006. Meat quality and composition of *Longissimus thoracis* from Arabian camel (*Camelus dromedaries*) and Omani beef: A comparative study. *Journal of Camelid Sciences*, 1: 37–47. www.cabidigitallibrary.org/doi/pdf/10.5555/20103054785

Kadim, I.T., Mahgoub, O., Al-Marzooqi, W., Al-Zadjali, S., Annamalai, K. & Mansour, M.H. 2006. Effects of age on composition and quality of muscle *Longissimus thoracis* of the Omani Arabian camel (*Camelus dromedaries*). *Meat Science*, 73(4): 619–625. https://doi.org/10.1016/j.meatsci.2006.03.002

Kadim, I.T., Mahgoub, O. & Purchas, R.W. 2008. A review of the growth, and of the carcass and meat quality characteristics of the one-humped camel (*Camelus dromedaries*). *Meat Science*, 80(3): 555–569. https://doi.org/10.1016/j.meatsci.2008.02.010

Kadim, I.T., Purchas, R., Al-Amri, I., Alkindi, A. & Abbas, G. 2020. Camel meat nutrient content and potential health benefits. In: O. Alhaj, B. Faye & R. Agrawal, eds. *Handbook of research on health and environmental benefits of camel products* (pp. 285–305). Palmdale, PA, IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-7998-1604-1.ch013

Kagunyu, A.W., Matiri, F. & Ngari, E. 2013. Camel hides: Production, marketing and utilization in pastoral regions of northern Kenya. *Pastoralism: Research, Policy and Practice*, 3(25). https://doi.org/10.1186/2041-7136-3-25

Kaindi, D.W.M. & Njage, P.M.K. 2020. Microbial aspect of lactic acid bacteria isolated from camel milk. In: O.A. Alhaj, B. Faye & R. Agrawal, eds. *Handbook of research on health and environmental benefits of camel products* (pp. 54–74). Palmdale, PA, IGI Global. https://doi.org/10.4018/978-1-7998-1604-1.ch004

Kamili, A., Faye, B., Tligui, N.S. & Bengoumi, M. 2020. Typologie des systèmes d'élevage camelins du sud du Maroc [Typology of camel farming systems in southern Morocco]. *Revue d'élevage et de médecine vétérinaire des pays tropicaux*, 73(2): 71–80. https://doi.org/10.19182/remvt.31862

Kappeler, S.R., van den Brink, H. (J.) M., Rahbek-Nielsen, H., Farah, Z., Puhan, Z., Hansen, E.B. & Johansen, E. 2006. Characterization of recombinant camel chymosin reveals superior properties for the coagulation of bovine and camel milk. *Biochemical and Biophysical Research Communications*, 342(2): 647–654. https://doi.org/10.1016/j.bbrc.2006.02.014

Kasterine, A. & Lichtenstein, G. 2018. *Trade in vicuña: Implications for conservation and rural livelihoods*. Geneva, International Trade Centre. www.intracen.org/resources/publications/trade-in-vicuna-implications-for-conservation-and-rural-livelihoods

Kearns, M., Ponnampalam, E.N., Jacquier, J-C., Grasso, S., Boland, T.M., Sheridan, H. & Monahan, F.J. 2023. Can botanically-diverse pastures positively impact the nutritional and antioxidant composition of ruminant meat? Invited review. *Meat Science*, 197: 109055. https://doi.org/10.1016/j.meatsci.2022.109055

Khaliq, A., Mishra, A.K., Niroula, A., Baba, W.N., Shaukat, M.N., & Rabbani, A. 2024. An updated comprehensive review of camel milk: Composition, therapeutic properties, and industrial applications. *Food Bioscience*, 62, 105531.

Khan, A. 2024. Saudi Arabia's camel leather market valued at $98.7 million: A new frontier in fashion? In: *Leather News*. [Cited 29 April 2025]. https://leathernews.org/saudi-arabias-camel-leather-market-valued-at-98-7-million-a-new-frontier-in-fashion

Khatun, R., Ahmed, S. & Hasan, A. 2018. Validation of the declared withdrawal periods of antibiotics. *Universal Journal of Public Health*, 6(1): 14–22. https://doi.org/10.13189/ujph.2018.060103

Kheira, B.N., Dadamoussa, B., Bendraoua, A., Mel, M. & Labed, B. 2017. Effects of co-digestion of camel dung and municipal solid wastes on quality of biogas, methane and biofertilizer production. *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, 40(1): 7–17.

Kherouatou, N. & Attia, H. 2003. A study of the dromedary milk casein micelle and its changes during acidification. *Brazilian Journal of Food Technology*, 6: 237–244.

Khorchani, T. 2021. *Optimisation des operations de traitement du cuir pour la valorisation de la peau de dromadaire* [Optimizing leather processing operations to enhance the value of camel hides]. Final Report. Projet VRR. Tunis, Ministry of Higher Education and Scientific Research. www.ira.agrinet.tn/images/Rapport_Final_VRR_Peau.pdf

Khorshid, F., Alshazly, H., Al Jefery, A. & M. Osman, A-M. 2010. Dose escalation phase I study in healthy volunteers to evaluate the safety of a natural product PM701. *Journal of Pharmacology and Toxicology*, 5(3): 91–97. https://doi.org/10.3923/jpt.2010.91.97

Khorshid, F., Rabah, S.O., Abuaraki, H.A., Ali, A.S., Noor, S.O. & Alkabkaby, H. 2015. Safety of oral administration of PMF a fraction derived from camel urine: acute study on mice. *International Journal of Emerging Technology and Advanced Engineering*, 5(6). www.ijetae.com/files/Volume5Issue6/IJETAE_0615_62.pdf

Khorshid, F., Osman, A-M. & Abdel-Sattar, E. 2009. Cytotoxic activity of bioactive fractions from PM 701. *Electronic Journal of Environmental, Agricultural & Food Chemistry*, 8(11).

Konuspayeva, G., Baubekova, A., Akhmetsadykova, S. & Faye, B. 2023. Traditional dairy fermented products in Central Asia. *International Dairy Journal*, 137: 105514. https://doi.org/10.1016/j.idairyj.2022.105514

Konuspayeva, G., Camier, B., Aleilawi, N., Al-Shumeimyri, M., Al-Hammad, K., Algruin, K., Alshammari, F. *et al.* 2017. Manufacture of dry- and brine-salted soft camel cheeses for the camel dairy industry. *International Journal of Dairy Technology*, 70(1): 92–101. https://doi.org/10.1111/1471-0307.12319

Konuspayeva, G., Camier, B., Gaucheron, F. & Faye, B. 2014. Some parameters to process camel milk into cheese. *Emirates Journal of Food and Agriculture*, 26(4): 354–358. www.bibliomed.org/gotodoi.php?mno=185920&gdoi=10.9755/ejfa.v26i4.17277

Konuspayeva, G., Faye, B., Baubekova, A. & Loiseau, G. 2012. Camel gruyere cheese making. In: *Proceedings of the 3rd Conference of the International Society of Camelid Research and Development, 29 January – 1 February 2012*, Sultan Qaboos University, Muscat, Oman.

Konuspayeva, G., Faye, B. & Duteurtre, G. 2022. Online camel milk trade: New players, new markets (update). *Revue d'élevage et de médecine vétérinaire des pays tropicaux*, 75(4): 95–101. https://doi.org/10.19182/remvt.37041

Konuspayeva, G. & Faye, B. 2020. Livestock systems in the midst of History's upheavals in Kazakhstan. In: J-F. Tourrand, P. Waquil, M-C. Maraval, M.T. Sraïri, L.M.G. Duarte & G.V. Kozloski, eds. *Livestock Policy* (pp. 212–224). Paris, CIRAD. https://agritrop.cirad.fr/597287

Konuspayeva, G. & Faye, B. 2021. Recent advances in camel milk processing. *Animals*, 11(4): 1045. https://doi.org/10.3390/ani11041045

Konuspayeva, G., Lemarie, É., Faye, B., Loiseau, G. & Montet, D. *2008. Fatty acid and cholesterol composition of camel's (Camelus bactrianus, Camelus dromedarius* and hybrids) milk in Kazakhstan. *Dairy Science & Technology*, 88(3): 327–340. https://doi.org/10.1051/dst:2008005

Konuspayeva, G.S. 2020. Camel milk composition and nutritional value. In: O.A. Alhaj, B. Faye & R. Agrawal, eds. *Handbook of research on health and environmental benefits of camel products.* pp. 15–40. Palmdale, PA, IGI Global. https://doi.org/10.4018/978-1-7998-1604-1.ch002

Koussou, M.O., Mahamat, A.M.A. & Grimaud, P. 2012. Campements nomades et commerce du lait de chamelle en peripherie de N'Djamena (Tchad) [Nomadic camps and camel milk trade on the outskirts of N'Djamena (Chad)]. *Revue Scientifique du Tchad*, 11(1): 34–41.

Lakshmanan, A., Jose, S. & Chakraborty, S. 2016. Luxury hair fibers for fashion industry. In: S.S. Muthu & M.A. Gardetti, eds. *Sustainable fibres for fashion industry: Volume 1*. (pp. 1–38). Singapore, Springer. https://doi.org/10.1007/978-981-10-0522-0_1

Latifah, W.N., Ngaeni, S.N., Rahman, R.A.S., Azka, I.M. & Zaen, M.A.M. 2018. Camel urine for health in Islam and science perspective. *Kaunia: Integration and Interconnection Islam and Science Journal*, 14(1): 15–19. https://doi.org/10.14421/kaunia.1326

Leistner, L. 1987. Shelf-stable products and intermediate moisture foods based on meat. In: L.B. Rockland & L.R. Beuchat, eds. *Water activity: Theory and applications to food*. Boca Raton, FL, CRC Press. https://doi.org/10.1201/978020373414

Lichtenstein, G. 2006. Manejo de vicuñas en cautiverio: el modelo de los criaderos de INTA Abrapampa [Management of vicuñas in captivity: The model of the INTA Abrapampa breeding farms]. In: B. Vilá, ed. *Investigación, conservación y manejo de vicuñas* (pp. 133–146). Lujan, Buenos Aires, Universidad Nacional de Lujan, Proyecto MACS. www.academia.edu/5089855/Manejo_de_vicu%C3%B1as_en_cautiverio_el_modelo_de_los_criaderos_de_INTA_Abrapampa

Lichtenstein, G. 2010. Vicuña conservation and poverty alleviation? Andean communities and international fibre markets. *International Journal of the Commons*, 4(1): 100–121. https://doi.org/10.18352/ijc.139

Lichtenstein, G. 2013. Guanaco management in Argentina: Taking a commons perspective. *Journal of Latin American Geography*, 12(1): 187–213

Lichtenstein, G. & Ros, C.C. 2021. Vicuña conservation and the reinvigoration of Indigenous communities in the Andes. In: P.K. Nayak, ed. *Making commons dynamic: Understanding Change Through Commonisation and Decommonisation*. 1st edition (pp. 102–122). Abingdon-on-Thames, UK, Routledge.

Lichtenstein, G. & Vilá, B. 2003. Vicuna use by Andean Communities: An overview. *Mountain Research and Development*, 23(2): 197–201.

Lorenzen, P.C., Wernery, R., Johnson, B., Jose, Sh. & Wernery, U. 2011. Evaluation of indigenous enzyme activities in raw and pasteurised camel milk. *Small Ruminant Research*, 97(1): 79–82. https://doi.org/10.1016/j.smallrumres.2011.01.014

Lund, A.K., Shah, A.H., Jatoi, A.S., Khaskheli, G.B., Malhi, M.C., Khaskheli, A.A., Khanzada, M.A. *et al.* 2020. Effect of heating on shelf life and sensory characteristics of camel milk. *Pure and Applied Biology*, 9(1): 74–79. http://dx.doi.org/10.19045/bspab.2020.90009

Lupton, C.J., McColl, A. & Stobart, R.H. 2006. Fiber characteristics of the Huacaya Alpaca. *Small Ruminant Research*, 64(3): 211–224. https://doi.org/10.1016/j.smallrumres.2005.04.023

Maitha, I.M., Kaindi, D.W.M., Wangoh, J. & Mbugua, S. 2019. Microbial quality and safety of traditional fermented camel milk product suusac sampled from different regions in North Eastern Kenya. *Asian Food Science Journal*, 8(2): 1–9. https://doi.org/10.9734/afsj/2019/v8i229986

Mamani-Linares, L.W. & Gallo, C.B. 2014. Meat quality, proximate composition and muscle fatty acid profile of young llamas (Lama glama) supplemented with hay or concentrate during the dry season. *Meat Science,* 96(1): 394–399. https://doi.org/10.1016/j.meatsci.2013.07.028

Manaer, T., Yu, L., Nabi, X. H., Dilidaxi, D., Liu, L. & Sailike, J. 2021. The beneficial effects of the composite probiotics from camel milk on glucose and lipid metabolism, liver and renal function and gut microbiota in db/db mice. *BMC Complementary Medicine and Therapies,* 21(1): 127.

Mansouri, M., Moslah, M., Atouani, M., Gafsi, M., Seddik, M.M., Toumi, A. & Khorchani, T. 2009. Clean technologies and treatment of dromedary skin in Tunisia. In: *Proceedings of the 2nd Conference of the International Society of Camelid Research and Development, 12 March 2009, Djerba, Tunisia*.

Martegani, J. 2017. Proyecto guanaco [Guanaco project]. *Boletín del Centro de Investigación y Tecnología del Cuero,* 2. INTI-Cueros Informa.

Martinez, Z., Iniguez, L.C. & Rodríguez, T. 1997. Influence of effects on quality traits and relationships between traits of the llama fleece. *Small Ruminant Research*, 24(3): 203–212. https://doi.org/10.1016/S0921-4488(96)00925-X

Maryniak, N.Z., Hansen, E.B., Ballegaard, A-S.R., Sancho, A.I. & Bøgh, K.L. 2018. Comparison of the allergenicity and immunogenicity of camel and cow's milk – a study in brown Norway rats. *Nutrients*, 10(12): 1903. https://doi.org/10.3390/nu10121903

McCann, S., Perapoch Amadó, M. & Moore, S.E. 2020. The role of iron in brain development: A systematic review. *Nutrients*, 12(7): 2001. https://doi.org/10.3390/nu12072001

McGregor, B.A. 2006. Production, attributes and relative value of alpaca fleeces in southern Australia and implications for industry development. *Small Ruminant Research*, 61(2): 93–111. https://doi.org/10.1016/j.smallrumres.2005.07.001

McGregor, B.A. & Quispe, E.C. 2018. Cuticle and cortical cell morphology of alpaca and other rare animal fibres. *The Journal of The Textile In*stitute, 109(6): 767–774. www.tandfonline.com/doi/full/10.1080/00405000.2017.1368112

Megersa, B., Markemann, A., Angassa, A. & Valle Zárate, A. 2014. The role of livestock diversification in ensuring household food security under a changing climate in Borana, Ethiopia. *Food Security*, 6(1): 15–28. https://doi.org/10.1007/s12571-013-0314-4

Mehta, R.D., Agrawal, R., Mehta, R.D. & Agrawal, R. 2020. Camel milk disguised cosmeceutical. In: O.A. Alhaj, B. Faye & R. Agrawal, eds. *Handbook of research on health and environmental benefits of camel products* (pp. 348–362). Palmdale, PA, IGI Global. https://doi.org/10.4018/978-1-7998-1604-1.ch016

MIDAGRI (Ministry of Agrarian Development and Irrigation). 2017. *Diagnóstico de crianzas priorizadas para el Plan Ganadero 2017–2021* [Diagnosis of priority livestock farms for the 2017–2021 Livestock Plan]. Lima, Directorate of Economic Studies and Agricultural Information. www.fao.org/faolex/results/details/es/c/LEX-FAOC174289

MIDAGRI. 2022. El 87% de la población mundial de alpacas se encuentra en el Perú [87% of the world's alpaca population is found in Peru]. In: *MIDAGRI.* [Cited 7 May 2025]. www.gob.pe/institucion/midagri/noticias/636546-midagri-el-87-de-la-poblacion-mundial-de-alpacas-se-encuentra-en-el-peru

Mihic, T., Rainkie, D., Wilby, K.J. & Pawluk, S.A. 2016. The therapeutic effects of camel milk: A systematic review of animal and human trials. *Journal of Evidence-Based Complementary & Alternative Medicine*, 21(4): 110–126. https://doi.org/10.1177/2156587216658846

MINAGRI (Ministry of Agriculture and Irrigation). 2019. *Potencial productivo y comercial de la alpaca* [Productive and Commercial Potential of the Alpaca]. Peru.

Ministry of Culture of Saudi Arabia. 2024. *Camel couture: Exploring camel products in contemporary fashion*. Riyadh, Fashion Commission.

Ministry of the Environment, Government of Catamarca. 2022. *Resumen general: Esquila de vicuñas en silvestría. Temporada 2022* [General summary: Shearing of vicuñas in the wild. 2022 season]. Provincial Directorate of Biodiversity and Protected Natural Areas.

Mohamed, I.M.A. & El Zubeir, I.E.Y.M. 2014. Effect of heat treatment on keeping quality of camel milk. *Annals: Food Science & Technology*, 15(2): 239–245.

Mohammed, A. 2003. *Organisation d'un réseau de collecte du lait en Mauritanie*. Lait de chamelle pour l'Afrique, Niamey (Niger) [Organizing a milk collection network in Mauritania. Camel milk for Africa, Niamey (Niger)]. Rome, FAO. www.fao.org/4/aj038f/aj038f.pdf

Moore, K.E., Blache, D. & Maloney, S.K. 2011. Fibre diameter and insulation in alpacas: The biophysical implications. *Small Ruminant Research*, 96(2): 165–172. https://doi.org/10.1016/j.smallrumres.2011.01.012

Mortimore, M.J. & Adams, W.M. 2001. Farmer adaptation, change and "crisis" in the Sahel. *Global Environmental Change*, 11(1): 49–57. https://doi.org/10.1016/S0959-3780(00)00044-3

Mueller, J.P., Rigalt, F., Cancino, A.K. & Lamas, H. 2010. *Calidad de las fibras de camélidos sudamericanos en Argentina* [Quality of South American camelid fibres in Argentina]. www.produccion-animal.com.ar/produccion_de_camelidos/camelidos_general/23-Calidad_de_fibras.pdf

Mueller, J.P., Rigalt, F., Lamas, H., Sacchero, D.M., Cancino, A.K. & Wurzinger, M. 2015. Fibre quality of South American camelids in Argentina: A review. *Animal Genetic Resources*, 56: 97–109. https://doi.org/10.1017/S2078633614000496

Mustafa, A.B., Faraz, A. & Bashari, M. 2023. Challenges of camel milk as superfood and health booster: A review. *Emerging Challenges in Agriculture and Food Science*, 8: 37–58. https://doi.org/10.9734/bpi/mono/978-81-19217-36-6/CH3

Mwinyihija, M. & Mekonnen, H. 2016. Preview of camel (*Camelus dromedarius*) hides marketing and challenges in Eastern Africa. *Journal of African Leather and Leather Products Advances*, 3(1): 18–27.

Nagy, P.P., Skidmore, J.A. & Juhasz, J. 2022. Intensification of camel farming and milk production with special emphasis on animal health, welfare, and the biotechnology of reproduction. *Animal Frontiers*, 12(4): 35–45. https://doi.org/10.1093/af/vfac043

Nansalmaa, T., Otgonjargal, L. & Altantuya, D. 2013. Sheep, camel wool market perspectives and government policy. *Mongolian Journal of Agricultural Sciences*, 11(2): 120–124. https://doi.org/10.5564/mjas.v11i2.231

Nasr, A.I. 2015. Evaluation of Egyptian camel hides for leathers manufacturing. *World Applied Sciences Journal*, 33(8). https://doi.org/10.5829/idosi.wasj.2015.33.08.15604

Nasr, A.I. 2020. Review article: Shedding light on camel leather. *Journal of Camelid Science*, 13: 1–9.

Noor, S.O., AlAttas, S.G., Khorshid, F., Elsourojy, Y. & Tawfik, N. 2015. *In-vitro evaluation of cytotoxicity, antiviral and virostatic activity of PMF derived from camel urine.* Presentation at Energy, Environment and Material Science, International Conference on Energy, Environment and Material Science (EEMAS 2015), Crete, Greece, 2015.

OECD (Organisation of Economic Co-operation and Development). 2013. *Review of agricultural policies: Kazakhstan 2013.* Paris, OECD. www.oecd-ilibrary.org/agriculture-and-food/oecd-review-of-agricultural-policies-kazakhstan-2013_9789264191761-en

Olarte, C.U., Calsin, B., Oros, O. & Ormachea, E. 2023. Variación del diámetro y porcentaje de medulación en la fibra de alpacas Huacaya (Vicugna pacos) [Variation in the diameter and percentage of modulation in the fibre of Huacaya alpacas (*Vicugna pacos*)]. *Revista de Investigaciones Veterinarias del Perú*, 34(6). https://doi.org/10.15381/rivep.v34i6.26957

Pacheco-Lopez, P. 2011. *Strategic directions on industrial policy in Mongolia.* Vienna, UNIDO. https://kar.kent.ac.uk/91594/1/Mongolia.pdf

Parmar, N.B. 2013. *Characterization of ghee prepared from camel milk and evaluation of its shelf life during storage.* Anand, India, AAU. http://krishikosh.egranth.ac.in/handle/1/5810005253

Paucar, Y., Quispe, M., Hunter, L. & Quispe, E. 2024. *III Seminario Internacional en Producción Sostenible en Camélidos Sudamericanos: Asegurando la Biodiversidad* [Proceedings of the 3rd International Seminar on Sustainable Production in South American Camelids: Ensuring Biodiversity]. Lima, La Molina. www.cip.org.pe/publicaciones/2025/enero/portal/libro-iii-sem-prod-camelidos-sudamericanos-edicion-digital.pdf

de Pereny, M.L., Ramlogan, R. & Miozzo, M. 2020. Standardization and segmented governance in the Peruvian alpaca fibre value chain. *Innovation and Development*, 10(2): 223–244. https://doi.org/10.1080/2157930X.2019.1580937

Polidori, P., Antonini, M., Torres, D., Beghelli, D. & Renieri, C. 2007. Tenderness evaluation and mineral levels of llama (*Lama glama*) and alpaca (*Lama pacos*) meat. *Meat Science*, 77(4): 599–601. https://doi.org/10.1016/j.meatsci.2007.05.011

Poma, G. & Ayala, C. 2022. Características físicas de la fibra de llamas (*Lama glama*) a la primera esquila en la mancomunidad de municipios aymaras sin fronteras [Physical characteristics of llama fiber (*Lama glama*) at the first shearing in the association of Aymara municipalities without borders]. *Revista de Investigación e Innovación Agropecuaria y de Recursos Naturales*, 9(1): 19–25. https://doi.org/10.53287/xrpy4094ec47e

Ponnampalam, E.N., Plozza, T., Kerr, M.G., Linden, N., Mitchell, M., Bekhit, A.E.D.A., Jacobs, J.L. *et al*. 2017. Interaction of diet and long ageing period on lipid oxidation and colour stability of lamb meat. *Meat Science*, 129: 43–49. https://doi.org/10.1016/j.meatsci.2017.02.008

Programa Empoderar. 2018. *Emprendimientos organizados para el desarrollo rural autogestionario* [Organized ventures for self-managed rural development]. La Paz, Ministry of Rural Development and Lands.

Programa Pro-camélidos. 2019. *Análisis competitivo de la cadena productiva de la fibra de camélidos* [Competitive analysis of the camelid fibre production chain]. La Paz, Plurinational State of Bolivia.

Programa Pro-camélidos. 2024. *Programa de Fortalecimiento Integral del Complejo Camélidos en el Altiplano Boliviano*. Transformación y comercialización de productos camélidos [Comprehensive Strengthening Programme for the Camelid Complex in the Bolivian Altiplano. Processing and marketing of camelid products]. La Paz, Plurinational State of Bolivia, Ministry of Rural Development and Lands. www.ifad.org/es/w/proyecto/1100001721

PROMPERÚ (Trade, Tourism and Investment Commission of Peru). 2024. Exportaciones 2023. [Exports 2023]. In *PROMPERÚ*. Lima. [Cited 29 April 2025]. https://hdl.handle.net/20.500.14152/6597

Quiñones Ramirez, H., Trejo Cadillo, W. & Juscamaita Morales, J. 2016. Evaluation of the quality of a liquid fertilizer produced vía homolactic fermentation of alpaca feces. *Applied Ecology,* 15(2). https://revistas.lamolina.edu.pe/index.php/eau/article/view/753

Quispe, E.C. 2024. *Diagnóstico del Sector Camélidos en Bolivia* [Diagnosis of the Camelid Sector in Bolivia]. La Paz, Ministerio de Desarrollo Rurral y Tierras, Programa de fortalecimiento integral del complejo camélidos en el altiplano (Pro-Camélidos).

Quispe, E.C., Chipa, L. & Pinares, R. 2015. Análisis económico y de la producción del descerdado manual de la fibra de llamas (*Lama glama*) Chaku [Economic and production analysis of manual dehairing of llama *(Lama glama*) fibre (Chaku)]. *Archivos de Zootecnia*, 64(246): 191–198. https://doi.org/10.21071/az.v64i246.397

Quispe, E.C., Machaca Machaca, V., Paucara Ocsa, V., Paucar-Chanca, R., Escobedo Enriquez, M., Huere Peña, J.L. & Aliaga Gutiérrez, J.L. 2023. Evaluación de fibras finas y gruesas de llamas (*Lama glama*) K'ara criadas en condiciones altoandinas de Perú [Evaluation of fine and coarse fibres from K'ara llamas (*Lama glama*) raised in high Andean conditions in Peru]. *Revista de Investigaciones Veterinarias del Perú*, 34(5): e24817. https://doi.org/10.15381/rivep.v34i5.24817

Quispe, E.C., Ramos, H., Mayhua, P. & Alfonso, L. 2010. Fibre characteristics of vicuña (Vicugna vicugna mensalis). *Small Ruminant Research*, 93(1): 64–66. https://doi.org/10.1016/j.smallrumres.2010.03.019

Quispe, E.C., Rodríguez, T.C., Iñiguez, L.R. & Mueller, J. 2009. Producción de fibra de alpaca, llama, vicuña y guanaco en Sudamérica [Production of alpaca, llama, vicuña and guanaco fibre in South America]. *Animal Genetic Resources Information*, 45: 1–14. https://doi.org/10.1017/S1014233909990277

Quispe, E.C., Sánchez, F., Filella, J.B. & Alfonso, L. 2014. Variation of commercially important characteristics among sampling sites for vicuña (*Vicugna vicugna mensalis*) fleeces. *Journal of Camelid Science*, 10:17–30.

Rabehi, S.A., Rezzaz, M.A., Kherrour, L. & Souiher, K. 2023. Towards the development of ecotourism in the ouled-nail mountains: A case study of the Djelfa municipality in Algeria. *GeoJournal of Tourism and Geosites*, 50(4): 1411–1429. https://doi.org/10.30892/gtg.50422-1140

Radolf, M., Wurzinger, M. & Gutierrez, G. 2022. Livelihood and production strategies of livestock keepers and their perceptions on climate change in the Central Peruvian Andes. *Small Ruminant Research*, 215: 106763. https://doi.org/10.1016/j.smallrumres.2022.106763

Raggi, L.A. 2025. Estado de situación de los camélidos sudamericanos en Chile [Status of South American camelids in Chile]. *SIDALC*. www.sidalc.net/search/Record/dig-odepa-20.500.12650-74052/Description

Rai, A.K. & Khanna, N.D. 1994. Draught performance of Indian camels of Bikaneri breed. *The Indian Journal of Animal Sciences*, 64(10). https://epubs.icar.org.in/index.php/IJAnS/article/view/31078

Raiymbek G., Kadim I., Mahgoub O., Konuspayeva G. & Faye B. 2025. Comparative minerals and vitamins composition of Bactrian (Camelus bactrianus) and dromedary (Camelus dromedarius) meat. *Food Sci. Engin.*, 6(2), 226-243, https://doi.org/10.37256/fse.6220256365

Raiymbek, G., Faye, B., Kadim, I.T., Serikbaeva, A. & Konuspayeva, G. 2019. Comparative fatty acids composition and cholesterol content in Bactrian (*Camelus bactrianus*) and dromedary camel (*Camelus dromedarius*) meat. *Tropical Animal Health and Production*, 51(7): 2025–2035. https://doi.org/10.1007/s11250-019-01894-2

Raiymbek, G., Faye, B., Serikbayeva, A., Konuspayeva, G. & Kadim, I.T. 2013. Chemical composition of Infraspinatus, *Triceps brachii*, *Longissimus thoraces*, *Biceps femoris*, *Semitendinosus*, and *Semimembranosus* of Bactrian (*Camelus bactrianus*) camel muscles. *Emirates Journal of Food and Agriculture*, 25(4): 261–266. https://doi.org/10.9755/ejfa.v25i4.15492

Raiymbek, G., Kadim, I., Konuspayeva, G., Mahgoub, O., Serikbayeva, A. & Faye, B. 2015. Discriminant amino-acid components of Bactrian (*Camelus bactrianus*) and Dromedary (*Camelus dromedarius*) meat. *Journal of Food Composition and Analysis*, 41: 194–200. https://doi.org/10.1016/j.jfca.2015.02.006

Ramos Ramírez, M.E. 2019. *Desarrollo de cabanossi con carne de llama (Lama glama) procedente de diferentes regímenes de alimentación* [Development of cabanossi with llama meat (*Lama glama*) from different feeding regimes]. Lima, Universidad Nacional Agraria La Molina. PhD dissertation. https://hdl.handle.net/20.500.12996/4211

Rawdah, T.N., Zamil El-Faer, M. & Koreish, S.A. 1994. Fatty acid composition of the meat and fat of the one-humped camel (*camelus dromedarius*). *Meat Science*, 37(1): 149–155. https://doi.org/10.1016/0309-1740(94)90151-1

Reyes García, M., Gómez-Sánchez Prieto, I. & Espinoza Barrientos, C. 2017. *Tablas peruanas de composición de alimentos*. 10ma ed [Peruvian Food Composition Tables. 10th edition]. Lima, Ministry of Health, National Institute of Health. www.gob.pe/institucion/ins/informes-publicaciones/4231115-tablas-peruanas-de-composicion-de-alimentos-tpca

Ribot, J.C. & Peluso, N.L. 2003. A theory of access. *Rural Sociology*, 68(2): 153–181. https://doi.org/10.1111/j.1549-0831.2003.tb00133.x

Rodríguez Claros, T. 2006. Producción de Fibra de Camélidos: Calidad de fibra de llama descerdada y clasificada [Camelid fibre production: Quality of dehaired and graded llama fibre]. In: A. Cardozo, ed. *Camélidos* (pp. 361–374). Cochabamba, Plurinational State of Bolivia, Centro de Investigaciones en Forrajes.

Rodríguez, D.L. 2008. *Una perspectiva mundial sobre el valor económico total del pastoralismo* [A global perspective on the total economic value of pastoralism]. Nairobi, International Livestock Research Institute (ILRI).

Sacchero, D., Lamas, H., Maurino, J. & Galfione, L. 2024. A study on dehairing of vicuña fiber: evaluation of yields and quality characteristics that impact on its transformation and textile added value. *The Journal of The Textile Institute*, 116(2): 276–282. https://doi.org/10.1080/00405000.2024.2330719

Sacchero, D., Quiroga Roger, J., Romero, S., Maurino, J. & Gonzalez, E.B. 2022. Community-based vicuña (*Vicugna vicugna*) shearing in the arid Puna of Argentina: Body weight and fiber traits obtained during the chakus. *Small Ruminant Research*, 216(106829). www.sciencedirect.com/science/article/pii/S0921448822002188?via%3Dihub

Sacchero, D.M., Maurino, M.J. & Lanari, M.R. 2006. Differences on quality and proportion of down in individual fleece samples of guanaco (*Lama guanicoe*) from different ecoregions of Argentina. *Revista Argentina de Producción Animal*, 26: 211–216.

SAG (Ministry of Agriculture of Chile). 2016. Puesta en valor del guanaco en sector norte de Tierra del Fuego, mediante su caza racional y sustentable, basada en el aprovechamiento de carne, pieles y derivados [Enhancing the value of the guanaco in the northern sector of Tierra del Fuego, through its rational and sustainable hunting, based on the use of meat, hides and derivatives]. Santiago. www.sag.gob.cl/sites/default/files/273_2016_mag.pdf

Saleh, S.K., Mira, E.K.I., Marzouk, N.M. & Abu-Zied, S.M.A. 2008. Effect of pasteurization on some chemical and bacteriological parameters on camel milk. *Bulletin of the National Research Centre (Cairo)*, 33(3): 287–297.

Salvá, B.K. 2009. Caracterización de la carne y Charqui de Alpaca *(Vicugna pacos)* [Characterization of Alpaca Meat and Jerky (*Vicugna pacos*)]. Universidad de León, Facultad de Veterinaría, Departamento de higiene y tecnología de alimentos. Ph.D. dissertation. http://hdl.handle.net/10612/826

Salvá, B.K., Fernández-Diez, A., Ramos, D.D., Caro, I. & Mateo, J. 2012. Chemical composition of alpaca (*Vicugna pacos*) charqui. *Food Chemistry*, 130(2): 329–334. https://doi.org/10.1016/j.foodchem.2011.07.046

Salvá, B.K., Zumalacárregui, J.M., Figueira, A.C., Osorio, M.T. & Mateo, J. 2009. Nutrient composition and technological quality of meat from alpacas reared in Peru. *Meat Science*, 82(4): 450–455. https://doi.org/10.1016/j.meatsci.2009.02.015

Savica, V., Calò, L.A., Santoro, D., Monardo, P., Mallamace, A. & Bellinghieri, G. 2011. Urine therapy through the centuries. *Journal of Nephrology*, 24 Suppl 17: S123-125. https://doi.org/10.5301/JN.2011.6463

Schmid, A., Collomb, M., Sieber, R. & Bee, G. 2006. Conjugated linoleic acid in meat and meat products: A review. *Meat Science*, 73(1): 29–41. https://doi.org/10.1016/j.meatsci.2005.10.010

Schwartz, H. 1986. The potential of the camel (*Camelus dromedarius*) as a transport and draught animal. FAO-MINEADEP Workshop on "Camels", Kuwait, 1 October 1986. www.researchgate.net/publication/260104461_

Seboussi, R., Faye, B., Askar, M., Hassan, K. & Alhadrami, G. 2009. Effect of selenium supplementation on blood status and milk, urine, and fecal excretion in pregnant and lactating camel. *Biological Trace Element Research*, 128(1): 45–61. https://doi.org/10.1007/s12011-008-8251-3

Seifu, E., Abraham, A-L., Kurtu, M.Y. & Yilma, Z. 2012. Isolation and characterization of lactic acid bacteria from Ititu: Ethiopian traditional fermented camel milk. *Journal of Camelid Science*, 5: 82–98.

Sela, S., Pinto, R., Merin, U. & Rosen, B. 2003. Thermal inactivation of *Escherichia coli* in camel milk. *Journal of Food Protection*, 66(9): 1708–1711. https://doi.org/10.4315/0362-028X-66.9.1708

Shegaw, A., Ipsen, R., Kurtu, M.Y., Eshetu, M., Hansen, E.B., Hailu, Y., Waktola, A. & Dashe, D. 2020. Development of yogurt from camel milk using exopolysaccharide producing lactic acid bacteria. *Ethiopian Journal of Animal Production*, 20(1): 29–43.

Shoman, A., Serikbayeva, A., Mamayeva, L., Faye, B. & Tultabayeva, T. 2018. A biological analysis of endocrine-disturbing chemicals in camel meat sector in Kazakhstan. *EurAsian Journal of BioSciences*, 12(2): 473–479.

Shukla, P., Sakure, A., Pipaliya, R., Basaiawmoit, B., Maurya, R., Bishnoi, M., Kondepudi, K.K. *et al.* 2022. Exploring the potential of Lacticaseibacillus paracasei M11 on antidiabetic, anti-inflammatory, and ACE inhibitory effects of fermented dromedary camel milk (*Camelus dromedaries*) and the release of antidiabetic and anti-hypertensive peptides. *Journal of Food Biochemistry*, *46*(12): e14449.

Shunnaq, M. & Shunnaq, S.R. 2012. *Camel trekking in Jordan: Between oriental perception and authentic tourist expectation*. Vol. 451. Vienna, Verlag der Österreichischen Akademie der Wissenschaften. https://austriaca.at?arp=0x002d244c

Simopoulos, A.P. 2008. The importance of the Omega-6/Omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. *Experimental Biology and Medicine*, 233(6): 674–688. https://doi.org/10.3181/0711-MR-311

Singh, G. 1999. Draught animal energy research in India. In: *Empowering farmers with animal traction*. Proceedings of the workshop of the Animal Traction Network for Eastern and Southern Africa (ATNESA), Mpumalanga, South Africa, 1999.

Smith, M.A., Nelson, C.L., Biffin, T.E., Bush, R.D., Hall, E.J.S. & Hopkins, D.L. 2019. Vitamin E concentration in alpaca meat and its impact on oxidative traits during retail display. *Meat Science*, 151: 18–23. https://doi.org/10.1016/j.meatsci.2019.01.004

Smits, M.G. & Montety, G.J. 2009. Ammonia emission from camel dairy in the Netherlands. *Journal of Camel Practice and Research*, 16(2): 139–142.

Soleymanzadeh, N., Mirdamadi, S. & Kianirad, M. 2016. Antioxidant activity of camel and bovine milk fermented by lactic acid bacteria isolated from traditional fermented camel milk (Chal). *Dairy Science & Technology*, 96(4): 443–457. https://doi.org/10.1007/s13594-016-0278-1

Soltani, M., Boran, O.S. & Hayaloglu, A.A. 2016. Effect of various blends of camel chymosin and microbial rennet (*Rhizomucor miehei*) on microstructure and rheological properties of Iranian UF White cheese. *LWT - Food Science and Technology*, 68: 724–728. https://doi.org/10.1016/j.lwt.2016.01.028

Soto Volkart, N. & Molina Uriarte, R. 2016. *Evaluación del manejo de la población de guanacos en el área agropecuaria de Tierra del Fuego* [Evaluation of guanaco population management in the agricultural area of Tierra del Fuego]. Technical report 2016. Magallanes y Antártica Chilena, Punta Arenas, Servicio Agrícola y Ganadero División Protección Recursos Naturales Renovables (SAG).

Stemmer, A., Valle Zárate, A., Nuernberg, M., Delgado, J., Wurzinger, M. & Soelkner, J. 2005. La llama de Ayopaya: descripción de un recurso genético autóctono [The llama of Ayopaya: Description of an indigenous genetic resource]. *Archivos de zootecnia*, 54(206): 253–259.

Sulieman, A.M.E., Elamin, O.M., Elkhalifa, E.A. & Laleye, L. 2014. Comparison of physicochemical properties of spray-dried camel's milk and cow's milk powder. *International Journal of Food Science and Nutrition Engineering*, 4(1): 15–19.

Textile Exchange. 2021. *Responsible Alpaca Standard 1.0.* https://textileexchange.org/app/uploads/2021/06/RAF-101c-V1.0-Responsible-Alpaca-Standard.pdf

Textile Exchange. 2024. *Materials Market Report 2024*. [Cited 24 April 2025]. https://textileexchange.org/knowledge-center/reports/materials-market-report-2024/

Tolentino Garriazo, J.C. 2021. Caracterización de la piel de alpaca seco salado y procesada hasta pelambre con fines comestibles para perros [Characterization of dried, salte, and processed alpaca skin to fur for edible purposes for dogs]. Universidad Nacional Agraria La Molina, Facultad De Zootecnia. Thesis. https://hdl.handle.net/20.500.12996/4784

Turin, C. & Quiroga Mendiola, M. 2024. New market opportunities in the Andes, *Welt-Sichten*. Supplement(1–24).

Ulmer, K., Heermann, K. & Fisher, A. 2004. Meat products from camel meat. In: Z. Farah & A. Fischer, eds. *Milk and meat from the camel: Handbook on products and processing.* Zollikon, Switzerland, VDF Hochschulverlag AG.

Valdivia, C., Gilles, J. & Turin, C. 2013. Andean pastoral women in a changing world: Opportunities and challenges. *Rangelands*, 35(6): 75–81. https://doi.org/10.2111/RANGELANDS-D-13-00038.1

Veit, D. 2022. Fine animal hair. In: D. Veit, ed. *Fibers: History, production, properties, market* (pp. 327–350). Cham, Switzerland, Springer International Publishing. https://doi.org/10.1007/978-3-031-15309-9_10

Vias, S.G., Pacholek, X., Daouda, H. & Faye, B. 2004. Camel traction in Niger: Between tradition and modern use. In: *Working animals in agriculture and transport* (pp. 201–207). EAAP Technical Series 6. Leiden, the Netherlands, Wageningen Academic. https://doi.org/10.3920/9789086865185_019

Vilá, B. 2002. La silvestría de las vicuñas, una característica esencial para su conservación y manejo [The wildness of vicuñas, an essential characteristic for their conservation and management]. *Ecología Austral*, 12(1): 79–82.

Vilá, B. & Arzamendia, Y. 2022. South American camelids: Their values and contributions to people. *Sustainability Science*, 17(3): 707–724. https://doi.org/10.1007/s11625-020-00874-y

Virtue, J.G., Gee, P.D., Secomb, N.M., O'Leary, P.R. & Grear, B.P. 2016. Facilitating feral camel removal in Australia through commercial use. *The Rangeland Journal*, 38(2): 143–151. https://doi.org/10.1071/RJ15066

Wang, H., Liu, X. & Wang, X. 2005. Internal structure and pigment granules in colored alpaca fibers. *Fibers and Polymers*, 6(3): 263–268. https://doi.org/10.1007/BF02875652

Wang, X., Wang, L. & Liu, S. 2003. *The quality and processing performance of alpaca fibres*. www.researchgate.net/publication/303943573_The_quality_and_processing_performance_of_alpaca_fibres

Wanyoike, F.N., Mugunieri, L.G., Mtimet, N., Kiptoo, E. & Gulaid, I. 2018. *An analysis of the hides and skins value chain in Somaliland*. ILRI Research Report 50. Nairobi, International Livestock Research Institute. https://hdl.handle.net/10568/97102

Wilson, R.T. 2020. The one-humped camel in Eritrea and Ethiopia: A critical review of the literature and a bibliography. *Journal of Camel Practice and Research*, 27(3): 229–262. http://dx.doi.org/10.5958/2277-8934.2020.00034.X

Wood, J.D., Enser, M., Fisher, A.V., Nute, G.R., Sheard, P.R., Richardson, R.I., Hughes, S.I. & Whittington, F.M. 2008. Fat deposition, fatty acid composition and meat quality: A review. *Meat Science*, 78(4): 343–358. https://doi.org/10.1016/j.meatsci.2007.07.019

Wurzinger, M. & Gutierrez, G. 2022. Alpaca breeding in Peru: From individual initiatives towards a national breeding programme? *Small Ruminant Research*, 217. https://doi.org/10.1016/j.smallrumres.2022.106844

Wynne-Hughes, E. 2021. The battle of the camel: Revolution, transition and tourism in Cairo. *Political Geography*, 91: 102491. https://doi.org/10.1016/j.polgeo.2021.102491

Yacobaccio, H.D. 2006. Variables morfométricas de vicuñas (*Vicugna vicugna vicugna*) en Cieneguillas, Jujuy [Morphometric variables of vicuñas *(Vicugna vicugna vicugna*) in Cieneguillas, Jujuy]. *Investigación, conservación y manejo de vicuñas. Proyecto MACS*: 101–109.

Yateem, A., Balba, M.T., Al-Surrayai, T., Al-Mutairi, B. & Al-Daher, R. 2008. Isolation of lactic acid bacteria with probiotic potential from camel milk. *International Journal of Dairy Science*, 3(4): 194–199. https://doi.org/10.3923/ijds.2008.194.199

Zhang, Y., Sun, Y., Yu, Q., Song, S., Brenna, J.T., Shen, Y. & Ye, K. 2024. Higher ratio of plasma omega-6/omega-3 fatty acids is associated with greater risk of all-cause, cancer, and cardiovascular mortality: A population-based cohort study in UK Biobank. *eLife*, 12: RP90132. https://doi.org/10.7554/eLife.90132

Zhou, D. & Shu, T. 1995. The establishment and development of tourism in China. *Senri Ethnological Studies*, 38: 155–167.

SOURCES TABLE 2

i. **Martin, R., Linstädter, A., Frank, K. & Müller, B.** 2016. Livelihood security in face of drought: Assessing the vulnerability of pastoral households. *Environmental Modelling & Software*, 75: 414–423. https://doi.org/10.1016/j.envsoft.2014.10.012

ii. **Correra, A., Lefeuvre, J-C. & Faye, B.** 2008. Organisation spatiale et stratégie d'adaptation des nomades du parc national du Banc d'Arguin . la sécheresse [Spatial organization and adaptation strategy of nomads in the Banc d'Arguin National Park to drought]. *Sécheresse*, 19(4): 245–251.

iii. **Skidmore, J.A., Juhasz, J. & Nagy, P.** 2024. Welfare aspects of reproductive care and management of dromedary camels. In: B. Padalino & B. Faye, eds. *Dromedary Camel Behavior and Welfare: Camel Friendly Management Practices.* pp. 189–206. Cham, Switzerland, Springer International Publishing. https://doi.org/10.1007/978-3-031-48600-5_9

iv. **Alhadrami, G.A. & Faye, B.** 2022. Camel. In: P.L.H. McSweeney & J.P. McNamara, eds. *Encyclopedia of Dairy Sciences (Third Edition).* pp. 48–64. Oxford, Academic Press. https://doi.org/10.1016/B978-0-12-818766-1.00364-0

v. **Mughairi, H.A., Hajri, B.A., Rashdi, A.A., Masalmi, M.A. & Maskari, A.A.** 2024. Socio-economic aspects of camel farming: A case study from Oman. *International Journal of Sustainable Society*, 16(1): 34–52. https://doi.org/10.1504/IJSSOC.2024.136257

vi. **Koç, A. & Demir, P.A.** 2020. Socio-economic dimensions of camel breeding and camel wrestling in Turkey. *Journal of Camel Practice and Research*, 27(3). http://dx.doi.org/10.5958/2277-8934.2020.00039.9

vii. **Abazi, A., Senoussi, A. & Faye, B.** 2023. The Mehari camels (Camelus dromedarius) in the Algerian northern Sahara: What are its characteristics and what types of farming vocations adopted in the Ouargla region? *Journal of Camelid Science*, 17: 1–12.

viii. **Khanna, N.D., Rai, A.K. & Tandon, S.N.** 2004. Camel breeds of India. *Journal of Camel Science*, 1(1): 1–7.

ix. **Nagy, P.P., Skidmore, J.A. & Juhasz, J.** 2022. Intensification of camel farming and milk production with special emphasis on animal health, welfare, and the biotechnology of reproduction. *Animal Frontiers*, 12(4):35–45. https://doi.org/10.1093/af/vfac043

x. **El-Hage Scialabba, N.** 2022. Chapter 13 – Experiences of low-external-input livestock systems. In: N. El-Hage Scialabba, ed. *Managing healthy livestock production and consumption.* pp. 165–219. Cambridge, MA, Academic Press. https://doi.org/10.1016/B978-0-12-823019-0.00025-8

SOURCES TABLE 5

i. **Mamani-Linares, L.W. & Gallo, C.** 2011. Composición química y calidad instrumental de carne de bovino, llama (*Lama glama*) y caballo bajo un sistema de crianza extensiva [Chemical composition and instrumental quality of beef, llama (*Lama glama*) and horse meat under an extensive rearing system]. *Revista de Investigaciones Veterinarias del Perú*, 22(4): 301–311. https://doi.org/10.15381/rivep.v22i4.329

ii. **Ramos Ramírez, M.E.** 2019. Desarrollo de cabanossi con carne de llama (*Lama glama*) procedente de diferentes regímenes de alimentación [Development of cabanossi with llama meat (*Lama glama*) from different feeding regimes]. Lima, Universidad Nacional Agraria La Molina. PhD dissertation. https://hdl.handle.net/20.500.12996/4211

iii. **Cristofanelli, S., Antonini, M., Torres, D., Polidori, P. & Renieri, C.** 2004. Meat and carcass quality from Peruvian llama (*Lama glama*) and alpaca (*Lama pacos*). *Meat Science*, 66, 589–593. https://doi.org/10.1016/S0309-1740(03)00174-8

iv. **Mamani-Linares, L.W. & Gallo, C.B.** 2014. Meat quality, proximate composition and muscle fatty acid profile of young llamas (Lama glama) supplemented with hay or concentrate during the dry season. Meat Science, 96(1): 394–399. https://doi.org/10.1016/j.meatsci.2013.07.028

v. **Polidori, P., Antonini, M., Torres, D., Beghelli, D. & Renieri, C.** 2007. Tenderness evaluation and mineral levels of llama (*Lama glama*) and alpaca (*Lama pacos*) meat. *Meat Science*, 77(4): 599–601. https://doi.org/10.1016/j.meatsci.2007.05.011

vi. **Reyes García, M., Gómez-Sánchez Prieto, I. & Espinoza Barrientos, C.** 2017. Tablas peruanas de composición de alimentos. 10ma ed [Peruvian Food Composition Tables. 10th edition]. Lima, Ministry of Health, National Institute of Health. www.gob.pe/institucion/ins/informes-publicaciones/4231115-tablasperuanas-de-composicion-de-alimentos-tpca

vii. **USP (University of São Paulo).** 2022. Brazilian Food Composition Table (TBCA). Version 7.2. S.o Paulo, Brazil, Food Research Center (FoRC). www.fcf.usp.br/tbca

From alpacas to Bactrian camels, dromedaries, guanacos, llamas, vicuñas and wild camels, camelids contribute to food security, nutrition and economic growth. They provide transport and produce milk, meat and fibre, even under the most extreme climatic conditions. Camelids also hold strong cultural significance and make an important contribution to the conservation of fragile ecosystems. Crucially, they build resilience to the impacts of the climate crisis – particularly in mountains and drylands.

This volume forms part of the series *Camelids: Heroes of Deserts and Highlands, Nourishing People and Culture*, developed within the framework of the International Year of Camelids 2024, declared by the United Nations. It presents a comprehensive overview of the diverse production systems in which camelids are raised around the world, including regions where their presence has recently emerged or expanded, highlighting the wide range of products and services that camelids provide. This volume also explores the role of camelids and their products in both national and international markets, emphasizing their growing economic importance. Finally, it assesses efforts to manage wild camelid species.

ISBN 978-92-5-140449-2

9 789251 404492

CD8253EN/1/02.26