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Review

Equine Milk and Meat: Nutritious and Sustainable Alternatives for Global Food Security and Environmental Sustainability—A Review

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Simple Summary: The research dedicated to equine products, such as milk and meat for human consumption, requires further development in response to current global challenges. These products have the potential to fulfill the growing demand for essential nutrients critical to human health. Additionally, equine farming offers an environmentally sustainable alternative to traditional livestock systems. This review aims to highlight the potential of equine milk and meat as sustainable, nutritionally valuable food sources by examining their unique composition and health benefits; it also explores the sustainability of equine raising in the context of supporting the transition to greener agricultural practices.

Abstract: Global hunger and malnutrition continue to pose significant challenges, entailing innovative and environmentally responsible practices to improve food security. Equine products offer a valuable opportunity to diversify diets and combat nutritional deficiencies. Equine milk, rich in bioavailable nutrients, essential fatty acids, and hypoallergenic properties, serves as an excellent dietary supplement; this aspect could be applied particularly in regions where conventional dairy is inaccessible or unsuitable due to allergies, lactose intolerance, or other health conditions. Similarly, equine meat, known for its high-quality protein content, low fat content, and essential micronutrients like iron and zinc, provides an affordable and sustainable protein source for food-insecure populations. The ability of equines to thrive on marginal lands, coupled with their lower environmental impact compared to traditional livestock (such as ruminants), underscores their potential within sustainable agricultural systems. This review examines the role of equine products in addressing global hunger, highlighting their nutritional benefits, environmental advantages, and the necessity for further research to tackle challenges related to versatility, cultural acceptance, and policy integration.

Keywords: donkey and horse milk and meat; equine potential; global hunger; alternative foods; sustainability

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1. Introduction

Equine raising is recognized as one of the most sustainable agricultural practices, playing a vital role in supporting rural development, particularly in those regions where it serves as a key element of local economies. Horses (*Equus caballus*), donkeys (*Equus asinus*), and their hybrids (mules, the result of crossing the donkey male with the mare) are integral to this practice, contributing through their adaptability and diverse applications [1]. Equines are increasingly valued for their roles in tourism and agricultural labor, especially in areas where mechanization is limited [2–4]. Their high productivity, along with low feeding costs as part of their efficiency in grazing on pastures, makes them an economical option for rural communities [5]. Beyond these functions, equines are highly versatile, supporting activities such as leisure riding and equine-assisted therapy (hippotherapy) [6], which contribute to physical and mental well-being and in some cases have unexpected effects even applying in very short sessions (a meta-analysis applied in children with spastic palsy showed that 8–10 min of horseback riding had a significant impact in reducing the asymmetrical activity of the hip adductor muscles) [7].

In addition to their traditional uses, equines play a growing role in the production of animal-derived products like milk and meat. Equine milk, known for its hypoallergenic qualities and digestibility, is especially beneficial for individuals with conditions such as lactose intolerance, allergies, or metabolic disorders [8–12]. Similarly, equine meat offers a lean, high-quality protein source enriched with essential micronutrients, making it a valuable dietary option [13–15]. These products not only meet nutritional needs but also represent a sustainable alternative within the context of increasing global food demands [16], allergies [17,18], and digestive sensitivity [19,20]. By 2050, meeting the soaring global demand for animal-derived food products, projected to increase by 58–73%, will require sustainable solutions to enhance production efficiency while addressing resource limitations and balancing economic, social, and environmental sustainability [21].

Equine milk and meat are increasingly recognized for their remarkable nutritional value and health benefits, making them valuable alternatives in the food industry. Unlike cow's milk, equine milk is lower in fat and contains higher levels of several nutrients such as vitamin C (which is absent in bovine milk) [22–24]. This makes horse and donkey milk a suitable option for individuals with lactose intolerance or milk allergies. It is also considered closer in composition to human breast milk, making it easier to digest, particularly for infants with specific dietary needs [25]. It is popular in several areas where it has cultural and nutritional significance as Kazakhstan, Kyrgyzstan, Mongolia, Russia, and China—these countries have an old tradition of consuming mare's milk, as a fermented beverage named *kumis*, known for being nutritional and also medicinal—South Korea, Japan—in these regions, donkey and mare milk is considered a delicacy, being also a part of cosmetic products—Turkey, Arabian Peninsula, and other Middle Eastern countries—*kumis* is also popular—Italy, Spain, France—it started to have popularity, as the idea of being healthy has been spread; it is also preferred as a food supplement and in cosmetic products—it started to gain more interest also in the United States and Canada, since it represents an alternative to cow milk products. In Kazakhstan, Kyrgyzstan, and Mongolia, the consumption of *kumis* ranges between 1 and 2 L/day/person. In Russia, the registered quantities are from 1–2 L/week/person (it is less common than cow's and goat's milk or products). In China, it is considered a niche market in most areas, but the volume is around 1–2 L/week/person for the people who consume it for health benefits. In South Korea and Japan, volumes that range from 0.5–1 L/week/person are registered, and the values are sustained by a small percentage of the population that prefers equine milk regularly. In Turkey and the Arabian Peninsula, while camel's milk is traditional, *kumis* consumption registers 0.5–1 L/week/person. In Europe, equine milk (as *kumis* and supplements) is consumed in quantities smaller than 1 L/week (especially in Italy, Spain, and France). In the USA and Canada, it is preferred by individuals with dairy allergies or those seeking healthier products, the reason for which the consumption does not surpass 1 L/month/person [24].

Equine meat, known for being lean and rich in protein, is also appreciated for its lower fat content and high levels of essential minerals such as iron and zinc. This makes it desirable, particularly in regions where other forms of meat may not be as accessible or affordable. When compared to beef, equine meat offers a healthier alternative, as it is lower in saturated fats and cholesterol, making it particularly advantageous for individuals aiming to manage their heart health [26–28]. Compared to rabbit meat, equine meat is better suited for diets emphasizing higher omega-3 fatty acid intake and offers superior sensory qualities, such as flavor and texture. On the other hand, rabbit meat is a low-fat option that is rich in polyunsaturated fatty acids (PUFAs), making it ideal for heart-healthy and low-calorie diets [29,30]. Compared to poultry meat, equine meat also has higher levels of omega-3. As a result of grazing on pastures, it is also lower in fat content, richer in iron, and more fibrous than poultry meat [31,32]. In comparison to sheep meat, equine meat is much leaner, with a significantly lower fat content and a healthier omega-3 fatty acid profile; while sheep meat, especially lamb, is prized for its tender texture and distinctive gamey flavor, horse meat tends to offer a sweeter, richer taste with a firmer texture, often resembling beef [26,33]. Additionally, equine meat is lower in saturated fats and contains more iron, making it a heart-healthy choice and suitable for treating anemia. In contrast, mutton, especially, tends to have a higher fat content, which may make it less favorable for those seeking leaner options [34–36]. In Europe, horse meat is popular in France (in dishes as horse steak or steak de cheval, cured meat or bresaola and sausages [36]), where consumption of 40,000–60,000 tons is registered annually [37], then in Italy (in traditional dishes as patissada de cavalo or horse stew [38]) in quantities that range between 5000 and 10,000 tons/annually [37] and also in Belgium (preferred as steak de cheval, burgundy horse meat stew, saucisses de cheval or sausages, and tartare de cheval [38] in approximately 4000 tons/annually [37]) and Switzerland (boeuf de cheval or horse beef stew, horse meat carpaccio, steak, sausages, and cured horse meat [38] but only in approximately 2000 tons/annually [37]). In Asia, Mongolia, Kyrgyzstan, Turkmenistan, and Japan are countries with tradition in this sense, but Kazakhstan is still in the first place for horse meat consumption in the whole world (more than 40,000 tons/annually [37] as beshbarmak or boiled horse meat with noodles or sausages [36]). In second place is Kyrgystan, with 10,000–20,000 tons/annually [37], where beshbarmak, stews, and sausages are preferred (the highest consumption is registered during various cultural festivals, especially Nowruz, which is the Persian New Year) [36]. In Mongolia, horse meat consumption is approximately 10,000 tons/annually [36], in traditional dishes such as beshbarmak, buuz (steamed dumplings filled with minced meat), horhog (horse meat with vegetables), shul (soup), tsuivan (noodle dish), khuushuur (deep-fried pastries filled with meat), airag with horse meat (combination between horse meat and milk), and tamir (dried horse meat) [37]. Then, Turkmenistan is well-known for this practice, where döşeme, or a type of meat stew, and aslama, or stew with horse meat and vegetables, are traditional dishes [37], in quantities that range between 5000 and 10,000 tons/annually [36]. In Japan, sakuraniku, basashi (raw horse meat), and uni-kushi (skewers) [38] are consumed in quantities from 3000 to 5000 tons/annually [37]. In South America, Argentina is a country where horse meat is consumed in rural areas, but in small quantities, beef being their first option; in Mexico and Canada, there are some communities where such practices exist, but again to a limited extent. Horse meat consumption is restricted or even forbidden in most states of the USA, United Kingdom, and Ireland (where horses are considered companion animals generally), and in India, there are religious restrictions (in some areas, horses are seen as sacred animals). In Saudi Arabia, Indonesia, and other Muslim-majority countries, even if it is not forbidden through religion, horse meat consumption is uncommon; in Israel, on the other hand, eating horse meat is banned for Jewish people under kosher dietary laws, and in Australia, it is culturally taboo (horses are considered companions or working animals) [39].

On the other hand, equine raising provides advantages when it comes to sustainable farming. In rural and marginal areas, where pastures and natural meadows are predominant, equine farming presents a sustainable, resource-efficient method of food production. The low environmental impact of equines, along with their ability to thrive on natural grasslands, supports eco-sustainable farming practices [21]. This approach not only supports landscape conservation and biodiversity but also strengthens food security by ensuring a reliable supply of both milk and meat. By incorporating equine products into local economies, communities can strengthen their resistance, improve nutritional intake, and foster sustainable agricultural practices that contribute to long-term environmental and social stability [5,32,40–42].

More than that, the adaptability of equines to diverse environments, from arid to temperate regions, further enhances their significance. Their ability to provide ecological, economic, and social benefits underscores their importance in promoting sustainable agricultural systems, addressing food security, and fostering rural livelihoods. This multifunctionality makes equines indispensable in ensuring both economic resilience and environmental sustainability in rural areas. At the same time, sanitary management practices such as disease prevention strategies, sanitary control measures, and animal welfare conditions are important. Through implementing these biosecurity and management practices, the risk of infectious diseases is reduced; this involves quarantining new horses for at least 30 days before introducing them to the herd and also ensuring that all the new horses have health certificates, vaccinations, and negative disease test results. Also, cleaning and disinfecting transportation equipment and clothing after handling all the new horses is crucial; special attention should be given to the foals and older equines due to their susceptibility to getting ill, and good practice is to limit visitor access, to monitor the farm entrance and to use footbaths at their entrance contribute to minimizing the risk of introducing pathogens inside the herd. However, active immunity is a key concept in disease prevention, acquired through vaccination, which helps the body to produce antibodies (this action can prevent infectious diseases in equines if given before exposure to the illness such as tetanus, encephalomyelitis, rabies, West Nile virus—core disease vaccinations—and anthrax, botulism, equine herpesvirus, equine viral arteritis, influenza, Potomac horse fever, rotavirus A, strangles—risk-based disease vaccinations; also, adenovirus, African horse sickness, brucellosis, clostridial enterocolitis, contagious equine metritis, equine infectious anemia, vesicular stomatitis are other diseases that could appear in this case) [39]. When discussing welfare conditions for equine raised for milk and meat, they should benefit from enough space (stalls of 3 × 3 m for foals and small breeds up to 4.2 × 4.2 m for large breeds and 0.6–0.8 hectares of pasture per animal), clean living areas and the possibility to interact with others since this is their natural behavior. The stalls should be equipped with fresh watering machines and comfortable straw beds and should also be well lit (8–12 h of preferably natural light; if the light is artificial, the brightness has to be 100–150 lux); then, the diets must be balanced and sufficient, the equines should be handled with respect, and the daily care is essential, as is regular veterinary checks [40].

In conclusion, equine rearing offers nutritious and health-conscious alternatives through both milk and meat while contributing to rural economies and sustainable agriculture. Equine milk has a lower fat content and higher vitamin C levels compared to cow's milk, being an ideal option for individuals with lactose intolerance or milk allergies. Additionally, its closer composition to human breast milk enhances digestibility, particularly for infants with special dietary needs. More than that, equine meat is a lean, low-fat protein source enriched with omega-3 fatty acids and essential minerals, making it a valuable dietary choice compared to other meats such as beef, poultry, and lamb. In addition to its health benefits, equine farming is environmentally sustainable, as equines are well-suited to diverse climates and contribute to maintaining biodiversity. Their adaptability, low environmental impact, and multifaceted roles underscore their importance in fostering long-term economic and environmental resilience in rural communities.

2. Equine Population and Productions Worldwide

2.1. The Total Number of Equines Raised Worldwide

Data on the accurate number of equines raised worldwide are missing in many countries due to a lack of communication between organizations and governments. Still, it is estimated that the total number of horses, donkeys, and mules is 116 million (36 million are in 38 of the lowest-income countries). Data are essential not only for disease control and epidemiological research but also for finding solutions to actual problems such as climate change, water access, and global food challenges. There is a report that refers to 36 countries that managed to explore problems for governments, and it was able to recommend a couple of ideas in this respect. Also, studies that involved the United Kingdom, China, Mexico, India, Mexico, Kenya, and Senegal are available [37,43]. From the total number of registered equines, 57 million are horses, 50.5 million are donkeys (99% of the total number of the donkey population is in low-to-middle-income countries—LMICs), and 7.9 million are mules. Unfortunately, 22 of 36 countries have not reported their equid populations in the past decade. Governments in lower-income countries face challenges in collecting consistent and accurate livestock data. This results in limited insight into the socio-economic contributions of equids (such as donkeys and horses), emerging threats to their populations, and cross-border movements. The lack of reliable data contributes to the vulnerability of donkey populations, with some national populations in decline, though accurate statistics remain scarce [37,44,45].

According to other sources [41], while in 1980 a number of 59.63 million horses, 38.9 million donkeys, and 12.93 million mules were raised, in 2010, the situation would appear to reveal numbers like 59.76 million horses, 43.47 million donkeys, and 10.47 million mules (Table 1).

Table 1. The total number of equines between 1980 and 2010 (worldwide) *.

Equines	**Mil./Year**			
	1980	**1990**	**2000**	**2010**
Horses	59.63	61	57.76	59.76
Donkeys	38.9	43.76	41.63	43.47
Mules	12.93	14.83	12.93	10.47

* Source: [41].

2.2. The Equines Raised for Milk Production

Cattle account for 81% of global milk production, followed by buffaloes at 15%, goats at 2%, and sheep at 1%. Camels contribute 0.4%, and the rest comes from other dairy species like equines and yaks. In developing countries, about one-third of milk production comes from buffaloes, goats, camels, and sheep. Conversely, in developed nations, cattle are responsible for nearly all milk production. In several areas, non-cattle dairy species account for 38% of milk production in Asia, 22% in Africa, 3% in Europe, and only 0.5% in the Americas, with minimal production in Oceania [45].

In several regions, horse (*Equus caballus*) and donkey (*Equus asinus*) milk serve as essential sources of nutrition for subsistence farmers. Horses are typically used for dairy production in cooler climates, while donkeys are favored in dry, semi-arid areas. Milking equines is labor-intensive, requiring frequent sessions—usually 5 to 6 times a day. Additionally, a mare will not release milk unless its foal is present to stimulate it. In the steppes of Central Asia, horse milk is consumed in the form of *kumis*, a traditional fermented lactic-alcoholic beverage. Horse milk also plays a vital role as an animal protein source for pastoralists in Mongolia (in this region, yaks are the major source of milk and milk products). In contrast, donkey milk has become less common for consumption, though it is still used for medicinal purposes in some African communities [46].

2.3. The Equines Raised for Meat Production

The global horse meat market, while a niche sector compared to larger industries like beef and poultry, holds significant cultural and economic importance in certain regions, especially Kazakhstan, China, and parts of Europe. The industry is influenced by varying factors, including shifting global consumption trends, ethical debates surrounding horse slaughter, and the maintenance of demand in key markets. Kazakhstan is the global leader in horse meat production, slaughtering around 450,000 horses annually, making it the largest producer worldwide. The country's vast pasturelands are ideal for equine farming, driving this high level of production [44]. Horse meat is a central component of traditional diets in Kazakhstan and neighboring countries such as Kyrgyzstan and Turkmenistan, where it is consumed in various forms, including *kumis*, a fermented mare's milk drink. This cultural attachment to horse meat ensures its continued demand and significant role in the region's culinary heritage. In 2021, Kazakhstan exported around 10,000 tons of horse meat, primarily to Russia and other Central Asian nations. However, export figures can fluctuate based on regional trade agreements and global demand. The Kazakh government has made efforts to support the industry, bolstering both domestic consumption and international exports [36,45,46].

In China, the consumption of horse meat is less widespread compared to Kazakhstan or Europe, but it holds a niche market, especially in the northern regions like Inner Mongolia. Though production data are not as readily available, estimates suggest that China produces several thousand tons of horse meat annually. Horse meat is used in traditional dishes and sometimes consumed for medicinal purposes, particularly in rural and pastoral regions. The demand in China remains low compared to the other regions, but it is still an important dietary component in specific areas [36,44,47].

In Europe, countries like France, Italy, and Romania have long-standing traditions of consuming horse meat, albeit to varying degrees. France has historically been one of the largest consumers of horse meat in Europe. Although the demand has waned in recent decades, the country produced about 33,000 tons of horse meat in 2020. Horse meat is still available through specialized butchers and restaurants, where it is marketed as a healthy and lean alternative to beef. In Italy, the interest in horse meat has seen a resurgence, particularly in traditional regions like Lombardy and Tuscany. Italy produced approximately 4000 tons of horse meat in 2020, much of which is used in sausages and premium dishes like horse steaks. Romania produces a steady supply of horse meat, primarily for local consumption. With a horse population exceeding 1 million, Romania's annual production hovers around 10,000 tons [36,44,48].

According to other sources [49,50], the global livestock of horses has increased by 1,762,110 heads and by 83,356 heads when analyzing the donkey herds between 2019 and 2022. The production of donkey meat decreased by 20,965.89 tons in this period, and the carcass weight increased by 20 g/year during the given period (Table 2). For horses, there are not enough data available.

Table 2. Equine meat production worldwide (2019–2022) *.

Item		Unit	Year			
			2019	**2020**	**2021**	**2022**
Livestock	Horses	N	58,819,179	59,592,065	59,780,596	60,581,289
	Donkeys	N	51,603,917	52,636,569	52,075,158	51,687,273
Production	Meat of horses	t	-	-	-	-
	Meat of donkeys	t	125,270.58	123,654.85	114,993.36	104,304.69
Yield/carcass weight	Horses	100 g/An	-	-	-	-
	Donkeys	100 g/An	876	883	885	896

* Source [50]—N = number of heads per year; t = tones; 100 g/An = the amount produced per year.

The global demand for horse meat, while still concentrated in specific regions, is gradually increasing as consumers seek healthier, leaner meat options [15]. Although the market for horse meat remains small in countries like Japan and Belgium, these nations feature niche markets, particularly in urban areas where there is a growing appreciation for diverse culinary experiences [44]. This trend reflects a broader interest in alternative, nutritious meats as part of more varied diets [51].

3. Equine Milk—Benefits for Human Consumption

3.1. Historical Uses

The medicinal properties of various substances, including equine milk, have been recognized since ancient times by influential figures whose writings still inform our understanding of health and wellness. Herodotus (c. 484–c. 425 BCE), the renowned Greek historian, offers valuable insights into the use of equine milk in his seminal work Histories. He describes the nomadic Scythian tribes and other Central Asian people, who relied on mare's milk as a vital resource. Herodotus highlights the consumption of fermented mare's milk, particularly in the form of *kumis*, a traditional fermented beverage. He underscores not only the nutritional benefits of mare's milk but also its crucial role in the nomadic lifestyle, providing essential nourishment during long journeys and harsh conditions [52]. Moreover, Hippocrates (c. 460–c. 370 BCE), often called the "Father of Medicine", also acknowledged the therapeutic properties of equine milk. In his comprehensive medical writings, he recognized mare's milk for its healing qualities, recommending it for various ailments, including digestive issues and respiratory conditions. It was especially valued as a tonic for overall health and was thought to be beneficial for patients with chronic illnesses such as tuberculosis and other respiratory diseases. This aligns with contemporary views on the potential health benefits of mare's milk, which is appreciated for its unique nutritional composition [53]. Then, Pliny the Elder (c. 23–79 CE), in his *Natural History*, offers additional insights into the use of equine milk, particularly in Central Asia. He emphasizes the health-promoting qualities of mare's milk and its restorative effects on the body, underscoring its importance in the diets and traditions of various cultures in the region [54]. Also, Galen (c. 129–c. 216 CE), a renowned physician of the Roman Empire, acknowledged the therapeutic benefits of mare's milk, particularly in addressing lung ailments and digestive issues. Similar to Hippocrates, he recommended equine milk as a restorative remedy to strengthen the body and support the immune system [55]. Marco Polo (1254–1324 CE), the famed Venetian explorer, recorded the widespread consumption of equine milk during his travels across Asia. He detailed the dietary habits of Mongol tribes, highlighting their reliance on *kumis*, a fermented mare's milk, as a crucial element of their sustenance. Polo noted that *kumis* played a significant role in maintaining their health and vitality, serving as both a nutritional cornerstone and a vital resource for their nomadic lifestyle, which demanded physical endurance and an active way of life [56]. Then, also Avicenna (c. 980–1037 CE), the renowned Persian polymath and a pivotal figure of the Islamic Golden Age, highlighted the benefits of equine milk in his groundbreaking medical treatise, *The Canon of Medicine*. He praised mare's milk for its nutritional value, recommending it for its strengthening effects and its ability to support the treatment of chronic illnesses. Furthermore, Avicenna recognized its effectiveness in alleviating inflammation and mitigating adverse reactions caused by the consumption of specific foods and beverages, emphasizing its therapeutic versatility [57].

Nowadays, many studies have emphasized the nutritional value and health benefits of equine milk, which has become an increasingly appreciated food product, especially in pastoral and rural regions. With a chemical composition that closely resembles human milk, equine milk is rich in lactose, essential fatty acids, and bioactive compounds that promote health [58]. Mare's milk is highly regarded for its immune-enhancing properties, which stem from its distinctive blend of proteins, vitamins, and minerals. It is believed to offer therapeutic benefits for managing digestive disorders, respiratory conditions, and chronic illnesses. Furthermore, equine milk is recognized for its ability to support immune function and contribute to overall health and vitality [59,60].

3.2. The Chemical Composition of Equine Milk

Horse and donkey milk are considered closer to human milk in terms of protein composition (horse milk has 1.5–2.5%, donkey milk has 1.5–2.0%, and human milk has 1.0–1.5%) and lactose content (horse and donkey milk have 6.0–7.0% and human milk has 1.0–7.5%) when compared to cow's milk (3.0–3.5% protein and 4.5–5.0% lactose) [23,60]. Studies show that most people can tolerate up to 14 g of lactose per day, and the fermentation process of horse milk further reduces its lactose content, enhancing its digestibility for those with sensitivities. Additionally, horse milk is low in calories, making it an ideal choice for weight-loss diets and reducing the risk of weight gain. However, due to its relatively low energy content, equine milk is not recommended as the sole source of nutrition for infants unless supplemented with vegetable oil (approximately 40 g per liter) to ensure sufficient caloric intake and essential nutrients for growth and development [61–67] (Table 3).

Table 3. The chemical composition of milk from various species *.

Item (%)	Species					
	Horses [a]	Donkeys [b]	Mules [c]	Cows [d]	Sheep [e]	Goat [f]
Total solids	10–12	9–11	10–12	12–13	18–20	12–14
Fat	1.0–2.5	1.0–1.5	1.0–2.0	3.5–4.5	6.0–7.0	4.0–5.0
Protein	1.5–2.5	1.5–2.0	1.5–2.5	3.0–3.5	5.5–6.0	3.0–4.0
Lactose (carbohydrates)	6.0–7.0	6.0–7.0	6.5–7	4.5–5.0	4.5–5.0	4.1–4.5
Ash	0.3–0.5	0.3–0.6	0.9–1.2	0.7–1.0	1.0–1.2	0.9–1.1
Water content	88–90	89–91	88–90	87–88	80–82	88–86

* Sources: [a] [68]; [b] [69]; [c] [70]; [d] [69] [e] [70]; [f] [71].

Sheep milk, with its higher fat content, is an excellent choice for those seeking a richer source of energy and nutrition. This makes it particularly beneficial for individuals with increased caloric needs, such as athletes, the elderly, or those recovering from illness. Its fat-rich composition is also valuable for people dealing with conditions like malnutrition or cachexia, where maintaining weight and muscle mass is crucial [69]. Moreover, the protein and fat content in sheep milk helps strengthen the immune system, aiding in recovery from infections or post-surgery convalescence. Goat milk, while having a more moderate fat content than sheep milk, still contains more fat than cow's milk [68–70]. Goat milk has been recommended for individuals with sensitive digestive systems or food allergies. Due to its smaller fat globules, goat milk is easier to digest, making it a suitable option for individuals who experience difficulty processing cow's milk. The reduced fat content makes them a preferred choice for people with cardiovascular concerns, as they contribute less to saturated fat intake, potentially lowering the risk of heart disease [71–75].

Individuals aiming to increase their intake without consuming high levels of saturated fats may opt for horse or donkey milk, as these offer a light yet nutritious choice, especially for those managing weight loss or caloric restriction in a healthy way. For people with sensitive digestion, horse and donkey milk are ideal choices, offering a gentler option without the added fat [76].

Clinical studies on the effects of consuming horse and donkey milk in children with various allergies have been documented since 1992. Donkey milk, in particular, has been the focus of several studies due to its high palatability, attributed to its lactose content of 6.0–7.0%, and its low allergenicity. Moreover, when produced under high hygiene standards and properly supplemented for nutrition, equine milk has been shown to be a promising alternative in the dietary management of children with conditions such as immunoglobulin E-mediated cow's milk protein allergy and food protein-induced enterocolitis, which typically manifests within the first 6 months of life [77]. However, the evidence regarding the effectiveness of equine milk in meeting the nutritional needs of children is not yet conclusive, as further research with larger studies is required to validate these findings. Despite its potential, donkey milk is used cautiously and is generally recommended for children over the age of one, as part of a solid food diet, or as an added ingredient [78–83].

3.3. Bioactive and Functional Compounds

The bioactive and functional compounds in other species' milk and equine milk share several similarities, but there are distinct differences in their composition and effects on human health [84].

Milk proteins primarily consist of casein proteins (alpha-casein, beta-casein, and kappa-casein), which account for approximately 80% of the total protein in cow milk and around 60–80% in the milk of other mammals, such as goats and sheep. These proteins form gels or clots in the stomach, promoting slow digestion and enhancing nutrient absorption. Caseins are also responsible for milk's white color and are a key source of essential amino acids and minerals, including calcium and phosphorus [85]. Whey proteins, including beta-lactoglobulin, alpha-lactalbumin, serum albumin, and immunoglobulins (IgA, IgG, and IgM), which are crucial for immune function, make up about 20% of the protein in cow milk and a higher percentage in goat and sheep milk. These proteins are quickly digested and are of high biological value, as they contain all the essential amino acids. Milk also contains small amounts of enzymes such as lipase and lacto-peroxidase, as well as proteins like lactoferrin and lysozyme, which have antimicrobial properties [86]. The comparison between species regarding these aspects is revealed in Table 4.

Table 4. The comparison between the bioactive and functional compounds of different breeds *.

		Species				
Item		**Horses** [a]	**Donkeys** [b]	**Cows** [c]	**Sheep** [d]	**Goat** [e]
Casein (%)		1.1–1.4	0.7–1.0	2.6–2.8	3.8–4.2	2.4–2.7
Bioactive peptides (mg/mL)		1.5–2.5	1.0–1.8	2.0–4.0	3.5–5.0	2.5–3.5
Conjugated linoleic acid (CLA)—mg/g fat		1.0–1.5	1.0–1.2	3.5–7.0	6.0–11.0	4.0–8.0
Omega-3 fatty acids (mg/100 g fat)		70–100	60–90	30–50	40–60	20–40
Unsaturated fats (%)		60–70	55–65	25–35	30–40	27–35
Digestibility level		High	Very high	Moderate	Low to moderate	high
Immunological properties		Rich in lactoperoxidase and cytokines; anti-inflammatory peptides	Contains growth factors and cytokines; hypoallergenic	Contains beta-lactoglobulin and casein-derived peptides with immune effects	Rich in antioxidant peptides and lactoperoxidase	Contains bioactive peptides promoting gut health
Vitamins	A (μg/100 mL)	18–25	20–30	28–40	50–75	40–50
	D (μg/100 mL)	0.1–0.2	0.1–0.3	0.1–0.2	0.3–0.5	0.2–0.4
	E (μg/100 mL)	40–60	50–70	60–80	80–100	50–70
	C (mg/100 mL)	1.2–1.8	1.5–2.0	1.0–1.5	1.0–1.8	1.2–1.8
	B complex	Lower levels of B2 vitamin than cow and sheep milk, low but comparable to cow and goat milk levels of B9, and lower levels of B1 than cow milk	Moderate levels compared to goat milk	Rich in B2 vitamin: 0.16 mg/100 mL and B12 vitamin: 0.4 μg/100 mL	Higher levels of B2 and B9 vitamins compared to cow milk	High levels of B2 and B3 vitamins
Minerals (mg/100 mL)	Ca	110–130	35–45	120–130	160–180	120–140
	P	85–100	20–30	90–100	110–130	90–100
	Mg	10–15	6–10	10–15	20–25	10–15
	K	150–200	150–200	140–150	150–200	180–200
	Na	35–40	15–20	40–50	45–55	40–50

* Sources: [a] [68]; [b] [86]; [c] [70]; [d] [69]; [e] [72].

Bioactive peptides are protein fragments released during digestion or fermentation that exert biological effects beyond basic nutrition. One such compound is lactoferrin-derived peptides. Lactoferrin, a multifunctional glycoprotein found in both the whey and casein fractions of milk, possesses antibacterial, antiviral, and anti-inflammatory properties. Additionally, peptides derived from lactoferrin may enhance iron absorption and help modulate immune responses [86–88].

Casein-derived peptides are another group of bioactive peptides. When casein is hydrolyzed, it releases peptides with a range of health benefits, including opioid-like peptides such as casomorphins, which have pain-relieving and relaxing effects. Some casein peptides also act as antihypertensive agents by inhibiting ACE (angiotensin-converting enzyme), potentially helping to lower blood pressure. Additionally, certain casein peptides have antioxidant properties, which help protect against oxidative stress and promote overall cellular health. Whey proteins are also a source of bioactive peptides with diverse health benefits. Among these are lactokinins, which have antihypertensive properties and contribute to lowering blood pressure. Peptides derived from alpha-lactalbumin are known to reduce inflammation and improve gut health. Additionally, immunomodulatory peptides, including those derived from immunoglobulins like IgA, help strengthen the immune system's defense against infections. Although not proteins, milk oligosaccharides—particularly abundant in human milk—serve as prebiotics, fostering the growth of beneficial gut bacteria and indirectly promoting digestive and immune health [85]. When comparing the protein content of milk from various species to donkey and horse milk, it is notable that cow's milk is predominantly composed of two types of proteins: casein (around 80%) and whey proteins (approximately 20%). Caseins are recognized for their gel-forming ability in the stomach, which supports slower digestion. Additionally, bioactive peptides derived from cow's milk proteins, such as lactoferrin and α-lactalbumin, have been shown to possess immunomodulatory, antibacterial, and anticancer properties. Casein-derived peptides exhibit antihypertensive effects and may support gut health. Sheep milk, with its higher protein content compared to cow milk—particularly its abundance of casein—offers greater nutritional value in terms of protein. It is also rich in bioactive peptides with antioxidant properties that enhance immune function and promote cardiovascular health. Additionally, sheep milk contains elevated levels of lactoferrin, a compound with potent antimicrobial properties [87].

Goat milk contains both casein and whey proteins, with a higher proportion of whey proteins than cow milk, which enhances its digestibility. Bioactive peptides derived from goat milk whey proteins offer anti-inflammatory and antimicrobial properties. Additionally, goat milk is rich in oligosaccharides, which support gut health by encouraging the growth of beneficial bacteria [73]. Donkey milk closely resembles human milk in composition, with a higher proportion of whey proteins and lower casein levels, making it potentially more suitable for individuals with milk allergies. Its bioactive peptides, including lysozyme, exhibit immune-modulating and antimicrobial properties. Additionally, donkey milk is rich in immunoglobulins, which play a crucial role in enhancing immune function [17,18,83]. Mare's milk exhibits a higher proportion of whey proteins and lower casein levels, akin to human milk, which enhances its digestibility. Additionally, it contains lysozyme and lactoferrin, which offer immune-modulating and antimicrobial benefits. Due to its lower allergenicity compared to cow milk, mare's milk serves as a suitable alternative for individuals with sensitivities [84].

When comparing the fat content across different species' milk, several key aspects emerge: cow's milk contains a mix of saturated and unsaturated fatty acids, which support energy needs and the absorption of fat-soluble vitamins. Additionally, the lipids in cow's milk include bioactive compounds such as conjugated linoleic acid (CLA), known for its potential anti-inflammatory and anti-cancer properties [86]. The sheep milk is richer in fat compared to cow milk, with a higher percentage of unsaturated fatty acids, including omega-3 fatty acids. These contribute to cardiovascular health and are beneficial for reducing inflammation and improving brain function [70]. Goat milk contains a higher proportion of short- and medium-chain fatty acids compared to cow milk, making it easier to digest and absorb. These smaller fat globules are particularly beneficial for individuals with digestive issues or absorption disorders. Additionally, goat milk contains conjugated linoleic acid (CLA), which is associated with potential health benefits, including anti-inflammatory effects [83].

When comparing the lactose content and digestibility of milk from different species, including donkey milk, several differences become apparent. While lactose-free alternatives are available, they may still contain other components that could cause issues for sensitive individuals [24]. Sheep milk has a higher lactose content than cow milk, but it is still tolerated by some people who have mild lactose intolerance due to its composition of proteins and fats that aid digestion [74]. Goat milk contains less lactose than cow milk, and its proteins are easier to digest. As a result, it is a better choice for individuals with mild lactose intolerance or those with sensitive digestive systems [73]. Although donkey milk contains similar levels of lactose to cow milk, its higher whey protein content makes it easier to digest for some individuals, including those with mild lactose intolerance. The mare milk contains similar lactose levels to cow milk but is more digestible due to its higher whey protein content. Considered easier to tolerate for those with mild lactose intolerance [75].

When comparing the immunological properties of different species' milk, several key points emerge. Cow milk contains immunoglobulins and other bioactive compounds, but its immune-modulating effects are generally less powerful than those found in donkey and sheep milk. While cow milk does support gut health and immune function to some extent, it is often regarded as less effective for individuals with immune system issues or allergies [89]. Sheep milk is rich in immunoglobulins and lactoferrin, which play a key role in enhancing immune responses. The milk's elevated protein content, particularly its immunoglobulins, aids in combating pathogens and promoting overall health [90]. Goat milk contains moderate levels of immunoglobulins and lysozyme, which provide immune support, though these levels are lower than those found in sheep and donkey milk [91]. On the other hand, donkey milk is rich in immunoglobulins, particularly IgG, making it an excellent option for enhancing the immune system. This has led to its use in helping individuals with weakened immune systems or digestive issues. Similarly, mare milk also contains high levels of immunoglobulins (especially IgG), which support immune health and are used to boost immunity in individuals with compromised immune systems [91].

When comparing the vitamins and minerals in different species' milk, including donkey milk, the following conclusions can be made. Cow milk is abundant in vitamins such as B2 (riboflavin), B12, and D, as well as essential minerals like calcium and phosphorus, all of which are vital for bone health and overall development. Sheep milk contains higher amounts of vitamins A, D, and E compared to cow milk, making it more nutrient-dense. It is also richer in calcium, iron, and zinc, which are crucial for bone health, immune function, and blood cell production [92]. Goat milk offers higher levels of calcium, potassium, and magnesium than cow milk, supporting bone health, nerve function, and muscle function [93–96]. Donkey milk stands out for its higher vitamin C content, which supports the immune system and acts as an antioxidant. It also contains moderate levels of calcium and magnesium, which aid in bone health. Mare milk also has elevated vitamin C levels, benefiting immune function and acting as an antioxidant, along with moderate amounts of calcium and magnesium to support bone health [97].

3.4. The Sensory Analysis of Equine Milk

Compared to cow's milk, equine milk is sweeter due to the higher content of lactose and smoother texture, and compared to goat's milk, it has a smoother texture, a more subtle flavor and it is less creamy [8]. The sensory analysis involves the fat content, flavor, sweetness, texture, color, smell, and astringency (Table 5).

The factors that influence the sensory attributes are as follows: the fat content is influenced by the breed (Percheron, Belgian Draft, Clydesdale), the diet (high-energy levels and season changes increase the fat content), the mare's health (healthy mares produce milk with more fat content), and the stage of lactation (at the beginning, the milk is lower in fat), the flavor is influenced by the diet, freshness, fat content (hay, grass, and oat can influence the sweetness and flavor, if the milk is fresh it has a milder flavor, while if it is older tends to have more pronounced aftertaste, and a higher fat content makes it creamier and flavorful), the sweetness is influenced by the stage of lactation (the colostrum is sweeter), the diet (good pastures lead to sweeter milk), and the health's mare (if the mare is healthy, produces sweeter milk); a lower fat content, and also freshness contributes to a lighter texture; some breeds as Purebred Arabian and high-carotene contents (found in pasture and carrots) produce a yellow color. The smell is influenced by grass and oats, which bring a pleasant scent, while improper storage can lead to specific and unwanted odors. The astringency is influenced by the fat levels (low fat content leads to less astringency) and by the mare's health (healthy mares have reduced astringency) [92].

Table 5. Sensory analysis of equine milk [98] *.

Sensorial Attribute	Exposure
Fat content	- has a fat content that ranges between 1.5 and 2.5%, which makes it light but creamy as texture
Flavor	- sweet, mildly creamy flavor, slightly bitter
Sweetness	- naturally sweet due to high lactose content
Texture	- light, watery, smooth
Color	- white to pale yellow, sometimes slightly opalescent due to low fat content and smaller fat globules
Smell	- mild, pleasant, fresh odor
Astringency	- low, which means the aftertaste is now dry

* Source [98].

3.5. Dairy Equine Raising

3.5.1. Dairy Equine Diets

Equines raised for milk, such as horses and donkeys, have unique nutritional needs. Their diets must be carefully balanced to support optimal milk production while maintaining their overall health [93–97,99]. First and foremost, their diet needs to be well-rounded, including high-quality forage like grass or hay (Table 6).

Table 6. Nutritional profile of high-quality forages for equine *.

Item	Protein (%)	Digestibility (%)	Fiber (%)	Fat (%)	Energy (ME) (MJ/kg)	Minerals (%)	Vitamins
Grass/pasture	10–15	60–80	20–30	1–2	8–12	0.3–0.6 Ca 0.2–0.3 P 0.1–0.2 Mg 2–3 K	500–1000 IU/kg Vit. A 15–30 mg/kg vit. E traces of Vit. K and D
Hay (timothy and meadow)	6–14	50–60	30–40	1–2	6–9	0.4–0.6 Ca 0.2–0.4 P 0.2 Mg 1–2 K	1000–1500 IU/kg 10–20 mg/kg vit. E traces of vit. K
Alfalfa hay	18–22	55–65	25–30	2–3	9–12	1.2–1.8 Ca 0.2–0.4 P 0.2 Mg 1–2 K	1500–2500 IU/kg 30–50 mg/kg vit. E traces of vit. K and D
Meadow hay	8–15	50–60	30–40	1–2	6–10	0.3–0.6 Ca 0.2–0.4 P 0.1–0.2 Mg 1–2 K	500–1000 IU/kg vit. A 15–25 mg/kg vit. E traces of vit. K

* Source [100].

In addition, they require supplemental grains and minerals to ensure sufficient intake of protein, energy, vitamins, and minerals. A fiber-rich diet is essential for promoting healthy digestion and supporting milk production. The digestive process in horses is specific, with the following characteristics [101–104]:

- Forage forms the cornerstone of equine milk diets, playing a vital role in supporting healthy digestion, especially since horses and donkeys are non-ruminant herbivores (hindgut fermenters). Providing high-quality hay in adequate quantities is essential to ensure they consume enough fiber to maintain digestive health. For lactating equines, hay intake may need to be adjusted to meet the higher energy demands. Pasture also plays a significant role in their feeding, as fresh pasture can supplement their diet when available and during favorable seasons. However, proper pasture management is crucial to prevent overgrazing and maintain nutrient balance, with rotational grazing being an effective strategy.
- Concentrates and grains are essential for meeting the high energy demands of lactating equines. Oats and barley are commonly used for this purpose, with oats being preferred for lactating mares due to their easy digestibility and steady energy release. It is recommended to grind and soak the feed in sufficient water before feeding to help prevent colic—a common equine digestive issue caused by insufficient water intake, sudden dietary changes, or the consumption of dry, hard-to-digest feed. Soaking or grinding feed improves its digestibility, reduces the risk of intestinal blockages, and promotes better hydration, which is critical for maintaining gastrointestinal function and reducing the risk of dehydration. Existing studies also underscore the importance of proper feeding practices, such as soaking hay and ensuring continuous access to clean water. Horses that receive dry hay or limited water access have a higher risk of developing colic (this type of forage leads to forming compacted masses in the digestive tract, causing pain and even obstructions), as the sudden changes in their diets could cause the same reaction. Equines are vulnerable to colic because of their unique digestive system (they have small stomachs compared to their body size—10–15 L or about 10% of their digestive systems—and a large cecum—approximately 30–40 L, which represents 15–20% of their digestive capacity, that functions properly with enough fiber and water intake; since they are non-ruminant and cannot vomit due to a specific gastroesophageal sphincter at the entrance in their stomach, it is necessary to consume small amounts of feed, throughout the entire day—this is a proper way to maintain the gastrointestinal motility). All these measures reduce the risk of impactions, gas buildup, and twists of the intestines, which could lead to colic [105]. Consulting an equine nutritionist or veterinarian is highly recommended to customize diets and feeding regimens to meet specific needs and conditions. Additionally, supplements are advisable for lactating equines to meet their specific nutritional needs. Depending on their condition and milk production levels, incorporating a small amount of vegetable oil, such as soybean or sunflower oil, into their diet can provide extra energy. This strategy helps increase calorie intake without disrupting the protein balance, ensuring that the animals maintain optimal health and sustain adequate milk production.
- Protein should come from both forage and concentrates to meet the nutritional needs of lactating equines. High-quality grass hay serves as an excellent protein source, but lactating mares and donkeys may require additional supplementation. Alfalfa hay, known for its higher protein content, is a suitable option. Alternatively, protein supplements such as soybean meal can be included in the diet. Amino acids are also essential for optimal milk production, with lysine and methionine being particularly crucial for dairy animals. For equines, the levels of lysine and methionine are also crucial. For a 500 kg horse, a quantity of 15–20 g of lysine/day and 10–15 g of methionine/day. Lysine contributes to collagen formation, calcium absorption, enzyme function, and milk production (for maintenance, the minimum daily intake is 0.45–0.5% of the total diet), and for lactating equines, the baseline could be increased by 0.6–0.8% of the

total diet (optimum sources are alfalfa hay, soybean, and canola meals, oats or lysine powder or pellet). Methionine is important in keratin formation, liver detoxification, fat metabolism, and lactation; for maintenance, 0.2–0.25% of the total diet is needed, and for lactation, a surplus of 0.3–0.35% of the total diet is recommended (good sources of methionine are grains as oats and barley, hay, soybean and canola meals and methionine powder or pellet) [106].

- Equines require adequate intake of essential minerals and vitamins to maintain strong bones and proper metabolic function. High-quality forage combined with targeted supplementation helps meet these nutritional demands—calcium and phosphorus are crucial with the calcium-to-phosphorus ratio balanced at approximately 2:1 and lactating equines requiring increased calcium levels to support milk production; magnesium is vital for proper muscle function while potassium is essential for maintaining electrolyte balance, particularly during lactation. Vitamins A, D, and E play critical roles in equine health. Vitamin D supports calcium absorption and bone strength, vitamin E acts as a powerful antioxidant and supports immune function, and vitamin A is essential for vision growth and overall health. Calcium plays an important role in various functions of the body, particularly in bone and muscle function, as in nerve transmission; the deficiency leads to parturient hypocalcemia (this occurs in the first days after foaling, causing weakness, lack of coordination, and in severe situations the inability to stand), muscle tremors (low calcium levels cause muscle spasms, tremor, and in severe situations even seizures). Magnesium is another crucial mineral that plays an important part in the same direction as calcium. The deficiency reveals specific signs as follows: muscle tremors and even stiffness (it is important in muscle relaxation, and low levels could create spasms, twitching, and stiffness), low milk production (magnesium deficiency negatively impacts lactation), and even behavioral changes (irritability and hyper-excitability are common reactions to magnesium deficiency). During lactation, inadequate levels of calcium, magnesium, and phosphorus can lead to metabolic bone disease that causes fragile bones that are susceptible to fractures. Also, vitamin deficiencies are dangerous. A lack of vitamin A can lead to vision problems, dry coat and hair loss, skin problems, impaired immune function, reproductive issues, and delayed growth in foals. A lack of vitamin E leads to muscle atrophy, neurological issues (wobbly gait, loss of reflexes or head tilting), excessive sweating, reproductive issues, immune system conditions, equine motor neuron disease (progressive muscle weakness, loss of muscle mass, and difficulty standing), dry hair and skin problems. The recommended supplements in this case are calcium carbonate/phosphate, dicalcium phosphate, calcium and phosphorus balancer, magnesium oxide, magnesium sulfate, or chloride. When speaking about vitamin deficiency, retinol available in oil or powder form, carotene from grass and carrots, or cod liver oil are recommended to supply with vitamin A. Natural vitamin E, vitamin E in oil or powder, and pasture or good quality hay are added to supply the lack of this vitamin; Biotin and methionine are indicated to satisfy vitamin B7 levels and to support the coat characteristics. Zinc and copper chelates and selenium supplements are precious for overall health, as are omega-3 fatty acids found in flaxseed, linseed, algal, or fish oil [107–110].
- Since milk is primarily composed of water, lactating equines have significantly increased water demands to support milk production. It is essential to provide them with ample fresh and clean water at all times to ensure optimal hydration and milk yield.

A model of diet used in dairy equines (mares and donkeys) is presented in Table 7.

It is also important to calculate the needs regarding the level of production, knowing that the peak of lactation in mares is in the first 2–3 months when the foal needs the most nutrients for growth. After this stage, milk production gradually declines as the foal starts consuming solid feed, so the milk is not his exclusive feed. By the age of 6 months, foals generally eat substantial amounts of grass, hay, and grain as they approach weaning (as a consequence, milk production starts to significantly reduce [112]) (Table 8). The quantity is also influenced by the breed (heavy ones produce more than the light breeds), nutrition (proper diets that meet the needs of supporting the production are crucial), age of the mare (old females may produce less milk than young ones), health of the mare including their mammary gland (health issues may influence the milk production), and also the foal's size (larger products demand more milk). Therefore, it is vital to monitor the mare's milk production to ensure proper development of the foal to adjust the diet based on the quantity produced (high-quality forage and concentrates are crucial, especially during the first stages of lactation period), and respect the weaning moment (generally when the foal is around 6–9 months; it is recommended to apply gradual weaning when the foal also consumes solid food) [113].

Table 7. Model of diet for 100 kg live weight of lactating equines *.

Item	Quantity/Day	Protein (g)	Energy (MJ)	Fiber (g)
Forage	2 kg	300	16	6000
Concentrates	0.75 kg of oats or barley	90	7.5	56.25
Alfalfa hay (optional for protein intake)	0.5 kg	100	3	500
Vegetable oil (optional)	25 g	-	0.925	-
Mineral supplement	15 g	-	-	-

* Source: [111].

Table 8. Diet for lactating mare (live weight 500 kg; milk production 2–4 L/day) *.

Item	Quantity/Day	Protein (g)	Energy (MJ)	Fiber (g)
Forage	7–8 kg	1050–1200	56–64	21,000–24,000
Concentrates	2.5–3 kg	250–300	20–25	150–210
Alfalfa hay (optional for protein intake)	1.5–2 kg	300–400	9–12	1500–2000
Vegetable oil (optional)	50–75 g	-	1.85–2.775	-
Mineral supplement	50 g	-	-	-

* Source: [111].

The milk production registered in donkeys is approximately 0.5–1 L/day in the first period of lactation; when the foal is 4–6 months, the quantity drops as he starts grazing more and consuming solid foods. The colostrum phase, when the female produces less than 1 L/day, lasts for 24–48 h after foaling, then the peak lactation comes for 1–3 months, when 0.5–1 L of milk is produced daily. The next stage is represented by the declining lactation phase (3–6 months/after foaling) when only 0.3–0.5 L of milk are produced per day; in the late phase of lactation (6–9 months/after foaling), only 0.2–0.3 L/daily are produced. A model of diet for a 250 kg donkey, with 0.5–1 L of milk/daily, is presented in Table 9 [114].

Table 9. Diet for lactating donkey (live weight 250 kg; milk production 0.5–1 L/day) *.

Item	Quantity/Day	Protein (g)	Energy (MJ)	Fiber (g)
Forage	6–7 kg	800–1000	25–30	5000–6500
Concentrates	0.5–1 kg	50–150	8–16	100–200
Alfalfa hay (optional for protein intake)	1–1.5 kg	250–375	9–12	1000–1500
Vegetable oil (optional)	25–50 g	-	1–2	-
Mineral supplement	20–30 g	-	-	-

* Source: [111].

3.5.2. Dairy Equine Water Requirements

Lactating equines have higher water needs than those that are non-lactating, up to 50% higher due to the high water content of milk (each liter has 87–88% water). This means that 1.5–2 L of water is required for each liter of milk. Normally, horses consume approximately 50–60 L of water daily, and adding the water requirements per each liter for a production of 2–4 L of milk/day leads to a daily need of approximately 54–64 L of water (it also depends on the season—hot water or high humidity increases this need, diet—hay or grain also increases the water intake, level of effort—due to sweating some increments could appear, etc.). Equines need to have free access to fresh water, the hay should be soaked, and electrolytes are recommended to be added for better hydration and a really important aspect in water management for equines is to be monitored for any level of dehydration (when the milk production decreases, lethargy occurs, dry gums and sunken eyes are identified) [114].

3.5.3. Pasture Management for Dairy Equines

Research highlights the advantages of pasture-based management for equine herds, showing that grazing systems enhance both the nutritional quality of mare's milk and the socio-ecological benefits of sustainable agriculture. Particularly in arid and semi-arid regions, these systems provide a practical approach to equine milk production while promoting biodiversity and preserving natural landscapes [110]. Equine milk stands out for its exceptional nutritional value and therapeutic potential, positioning it as a valuable component of human diets and a contributor to sustainable agricultural practices. However, challenges remain in raising awareness about its benefits and production techniques, which may limit its widespread adoption and hinder the growth of the industry [36]. However, the management of broodmares and foals involved in milk production demands meticulous planning, particularly regarding their nutritional needs and overall care. Prioritizing the health and well-being of both the mares and their offspring is crucial for ensuring the sustainability of the operation. Providing mares and foals with appropriate nutrition is essential not only for maintaining their health but also for producing high-quality milk. Additionally, addressing knowledge gaps related to optimal nutrition in equine dairy systems is vital for the long-term success of such enterprises [101].

Another key consideration is the ecological impact of equine farming. To reduce environmental harm, sustainable farming practices must be adopted, particularly in marginal areas where pastures and natural meadows are essential for maintaining ecological balance [108–111].

Lastly, it is crucial to prioritize food security and animal welfare. As with all forms of animal husbandry, ensuring humane treatment of animals is essential, along with ensuring that the production system contributes to local food security. While equine milk can provide valuable nutrition, its production must be managed in a way that supports long-term sustainability [107,108,113]. Thus, the successful growth of the equine milk industry relies on bridging communication gaps, adopting effective management practices for mares and foals, optimizing animal nutrition, addressing environmental challenges, and safeguarding food security and animal welfare, all while encouraging sustainable practices for long-term success.

In conclusion, sustainable pasture management plays a crucial role in maintaining the health of dairy equines and fostering environmental sustainability. Implementing rotational grazing is a primary strategy in this regard. By moving equines between different pasture areas, overgrazing is minimized, soil health is preserved, and pastures are given time to regenerate. This approach enhances the long-term productivity of the land while reducing the risk of soil erosion [113].

Another crucial element is maintaining pasture diversity. Promoting a variety of grasses and legumes in pastures supports healthy ecosystems and provides the diverse nutrients required by dairy equines. A mix of plant species ensures sustained pasture productivity throughout the year, even in changing weather conditions [112].

Also, soil health is equally vital—implementing sustainable practices, such as composting and applying organic fertilizers, enhances soil fertility, fostering the growth of nutrient-rich pasture grasses. Limiting the use of chemical fertilizers and pesticides is essential to reduce environmental impact and maintain ecological balance [113].

Lastly, optimizing water management is crucial—ensuring reliable access to clean water is essential for dairy equines, particularly during periods of high milk production when their water needs significantly increase. Pasture management strategies should prioritize the availability of fresh water to support both animal health and productivity [114].

4. Equine Meat—Benefits in Human Consumption

Equine meat consumption is common in several parts of the world, such as France, Italy, Belgium, and the Netherlands, where it is considered as traditional and even premium dish, and also in Argentina and Brazil, countries where small markets for horse meat exist; the United States of America and Canada do not have a tradition in this sense, the horse consumption being something rare (although it was more common in the past, particularly during the early 20th century, the practice has decreased significantly due to cultural norms, animal rights concerns, and legal restrictions; however, horse meat is still available in some specialty markets or through imports). Also, in Japan, Mongolia, and Kazakhstan, horse meat is an important part of the diet; in Mongolia, it is a staple food because of the main role of this species in their culture [115]. However, the topic remains controversial and less widespread in others.

Equines used for meat production are represented by horses and donkeys, and in some cultures, they are also represented by mules. Regarding the breeds, there is no such thing as meat breeds as in cattle or sheep; however, certain horses raised for work, racing, or horseback riding can be slaughtered after being removed from their activity and being fattened for a while (some countries also raise horses, especially for this purpose). Donkeys are preferred in certain regions of Asia, such as China, Japan, and Africa, due to the quality of their meat (in these cases, it is preferred in stews, dried meat, and sausages); donkey meat is appreciated for its tenderness and nutritional values because it is leaner than horse meat (some cultures think that it has medicinal properties). Lastly, mules are occasionally raised for this purpose, although this situation is not that common. As they are the offspring of male donkeys and mares, they have peculiarities from both species; generally, they are used for strength and endurance, but there are countries that also prefer to consume their meat as it is culturally accepted [116].

4.1. The Chemical Composition of Equine Meat

Horse meat is a lean meat, which offers a couple of health benefits. The chemical composition in this case can vary depending on factors like breed, age, diet, type of effort, and processing methods. However, on average, it is considered leaner than beef, sheep, and pork, with a slightly higher protein content and lower fat content. The water percent is around 70–75% (fresh meat), and the protein is around 20–24%, which makes this species a reference diet rich in high-quality protein that includes all essential amino acids (close to red meat); regarding the amino acids, horse meat also contains higher amounts of lysine and methionine than beef [117].

The total fat in horse meat is relatively low, ranging from 2–5%, which is lower than beef and pork; the fat content also varies depending on the part of the animal, with muscle cuts being leaner than fatty cuts. This aspect makes horse meat a leaner option, preferred by individuals who need a low-fat diet. Regarding saturated fat, horse meat tends to be lower in saturated fat compared to beef, with about 1–2% of saturated fat, which makes it a relatively healthier option (in beef is generally 5–7%); the monounsaturated (oleic acid—it is associated with reduced low-density lipoprotein cholesterol level, which improves the heart health) and the polyunsaturated fat (omega-3 and omega-6, which maintain the cellular function, sustain the cardiovascular health, reduce the inflammation in body, and supports the brain functions) are in higher proportion compared to beef [26]. Horse meat is also a healthier choice when compared with pork, meat with 9–20% total fat content, with high saturated fat (3–12% or higher if we include parts such as belly and ribs), and higher content of monounsaturated fat, especially in fatty cuts, compared to horse meat; pork is also poorer in omega-3, richer in saturated fat which contributes to elevated LDL cholesterol levels and it has more calories per serving as a consequence to higher fat content (245–290 kcal/100 g of meat, on average). Chicken breast is known as being low-fat, with a total fat content of 1.5–3.5% and only 0.5–1% saturated fat, while the chicken legs, which also contain the skin, have a total fat of 8–10% and 2–3% saturated fat [118].

Furthermore, horse meat has a moderate cholesterol content, similar to other lean meats (50–55 mg/100 g of meat). For beef and pork these limits range between 60 and 70 mg [119], and for chicken, between 60 and 75 g mg [47].

Horse meat is rich in protein [120] (20–24 g/100 g of meat) but lower than other species, such as beef, which has 20–26 g/100 g of meat (cuts like sirloin are higher in protein than horse meat); however, the beef keeps the disadvantage of having a higher fat content. The same problem also appears in pork, even if the protein is high (20–24 g/100 g of meat) [118]. When compared to skinless chicken breast (30 g of protein/100 g of meat), horse meat does not exceed the protein level in this case (other cuts, like legs or wings, have less protein per 100 g, and they also contain more fat, especially if the skin is on) [121].

As for the minerals, horse meat is an excellent source of hem iron, the type that is found in animal-based products (it is easily absorbed by the human body and it typically contains 2.5–4 mg/100 g of meat); horse meat also contains about 4–5 mg of zinc/100 g of meat, which is very important for the immune system, protein synthesis, and wound healing. There is also a content of 180–200 mg/100 g of meat phosphorus, which is essential for bone health and energy metabolism [122]. When comparing horse meat with beef, pork, and chicken, the iron level is the highest among the four (beef: 2–3 mg/100 g of lean cuts—sirloin and flanks; pork and chicken: 0.9–1.2 mg/100 g, lower than horse and beef meat). When comparing the zinc level, beef has 405 mg/100 g, pork has moderate levels of 2.5–3 mg/100 g, and chicken has 1–2 mg/100 g. Beef is a good source of phosphorus (180–210 mg/100 g), but with lower levels than horse meat; pork and chicken have similar levels of 200–220 mg/100 g [123].

Regarding the vitamin content, horse meat contains vitamin B12, which is essential for blood cell production and neurological function (10–20 mcg/100 g of horse meat, which covers the daily recommended intake a couple of times). Vitamin B6 is also present in horse meat in the proportion of 0.3–0.5 mg/100 mg of horse meat, which helps with amino acid metabolism and supports brain function. This product is also rich in vitamin B3 (5–7 mg/100 g), which is important for energy production and skin protection. Beef also has excellent levels of B12 (2–2.5 µg/100 g), good levels of B6, similar to horse meat (0.5–0.7 mg/100 g), and also good levels of B3 (4–5 mg/100 g). Pork, on the other hand, is a moderate source of B12 (0.8–1.0 µg/100 g), a good source of B6 (0.7–0.9 mg), and a very good source of B3 (6–8 mg/100 g). Lastly, chicken meat is lower in vitamin B12, compared to the other mentioned species (0.3–0.4 µg/100 g), but still a good source of vitamin B6 (0.6–0.8 mg/100 g) and a very good source of B3 (7–8 mg/100 g) [124]. The comparison between species is revealed in Table 10.

When it comes to carbohydrates, horses, like many other species, contain virtually no carbohydrates, making horse meat a protein-rich and also fat-rich product.

Donkey meat is similar to horse and mule meat in many aspects (Table 11), but it has its own unique nutritional profile. When describing donkey meat (per 100 g), it can be stated that it is a lean, high-protein meat (1–24 g, providing all the essential amino acids, supporting muscle growth and tissue repair), with moderate levels of iron, zinc, and phosphorus; it is also a rich source of B12, a moderate source of vitamin B6, and a moderate source of B3. It is also low in fat and cholesterol (50–60 mg), making it a heart-healthy option compared to some other meats. The vitamin content, particularly B12 and niacin, makes it beneficial for overall health, especially for energy metabolism and immune support. Lastly, mule meat, similar to donkey and horse meat, is considered lean and a nutritious source of protein, as well. When it comes to chemical composition (per 100 g), the mule meat has around 2–4% of fat, with 1–1.5% of saturated fat, and cholesterol of 50–60 mg, 20–24 g of protein (which, like donkey meat, provides all essential amino acids for muscle growth and other tissue protection) [123,124].

Table 10. The comparison between different types of meat *.

Nutrient **	Horse Meat [a]	Donkey [b]	Beef [a]	Pork [a]
Calories (kcal)	120–140	130–150	250–300	245–290
Protein (g)	20–24	20–22	26–30	25–30
Total fat (g)	2–5	2–4	15–20	20–25
Saturated fat (g)	1–2	0.8–1.5	5–7	7–10
Monounsaturated fat (g)	1.5–2.5	1.0–2.0	6–10	7–10
Polyunsaturated fat (g)	0.5–1.5	0.5–1.0	0.5–1.5	1–3

* Sources: [a] [120]; [b] [121] ** per 100 g, on average.

Table 11. Comparative profile of different types of meat *.

Nutrient (per 100 g)	Horse Meat	Donkey Meat	Mule Meat
Calories (kcal)	120–140	130–150	130–150
Protein (g)	20–24	20–24	20–24
Total fat (g)	2–5	2–4	2–4
Saturated fat (g)	1–2	1–1.5	1–1.5
Cholesterol (g)	50–60	50–60	50–60
Monounsaturated fat (g)	1.5–2.5	1.0–2.0	1.0–2.0
Polyunsaturated fat (g)	0.5–1.5	0.5–1.0	0.5–1.0
Iron (mg)	3–4	3–4	3–4
Zinc (mg)	4–6	4–6	4–6
Phosphorus (mg)	200–250	200–250	200–250
Vitamin B3 (mg)	5–8	5–8	5–8
Vitamin B6 (mg)	0.3–0.5	0.3–0.5	0.3–0.5
Vitamin B12 (µg)	2.5–3.5	2.5–3.5	2.5–3.5

* Source [124].

4.2. The Bioactive and Functional Compounds in Equine Meat

Equine meat contains bioactive and functional compounds that contribute to several health benefits beyond basic nutrition (they support various physiological functions, such as antioxidant activity, immune modulation, and metabolic health) [125].

The bioactive peptides contained in equine meat are released during digestion and protein breakdown; these components have many health benefits, such as the following [126]:

- Antioxidant effect: Several peptides have the ability to destroy free radicals, reduce oxidative stress, and offer protection from cell damage (this aspect is very important for reducing the risk of heart disease and other chronic problems, even cancer).
- Immune-modulating activity: The bioactive peptides can modulate the immune function of the body by enhancing the body's defense mechanisms against viruses and bacteria and improving overall immune responses.
- Antihypertensive effects: Some peptides from equine meat may act as angiotensin-converting enzyme (ACE) inhibitors, supporting cardiovascular health and reducing blood pressure.

The iron [126]:

- Heme iron is a type of iron found in animal-based foods, very easy to be absorbed by the human body (compared to non-heme iron from plant sources), and equine meat is a very good source in this sense;
- Adequate iron intake can prevent iron deficiency anemia and support the overall metabolic processes (immune system and energy production).

Creatine [125]:

- Equine meat contains creatine, a substance that helps provide energy to muscles during intense physical activity (it is particularly important for muscle function and repair).
- The functional role of this compound is to support athletic performance, muscle recovery, and muscle health.

Taurine [125]:

- Equine meat is a good source of taurine, an amino acid that is important for heart health, nervous system, and bile salt formation.
- It has been proved that taurine has antioxidant properties and supports cardiovascular health because it improves blood vessel functioning while also improving the risk of heart diseases.

Vitamins [126]:

- Equine meat is rich in vitamin B12 (which helps prevent anemia and neurological problems) and B3 (which contributes to metabolic processes and energy production in human body).

Zinc levels [126]:

- Equine meat has high amounts of zinc, which is crucial for DNA and protein synthesis, immune system, skin protection, etc.

Phospholipids [126]:

- Phospholipids are in a small amount in equine meat (1–2% in muscle and 3–6% in organs like liver).
- Phospholipids are important in the formation of cell membranes and support the brain and nervous system.

Polyunsaturated fatty acids (PUFA) [125]:

- It is a well-known fact that equine meat is very rich in omega-3 and omega-6 fatty acids, which are crucial for brain and heart health.
- They have anti-inflammatory effects while also contributing to healthy cholesterol level maintenance (cardiovascular health support).

Conjugated linoleic acid (CLA) [125]:

- Equine meat contains modest amounts of conjugated linoleic acid, which in ruminant meats is in higher proportion.
- It has multiple purposes in human body from anti-cancer properties to weight control, since it improves lipid metabolism; it also has anti-inflammatory and antioxidant activity.

4.3. The Sensory Analysis of Horse Meat

The sensory analysis comprises the juiciness, flavor, texture, color, fat content (marbling), tenderness, smell, and overall acceptability (Table 12). The factors influencing these aspects are the cultural influences (in many countries, horse meat is viewed as a delicacy and it has a positive sensory response; on the other hand, in some cultures it is considered a taboo, which makes the perception over these sensory qualities quite negative) and the type of cooking (grilling, slow-cooking or including the meat in minced dishes or sausages has an impact on the tenderness and juiciness of horse meat; also the overcooking leads to dryness, slow-cooking and marinating being indicated to obtain juicy and tender portions); on the other hand, the ethical perception and the consumer education are important in this sense: in several markets, ethical problems regarding this type of meat (where horses are seen as companions or when the animal welfare is a concern) can influence in a negative way the consumer choices, despite its qualities; also knowing the benefits of consuming horse meat such as for its high levels of protein and iron and low levels of cholesterol can lead to its acceptance) [127].

Table 12. Sensory analysis of horse meat *.

Sensorial Attribute	Exposure
Juiciness	- Less juicy than other types of meat (due to its low fat content); to obtain juicy dishes is indicated to be marinated or slow-cooked)
Flavor	- Distinct, slightly sweet, savory, gamey (milder than venison, more intense than beef)
Texture	- Tender, often less fibrous than beef
Color	- Darker than beef (from deep red to dark purple)
Fat content	- Leaner than beef, less marbled (intramuscular fat)
Tenderness	- Can vary depending on the cut
Smell	- Slightly sweet, gamey flavor
Overall acceptability	- Often appreciated for its unique flavor and tenderness when horse meat consumption is accepted

* Source [127].

The factors that influence the sensorial aspects are various; the flavor is influenced by breed, diet, and processing (the breed has slight influence over meat's flavor; the horses which are fed with hay or grass have milder, sweeter meat than those fed with grains, and aging and marination influence the tenderness and the flavor of the meat). The juiciness and the texture depend on the cut (tenderloin and ribs are juices, the shoulder and flanks are drier), on the type of cooking (marinating and slow-cooking are recommended for juicy dishes), and on the age of meat (when the horse is younger, the meat has a higher tenderness and juiciness), while the color is influenced by the freshness (fresh meat is generally darker), diet (grass-fed horses have darker colors—from intense red to purple—due to vitamin E and beta-carotene which contribute to myoglobin production), and post-mortem handling (how the meat is processed and stored can impact its color). The fat content depends on the breed and diet (some breeds such as Belgian Draft, Percheron, Clydesdale, etc., and those grain-fed may have slightly more fat content than the horses that receive only hay or grass), the age (older horses may have slightly higher fat content) [128,129].

4.4. Meat Equine Raising

4.4.1. Meat Equine Diets

The equines reared for meat production need proper nutrition to provide good meat quality (tenderness, flavor, and balanced fat content), as well as to keep their health and growth in optimal ranges [126,127].

The energy requirements: Equines raised for this purpose need adequate energy to support their muscle development and to have a good body condition; the necessary depends on age, body weight, activity level, and growth moment. The energy sources include high-quality forages such as grass and hay, grains such as barley, oat, and corn, and other concentrated feeds (which provide carbohydrates and fats needed in the diet). The fat intake should be controlled to maintain lean meat; high-energy grains are recommended in moderate quantities to prevent excessive fat deposits.

The fat: High amounts need to be avoided in administration for equine raised for meat because they negatively impact the meat quality; however, in colder months or high growth stages, they need moderate amounts of healthy fats to support their energy needs and muscle growth (as sources it would be recommended to include in their diet corn and oats as grains, sunflower, and soybean oil as vegetable oils and also high-quality forages).

The protein requirements: Since protein is vital for muscle development and growth, equines raised for meat production need a high-quality protein source and also an accurate amino acid profile, which is very important for young equines to develop correctly (lysine and methionine are particularly important for muscle growth and protein synthesis). For equines, the levels of lysine and methionine are also crucial. For a 500 kg horse, a quantity of 15–20 g of lysine/day and 10–15 g of methionine/day. The minimum daily intake of lysine is 0.45–0.5% of the total diet, and for muscle growth, 0.5–0.6% of the total diet should be added (optimum sources are alfalfa hay, soybean, and canola meals, oats or lysine powder or pellet). For maintenance, 0.2–0.25% of the total diet of methionine is needed, and for muscle growth, a surplus of 0.3–0.35% of the total diet is recommended (good sources of methionine are grains such as oats and barley, hay, soybean, and canola meals and methionine powder or pellet) [130].

The mineral and vitamin requirements: Refer first of all to calcium and phosphorus and the ratio between them (2:1), as the optimal balance between these minerals is crucial for bone health and muscle function; then, magnesium and potassium are important for muscle growth, nerve protection and function, and also electrolyte balance. Last but not least, vitamin A is important for the immune system, growth, and site. Vitamin D is crucial for calcium absorption and bone health. Vitamin E is a great antioxidant that supports the immune system and muscle growth. The B complex is very important for metabolic processes and energy production.

The fiber intake: The equines need a high-fiber diet to maintain healthy digestion and gastrointestinal function; the forage is the base of their diet as it contributes to gut health, reduces colic incidence, helps to assimilate nutrients, and, as a consequence, contributes to producing high-quality meat by supporting a good metabolism.

A type of diet used in equines raised for meat is presented in Table 13.

Table 13. Model of diet for meat equines *.

Feeding Time	Type of Feed	Quantity	Effect
Morning	Forage	2–3 kg of high-quality grass or alfalfa hay	Offers essential fiber, vitamins, and minerals for digestion and growth
	Concentrates	1 kg of barley/oats	Offers energy and protein for growth and muscle development
	Protein	0.5 kg of soybean meal	Offers enough protein for muscle development
	Salt	Mineral block/loose salt	Offers proper mineral balance (Ca, P, Mg)
Noon	Forage	2–3 kg of hay	Offers essential fiber, vitamins, and minerals for digestion and growth
	Concentrates	0.5–1 kg of corn	Offers energy and protein for growth and muscle development
	Vegetable oil	50–100 mL of sunflower/soybean oil	Used to provide healthy fats and additional energy
Evening	Forage	2–3 kg of hay/pasture	Helps the health and digestion process
	Protein supplement	0.5 kg of alfalfa/legume-based protein supplement	Helps muscle growth

Table 13. *Cont.*

Feeding Time	Type of Feed	Quantity	Effect
Observation	Water	Fresh and clean water ad libitum	Provides proper hydration and digestive health
	Supplements	As required	Additional minerals and vitamins may be provided
	Pasture grazing	If available	Grazing during the day with supplemental feeding during cooler months
	Adjustments	As required	Some adjustments may be needed according to age, size, weight, sex, growth stage

* Source: [131].

4.4.2. Water Requirements for Meat Equines

The water intake: Water is essential for hydration and digestion, so equines need free access to clean, fresh water ad libitum, especially in summer or during periods of high feed intake. It contributes to nutrient absorption, protein metabolism, and muscle development, and very importantly, sustains overall health, also preventing digestive disorders (colic and impaction). Water maintains a normal body temperature (which is crucial and harder to regulate in hot climates or during effort), it contributes to cellular functions (nutrient absorption, metabolic processes, toxin elimination) and digestion (as their diets are based on high-fiber intake, they need proper quantities of water, for the microbial fermentation in the cecum and colon to function well); water is important also in saliva production (it contains enzymes that contribute to carbohydrate digestion), being also a nutrient carrier (it dissolves and carry nutrients as amino acids, vitamins, and minerals, which are important for muscle development of horses raised for meat). It is also crucial in protein metabolism, which is involved in muscle growth: water is involved in the dissolving and transportation of the amino acids, leading to high protein synthesis, and also in urea excretion (excessive nitrogen from protein metabolism is converted into urea in the liver, and has to be eliminated through the urine). Adequate water intake also improves feed consumption (equines consume high amounts of feed when they have water ad libitum), which leads to muscle growth through the following scheme: they require an adequate balance of electrolytes like so sodium, calcium, and potassium, and the water transports and balance these substances, essential for muscle development (these also help in muscle cramp occurrence). The water intake ranges between 8 and 12 L/day/100 kg live weight (a surplus of 20–30% could be needed for high-fiber diets); also, if the weather is very hot, consumption increases by 50% [132].

4.4.3. Pasture Management for Meat Equines

Pasture management is very important for equines raised for meat production, as it helps support their health, ensures efficient feeding, and helps maintain environmental sustainability. This includes the following [110]:

- Grazing intensity: The management should be directed to ensure pastures are not overgrazed (pastures should be grazed down to a height of 4–7 cm; if the graze is under the lowest limit, there is a sign of overgrazing).
- Rotational grazing: The pastures should be divided into portions, and equines should be rotated through different sections; also, the pastures need to regenerate, and through rotational grazing the parasite buildup is reduced, which is crucial for health of the animals and also of the land (70% of the ground has to be covered by vegetation; the rotational grazing involves dividing the pasture into paddocks that can be grazed for 7–14 days and then left to regenerate for 30–60 days).
- Pasture rotation in winter: During wintertime, the grazing should be limited to prevent damage to grass and land; also, it is recommended to supplement with hay and other supplements during the cold weather.

- Pasture rest time: Generally, the pastures need to rest for 3–6 weeks, depending on season and grazing intensity (if the grass regrowth is slow or it does not exist, the pasture is considered as being overgrazed).
- Pasture diversity: This refers to encouraging a mix of grass species and legumes (for example, fescue and clover); also, diverse pastures are more resilient, and they provide nutrients while maintaining quality over time.
- Vegetation control: If the pastures are regularly monitored, the risk of toxic grass growing would be lower, which contributes to high-quality pastures.
- Fertilization and soil health: Involves using organic fertilizers to promote soil fertility; overuse of chemical fertilizers has to be limited to prevent long-term damage to soil health.
- Water access: Fresh and clean water has to be ad libitum, especially during grazing.
- Fencing: This helps prevent accidents and equine escapes.
- Pasture utilization efficiency: Sometimes, controlled grazing with proper feeding can maximize pasture productivity; also, grazing periods should be long enough to provide adequate nutrition while also allowing the pasture to rest.

These pasture management rules assure rational grazing, where equines raised for meat production benefit from healthy maintaining conditions, optimal growth rates, and more sustainable farming practices. For example, for a 500 kg horse, the recommendation is to beneficiate 1.5–2 ha, and for a 250 kg donkey, the recommendation is approximately 1.0–1.5 ha [111].

5. Sustainability in Equine Farming

These practices involve balancing environmental, economic, and social factors as follows:

- Reduced environmental impact: by applying farm management practices such as solar energy resources for barn lightning, manure management practices (composting or biogas stations), and agroforestry, equines raised for milk and meat production can reduce their carbon footprint. When compared to other species, equines are between the impact of swine and cattle in terms of sustainability and with benefits such as moderate land use and lower methane emissions; the disadvantage is they require careful pasture management. The cattle have the highest environmental impact as a consequence of high land and water use, low feed efficiency, and, more than this, significant greenhouse gas (GHG) emissions (one cow needs around 2.5–10 ha of land/year, including pasture and land used for crops). Swine has a lower impact than beef but is less sustainable than poultry and equine due to moderate GHG emissions and water dispense (0.1–0.3 ha/pig is recommended). Chicken is considered the most environmentally friendly option, with low resource requirements and efficient feed conversion (1 kg of chicken meat needs 1.3 m^2 of land for production). Equines need 1.5–2 ha/capita for grazing [133].
- Minimizing feed miles by sourcing feed locally is a practical strategy to reduce the environmental impact of equine dairy or meat production. By relying on nearby feed producers, farms can significantly lower greenhouse gas emissions from transportation, cut costs associated with fuel and logistics, and support the local agricultural economy. Local feed sourcing ensures fresher, higher-quality feed with less risk of spoilage, benefiting animal nutrition and productivity. Strategies such as partnering with local farmers, growing forage on-site, using seasonal feeds, and integrating crop-animal systems further enhance sustainability. This approach not only reduces environmental degradation but also strengthens community ties and promotes efficient, eco-friendly farming practices [133].
- Water is another significant environmental input for livestock; for 1 kg of beef, approximately 15,000 L are needed (dairy cows require around 100 L of water/day), for 1 kg of pork, around 6000–10,000 L of water are consumed, and equines requests range from 30–100 L/daily (the water footprint of horse meat per kg is approximately 4000–5000 L) [134].

- The methane emissions represent another concern these days; cattle emit up to 200–500 L of methane/daily or 80–120 kg/year/cow (methane emissions from cattle account for about 60% of the total methane emissions from livestock globally); pigs produce 0.4–0.6 kg/year, and equines emit 0.1–0.3 kg/capita/year [135].
- Ethical animal care is a cornerstone of sustainable equine farming, whether for milk or meat production, ensuring the animals' well-being and fostering long-term farm productivity. Providing spacious, well-ventilated barns with comfortable bedding helps reduce stress and prevent common health issues such as respiratory problems or joint strain. Access to high-quality pasture allows equines to graze, exercise, and exhibit natural behaviors like socialization and herd dynamics, which are essential for their mental and physical health. Lactating mares benefit from stress-free environments, as this directly influences milk yield and quality, while equines raised for meat develop better muscle tone and health through regular activity. Tailored nutrition, including balanced diets rich in fiber, protein, and essential nutrients, combined with humane handling practices, further ensures ethical care. Routine health monitoring and veterinary attention help prevent disease and promote welfare. Such practices not only enhance animal well-being but also improve the quality of milk and meat, contributing to sustainable and ethical farming operations [107].
- Climate change resilience is crucial for the sustainability of equine farming, particularly as changing weather patterns and extreme conditions impact forage availability and water resources. Implementing adaptive practices such as planting drought-resistant grasses and legumes in pastures ensures that equines have access to consistent, nutrient-rich forage even during dry spells. Improved water storage systems, such as rainwater harvesting or pond construction, can provide a reliable water supply to meet the high hydration demands of equines, especially those raised for milk or meat production. Rotational grazing strategies can help maintain pasture health by preventing overgrazing and promoting regrowth during periods of environmental stress. Additionally, incorporating climate-resilient shelter designs, such as barns with enhanced ventilation and insulation, helps protect equines from extreme heat or cold. By adopting these measures, equine farms can mitigate the adverse effects of climate change, ensuring both animal welfare and the continuity of production systems [134].

6. Conclusions

Dairy and meat equine farming represents a sustainable and nutritious alternative for milk and meat production. The milk is suitable for dietary restrictions, is low-fat, and high in vitamin C—similar to human breast milk. Equine meat is lean, with high levels of omega-3 fatty acids, iron, and zinc, which makes it a healthier option compared to other types of meat. On the other hand, equine farming also supports sustainable agriculture by utilizing pastures, sustaining biodiversity, and promoting food security. Overall, equine raising is a key practice in long-term environmental and economic resilience since sustainability in equine farming hinges on a holistic approach that balances environmental, economic, and social considerations.

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