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Research article

The role of donkeys, their milk production and utilization in south-western Botswana

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Abstract: A study was conducted to assess the role of donkeys, their milk production, and utilization in southwestern Botswana. A cross-sectional descriptive survey and a case study were employed to generate data using a semi-structured questionnaire. A total of 25 respondents from Werda and Phepheng villages were interviewed through face-to-face interrogation techniques. The case study involved one commercial donkey farm in Werda village that produces and sells donkey milk. The study was conducted in June 2018. The average herd size of donkeys in the study area was 9.7 per household. Donkeys were primarily used for transportation of water and firewood, followed by ploughing, riding, meat production, and milk production. Moreover, donkeys are considered resilient animals, and they are more drought-tolerant than other livestock species. All respondents ranked donkeys superior to cattle, goats, and sheep in terms of drought resistance and ability to cope with feed and water shortages. In contrast to most farmers in the study area, one farmer in Werda village owned a herd exceeding 200 donkeys, which were used for milk production. This farmer used the donkey milk to make skincare products, namely donkey milk soap and lotion. Additionally, he sells raw donkey milk to consumers in Gaborone, as well as in other parts of the country, and South Africa, and the farmer considered in the case study sells one liter of donkey milk for 240 Pula (≈23.2 US$). Some respondents indicated that they consume donkey meat, which they prefer over the milk. There was no cultural stigma associated with rearing donkeys and consuming donkey products in the study areas. Most donkey owners do not milk their donkeys, but many expressed willingness to milk their animals if a reliable

market exists. Although this study is limited in scope in terms of sample size, it suggests potential for developing a local donkey milk industry.

Keywords: donkeys; draft power; milk production; Phepheng; transportation; uses; Werda

1. Introduction

Donkeys have played a key role in the history of human survival, serving as a primary source of employment and transportation, especially in marginalized societies. Donkeys (*Equus asinus*) are believed to have originated in northeast Africa approximately 5000 years ago [1,2] and subsequently spread into Asia, Europe, and the rest of the African continent [1,2]. Today, they are found in regions across the globe, with their native range extending from Somalia to Morocco and the Middle East [1,2]. In Africa, the livelihoods of resource-limited households significantly rely on donkeys for generating income.

In comparison to other equine species, donkeys possess numerous advantages. They are resilient animals that adapt well to environments with inadequate feeds and poor nutrition, exhibit greater tolerance to diseases that commonly affect domestic animals, and are preferred for pack and draught work due to their docile nature, making them easy to train and harness. Donkeys are important as domestic animals within human economies [3]. Their capacity to carry heavy weights and travel long distances in arid and desert environments has rendered donkeys as essential animals in the advancement of commerce in countries such as Egypt [4].

Donkey milk differs from cow's milk due to its lower protein and fat and higher lactose content [5]. It is used for its purported medicinal value and cosmetic applications. For instance, it has been traditionally used in Serbia for treating respiratory illnesses, asthma, and bronchitis [5].

Botswana's donkey population was reported to be 139,524 in 2019 [6], and most of the donkeys are owned by traditional smallholder farmers [7]. The daily activities of many communities in Botswana largely rely on donkeys [8,9]. In rural areas of Botswana, donkeys are the major mode of transportation, facilitating the movement of water drums, firewood, manure, harvested crops, and people [7]. Additionally, donkeys are used to generate income through the rental of donkey carts [10]. The rental of donkey carts in Botswana typically fetches 5-10 USD for transporting goods over a distance of 12 km [7].

People residing in the rural areas of Botswana use donkeys as a source of meat. The Barolong, Kgalagadi, and Kweneng areas in Botswana are known for the consumption of donkey meat [11]. Those who consume donkey meat assert that it is both healthy and nutritious [12]. In addition to human consumption, donkey meat in Botswana is also used as food for pets, including cats and dogs. Studies [11,13] have shown that the people in Botswana endorse the establishment of donkey meat processing facilities aimed at producing pet food and exporting the meat to regions where donkey meat is consumed. Nkala [14] further noted that a Chinese-owned facility, recognized as Botswana's first donkey "slaughter slab", was established in the Kweneng District in 2016, serving the dual purpose of exporting hides and processing meat locally for pet food production.

Donkeys produce limited amounts of milk. However, it has been noted that donkey milk closely resembles human milk in its composition, making it a viable substitute for human milk, especially in cases where mothers are unable to produce an adequate supply of milk for their infants [15]. While

donkey milk is produced and consumed in Botswana, there is a lack of documentation regarding its usage.

Donkey milk is considered a viable alternative for infants who are allergic to cow milk protein [16] and has traditionally served as a substitute for human milk in Europe [17]. It is believed to possess therapeutic benefits and is used in the prevention of atherosclerosis, as well as in the treatment of immune-related disorders [18]. Additionally, it is claimed to exhibit anti-inflammatory [5,18], anti-proliferative, and anti-tumor effects [5,19]. Furthermore, donkey milk is used in the production of value-added dairy products such as cheese and milk powder [20,21]. It is also used as a raw material in the cosmetics industry [22].

There has been a growing interest in donkey milk in Botswana, leading to the emergence of commercial donkey dairy farms in some regions of the country. For example, a donkey dairy farm established in Werda area, situated in the southwestern part of Botswana, is selling donkey milk to consumers and producing cosmetics such as, soap and body lotion derived from donkey milk. Users of donkey milk assert that it is beneficial in treating some human ailments, such as arthritis, heart problems, and asthma [23].

Limited work has been conducted on donkeys or their products in Botswana. Therefore, this study was conducted to assess the role of donkeys, their milk production, and utilization in southwestern Botswana.

2. Materials and methods

2.1. Description of the study area

The study was conducted in the greater Werda area, which is in the Kgalagadi South Sub-district that includes Werda village and the nearby rural communities such as Makopong, Phepheng, and Kokotsa. Werda is a local administrative and service center for the sparsely populated region. Werda and Phepheng villages were selected for this study based on the importance of donkeys and the dependence of the communities on donkeys for their day-to-day activities.

Werda village is located in southwestern Botswana, close to the South African border at a distance of 380 km from the Capital City, Gaborone. The total human population of Werda in 2022 was 3,349, and 89% of the population in Werda are followers of the Christian faith [24]. Werda has the second largest human population (11.4%) in the Kgalagadi South sub-district after Tsabong [24]. The annual population growth rate of Werda village was reported to be over 3%, which is the highest in the district [24]. The mean monthly minimum and maximum temperatures of the village were 4.0°C and 31.0°C, respectively, in 2022 [25]; whereas the mean annual rainfall for Werda was 360 mm for the period 1975–2013 [26]. Phepheng village has similar climatic conditions to Werda village. Phepheng is a village in the northeast of the Kgalagadi District of Botswana at a distance of 434 km from Gaborone. Its population was estimated at 1411 in 2022 [24].

2.2. Survey method

A cross-sectional descriptive survey and a case study were employed to generate data using a semi-structured questionnaire. A total of 25 respondents from Werda (10) and Phepheng (15) villages were interviewed through face-to-face interrogation techniques. The respondents were selected purposively based on possession of a donkey herd and their experience in donkey farming. Prior to the

commencement of the survey study, Chiefs of the respective villages were consulted, and they were briefed about the objective of the study. After permission was granted by the Chief, Village Development Committee (VDC) of the respective villages was consulted, who then assigned a Community Development Officer who assisted in the selection of households that participated in the study. Informed consent of the participants was obtained prior to commencement of the interview. Moreover, consent was obtained from individuals whose photographs are included in this paper. During the face-to-face interview, questions were asked by the researchers using the English language. However, for respondents who do not understand the English language, questions were asked using the local language (Setswana or Afrikaans), and the responses were translated to English by members of the research team who speak the languages.

The survey was used to generate information on herd composition, herd size, prevalence of disease, and uses of donkeys in the study area. On the other hand, a case study was conducted on a commercial donkey farm in Werda village that was established for milk production. The case study was used to generate information on milking practices and milk hygiene; reproductive and productive performances of donkeys; and storage, transportation, marketing, processing, and utilization of donkey milk.

Moreover, field observations were made in the study areas to visit the donkey herds, to assess management practices, milking procedures, and the source of water for the herd. Moreover, secondary data about donkeys in the study areas and in the country at large have been referred to and used as appropriate. Descriptive statistics were used to summarize the information generated and present the results. The study was conducted in June 2018.

3. Results and discussion

3.1. Survey study

3.1.1. Herd structure

Herd composition and size of donkeys in Werda and Phepheng villages are indicated in Table 1. Respondents in the study areas stated that donkeys are important in their livelihoods. Farm households in the area possess relatively large herds of donkeys. The average herd size of donkeys owned per household was 9.7, which ranged from one to 27 donkeys (Table 1).

Except for a single farm that maintains about 200 donkeys for commercial milk production (Figure 1), most farmers primarily keep donkeys for transportation and as draft animals. Farmers typically maintain male and female donkeys, although there is a tendency to have a higher number of male than female donkeys. This observation aligns with the findings of Swai and Bwanga [27] who reported that in northern Tanzania, the proportion of male donkeys was higher than that of female donkeys in a donkey herd with male to female ratio of 1.13:1. Respondents mentioned a preference for adult males over females, as they perceived that male donkeys possess greater strength and are more capable of performing heavier tasks than their female counterparts.

The size of the donkey herd in this study exceeds the figures previously documented for Botswana and Kenya. Twerda *et al*. [28] indicated that the typical donkey herd in Samburu, Kenya, consisted of 4 donkeys (ranging from 1 to 15), while the average donkey herd size in Turkana was 10 donkeys (with a range from 1 to 31), maintaining an equal proportion of male to female donkeys. Conversely, Aganga

and Seabo [29] found that farmers in southeast Botswana own an average of 9.2 donkeys (with a range of 2 to 40), primarily utilizing them as work animals. Additionally, it was reported that farmers in the Kweneng and Kgatleng districts of Botswana had an average of 13 donkeys [30].

Table 1. Herd size and herd composition of donkeys in the study areas (n = 25).

Variables	Range	Average
Total herd size	1-27	9.7 ± 7.1
Number of female donkeys	1-19	4.2 ± 5.8
Number of male donkeys	1-17	4.4 ± 4.0
Foals	1-18	4.1 ± 3.1

n = number of respondents; the data in the Table were generated through the survey.

A B

Figure 1. A dairy donkey farm in Werda village. A) A herd of donkeys in a kraal. B) A man holding donkey milk in a can after milking (Source: case study; photo by Eyassu Seifu; consent of the individual was obtained before taking the photographs).

3.1.2. Disease prevalence

Most of the respondents indicated that they have not encountered the problem of mastitis within their donkey herd (Table 2). Salimei and Fantuz [31] reported that mastitis is rare in equids, and the equid milk somatic cell count ranges between 3200 and 355000 cells/mL. Additionally, Salimei [17] and Salimei and Fantuz [32] indicated that donkey milk exhibits a low somatic cell count (SCC) ranging from 3.5 to 4.5 log SCC per mL.

The donkey owners in the study area asserted that their animals remain healthy and, consequently, they seldom administer treatment. The respondents mentioned that conditions or diseases affecting donkeys in the study area include heart attack, pneumonia, tick infestation, skin diseases, and coughs (Table 2). Mrema [30] stated that flies can cause eye sores in donkeys, especially during the summer season. Additionally, internal and external parasite infestations are observed in donkeys; however, farmers refrain from treating donkeys for these parasites, believing that such illnesses do not lead to death. According to Wells and Krecek [33], the most common health issues in donkeys in the Northwest Province of South Africa are tick infestations, wounds, and harness sores.

Table 2. Prevalence of disease in donkey herds in Kgalagadi South Sub-district, southwest Botswana (n = 25).

Variables	Response*
Major diseases that affect donkeys	Heart attack
	Pneumonia
	No known disease affects donkeys in the area
	Sometimes ticks infest donkeys
	Never heard that donkeys are sick
	Sometimes, skin disease affects donkeys
	Sometimes they cough
Is there a mastitis problem in your herd?	No, but once two donkeys contracted mastitis
Signs/symptoms of mastitis	Swelling of the udder, pus in the milk
How frequently do you clean the kraal?	Never clean the kraal
Do veterinarians regularly check the health of the donkeys?	Veterinarians take blood samples annually and examine them
Do you provide training on hygienic milking and milk handling practices to your workers?	Provide onsite training on milk hygiene, how to milk the donkeys, and general handling of the animal

n = number of respondents; the responses indicated were reported by all the informants; the data in the Table were generated through the survey study.

3.1.3. Uses of donkeys

In the study area, donkeys are used for different purposes (Table 3). The major function of donkeys in the area is to transport water and firewood (pull donkey cart), followed by ploughing, riding (for entertainment and to patrol cattle post), meat production, milk production, breeding, and transporting game meat after hunting, in that order. A donkey cart is used to transport people, water, and firewood in the study area (Figure 2). These observations agree with the findings of Aganga and Tsopito [34] who reported that farmers in the Gaborone region of Botswana use donkeys for plowing, planting, cultivation, and transport. They indicated that donkey power is used for household activities, such as transporting people and goods, and fetching water and firewood. In the Northwest Province of South Africa, donkeys are used for the transport of water, wood, and people [33].

Most of the donkey owners interviewed indicated that they were keeping more male donkeys than female donkeys during the time of data collection. Male donkeys are used for transporting water to cattle posts and for breeding purposes. Males are also used for ploughing and at an older age, households use them as a source of meat for home consumption. Donkey owners select the males for breeding stallions while the rest are castrated, and natural mating is used for breeding donkeys. Sometimes, the owners allow the male donkeys to mate with horses to give birth to mules because mules are very strong and faster than donkeys.

Table 3. Uses of donkeys in Kgalagadi South Sub-district in south-west Botswana (n = 25).

Variables	Response (% of total respondents)
Pull a donkey cart (to transport water and fuelwood)	100
Ploughing	90.9
Riding (entertainment and patrolling cattle post)	90.0
Meat production*	54.5
Milk production*	27.3
Used for breeding (males and females)	9.1
To transport game meat after hunting	9.1
Transport children to school using a donkey cart	9.1

**Donkey meat and milk are claimed to have medicinal values; n = number of respondents; the data in the Table were generated through the survey study.*

Figure 2. Donkey cart used to transport people in Werda village (Source: survey study; photo by Eyassu Seifu; consent of the individuals was obtained before taking the photographs).

In Italy, donkeys are used for milk production, which is used in the cosmetic industry, meat production, and onotherapy, i.e., the use of donkeys as companion animals (pet therapy), especially for people who are suffering from depression and loneliness [20,35,36]. Moreover, donkeys can offer valuable services to people who are affected by disability or discomfort mainly due to their docile behavior. Onotherapy is a method of using contact and educational techniques with donkeys to help people with challenges.

Donkeys have historically been used as pack animals for short-distance transport, for riding, and as draft animals [20]. Donkeys can also be used for recreational purposes such as ecotourism and riding [20]. Salimei and Fantuz [31] reported the use of donkeys for draught and transport purposes, milk production, and mule production.

Donkeys are used for various activities around the world [10]. Additionally, coping with labor shortages and the loss of other livestock due to drought and cultivation of land are the major uses of donkeys for smallholder farmers. Furthermore, farmers can increase their productive potential and expand their marketing options through the use of donkeys in agriculture and transport [10]. Moreover, donkeys provide a source of income to their owners by hiring donkeys or donkey carts for a transport service [10].

All the respondents (n = 25) indicated that donkeys rank first in terms of drought resistance and water shortage compared to cattle, goats, and sheep. Donkeys are also rated first among other livestock species kept by the respondents because they are multipurpose animals used for transportation, ploughing, riding, etc. Thus, donkeys provide more services compared to other livestock species. Moreover, donkeys are more tolerant to feed shortages compared to other livestock species. Furthermore, donkeys are renowned for their thirst tolerance [35], as donkeys survive the periodic droughts prevalent in Botswana, which is a major reason for the loss of cattle [30].

Respondents also reported that donkeys can manage 3-5 days without water, i.e., donkeys are more tolerant to water shortages next to camels. Furthermore, donkeys know which trees and grasses have more water for feeding and can survive on a small amount of water. Moreover, some of the respondents believe that donkeys are not destructive to the environment; they may be used to control *Prosopis* encroachment in the area and they are used to patrol animals at cattle posts.

Cattle-based agriculture in Africa is highly challenged by the impact of climate change and frequent droughts. Smallholder farmers in the drylands of Africa, like those in the Kalahari region of Botswana, are vulnerable to droughts. Thus, the dependency on cattle-based livelihood options is increasingly unsustainable, making diversification crucial. The promotion of climate-resilient sustainable development as a potential livelihood option is an important strategy for eradicating poverty. One of the climate-resilient animals with promising potential in this regard is the donkey. Donkeys have a range of physiological and behavioral adaptation mechanisms that give them superior drought survival characteristics compared to cattle [37].

With the advent of climate change and increasing desertification, communities in the Kgalagadi District of Botswana have become vulnerable to food insecurity and malnutrition. Poverty is widespread among the rural communities in Botswana [38], and smallholder farmers are more vulnerable to frequent droughts and climate change. Thus, donkeys' superior drought survival characteristics compared to cattle mean that they can contribute positively to the enhancement of climate-resilient sustainable food production, food security, and job creation in Botswana.

The female donkeys are used for breeding, riding, and monitoring animals at cattle posts. Riding them is also used to tame them. Apart from the one farmer who kept donkeys for milk production, the rest of the donkey owners do not milk their donkeys. However, respondents indicated that if they get a market for donkey milk, e.g., 50 BWP per liter of milk, they are willing to milk their donkeys and sell the milk. This suggests that the establishment of a donkey milk collection center in Werda may be a viable option to develop the donkey milk market in the area.

Some respondents said that they do not eat donkey meat because the donkey is the animal that Jesus used for transport, as indicated in the Bible. Still, others stated that donkeys are used to transport

game meat home after hunting.

The use of donkeys as a pack animal (i.e., packing goods on the back of donkeys) is not common in Botswana. One respondent indicated that in the northern part of the country, some people pack goods on the back of donkeys. However, donkey carts are mainly used to transport firewood and fetch water from boreholes in the Werda area (Table 3). Some respondents indicated that they see a bright future for donkeys because they are multipurpose animals that have a lot of benefits.

In some areas, the government has contracted individuals to transport children to school using donkey carts. According to Aganga et al. [7], people without donkeys usually hire them in rural communities in Botswana, and it would cost about 12 to 25 BWP (1.16–2.42 US$) to transport household materials and goods over a distance of about 12 km. Some respondents reported that they eat donkey meat, and they indicated that when they eat donkey meat, especially during winter, they do not feel the cold. However, there is no market for donkey meat and, culturally, it is not used for ceremonies such as weddings and funerals. Some informants also indicated that people prefer donkey meat to milk. The meat is cooked and consumed or made into biltong, a traditional dried meat commonly prepared in Botswana and South Africa. According to the respondents, milk production by donkeys is low and they are not aware of the possibility of selling donkey milk. Generally, there is no cultural stigma that hinders rearing donkeys and consuming donkey products in the study area.

Karatosidi *et al*. [36] reported that consumption of donkey meat is common in Italy, and especially male donkeys are used for high-quality meat production for a particular group of consumers. Donkey meat is also consumed by the Turkana tribes of Kenya [28]. Donkey meat is used to produce sausages or stews and braises in Italy. It has low fat and high iron and carbohydrate contents compared to beef [36]. Moreover, donkey meat is tender and sweeter compared to horse meat and is easily digestible [36]. Aganga *et al*. [39] reported that donkey meat is a good quality meat and it has a very high protein content compared to beef and is high in important minerals such as K, P, Fe, and Zn.

Moreover, donkey milk is in high demand by manufacturers of cosmetics due to its use in the production of soap and moisturizers [36,40]. It also has purported medicinal value and is used to treat ailments such as edema, nose bleeding, liver disease, poisoning, infectious diseases, wounds, and fevers [36]. Because of its close resemblance to human milk, donkey milk is used as a substitute for women's breast milk and thus used to feed infant children [40,41].

3.2. Case study

3.2.1. Milking procedure

Before milking, the donkeys are given water, followed by the provision of feed (supplement). Subsequently, the donkeys are allowed to relax for five minutes, after which the udder and teats are cleaned. Milkers ensure their hands are washed before cleaning the udder. Moreover, the dam and foal must maintain visual contact to initiate milk letdown. This practice is in line with the report by Kaskous and Pfaffl [42], who stated that the milk ejection reflex in donkeys can be triggered if the female donkey always has visual contact with her foal. The foal is not allowed to suckle the dam before milking, as allowing this would result in the foal consuming the milk within 10 seconds. The foals are allowed to suckle their dam only at night when they are together in the kraal. This practice aligns with the findings of Salimei and Fantuz [32] and Salimei and Fantuz [31] who indicated that the presence of the foal during milking is essential for most horses to achieve complete milk extraction. The milking

of donkeys is performed by hand and stainless steel containers capture the milk, while aluminum cans are used for storing the milk. After milking, the milk is strained using a metal sieve into a 5 L plastic container, after which it is frozen.

Table 4. Milking practices, milk yield, hygiene of milk, and reproductive performance of donkeys at a commercial farm in Werda district.

Variables	Response*
Frequency of milking	Two times
Time of milking	12:00 pm and 5:00 pm
Where do you milk donkeys?	In the open air
How often do you clean the milking parlour/barn?	The barn is not cleaned
Method of milking	Hand milking
Milking procedure	
Do the milkers wash their hands before milking?	Yes
Do you wash the udder and teats of the donkeys before milking?	Yes
Do you use clean individual towels to dry the teats after washing?	No
Type of containers used for milking	Stainless steel cans
Safety measures applied to prevent contamination of milk during milking	Currently, no safety measures are put in place but a milking parlor is under construction to ensure milk hygiene
Age of donkeys at first foaling	3 years
Lactation length (months)	5-8 months (average 6 months)
Average milk yield per day	1 liter

**The responses in Table 4 are based on a case study and information obtained from one commercial donkey dairy farm in Werda village, which is a farm with over 200 donkeys. This is the only farm that produces and sells donkey milk in the study area.*

In the study area, donkeys are milked twice a day at 12:00 and 5:00 pm (Table 4). Polidori *et al*. [43] and Salimei *et al*. [44] reported that the average milk yield during morning milking is less than that recorded for the afternoon milking (549.2 mL compared to 949.3 mL). The peak milk yield in donkeys is achieved by milking three times a day at three-hour intervals [43].

In the study areas, owners milk donkeys by hand (Table 4). Despite washing their hands, the udder, and the teats of donkeys before milking, the hand milking process may not be performed with optimal hygiene, potentially leading to microbial contamination of the milk. Salimei and Fantuz [32] and Salimei and Fantuz [31] suggested that mechanical milking reduces the risk of microbial contamination of milk and improves udder evacuation in equines compared to hand milking. In this study, the barn of the donkeys is not cleaned, and the milking occurs outdoors in a kraal that is laden with dust and dung (Figure 3). This situation increases the likelihood of microbial contamination of the milk. Thus, training and educating farm workers on the importance of hygienic milking practices could significantly enhance the quality of donkey milk in the future.

The age of donkeys at first foaling in the study area was reported to be three years. This finding

aligns with the report by Dai et al. [45] who indicated that age at first birth for Italian Jennies is three years. However, the value is lower than the figures reported by Twerda *et al*. [28] for Turkana and Samburu donkeys in Kenya, which are 5 and 5.4 years, respectively.

Figure 3. Hand milking of donkeys in an open kraal in Werda village (Source: case study; photo by Eyassu Seifu; consent of the individual was obtained before taking the photographs).

The average lactation length of donkeys in the study area is six months and varies from 5 to 8 months (Table 4). The average lactation length reported in this study is significantly lower than that reported by Twerda et al. [28] for donkeys in the Samburu and Turkana Districts of Kenya, which are 14.5 and 9.7 months, respectively. This variation could be attributed to differences in feeding and management practices. Aspri *et al*. [20] reported that the lactation length of donkeys in Italy ranges from 8 to 10 months. On the other hand, Salimei and Fantuz [31] reported a lactation length of 6 to 9 months for donkeys. Additionally, Salimei [17] stated that natural weaning for donkeys typically occurs at 7 months of age or later.

The average daily milk production of donkeys in the commercial donkey farm considered in the case study is 1 liter (Table 4), which is consistent with values reported in the literature. Salimei [17] indicated that the average milk yield of donkeys ranges from 350 to 850 mL per milking. Aspri *et al*. [20] noted that donkey milk production is relatively low, with an approximate output of 1.5 liters of milk per day per donkey when milked twice daily. Furthermore, these researchers observed that a higher milk yield can be achieved by milking donkeys three times a day rather than twice a day. Salimei and Fantuz [31] stated that donkey milk production can vary from 235 liters over a 180-day lactation period to 500 liters over a 300-day lactation period. Twerda *et al*. [28] reported an average milk yield of 1 liter per day during the dry season and 3 liters per day during the rainy season for donkeys in Kenya.

There has been a growing interest in donkeys due to the increasing demand for their products, particularly their milk and hides. Reports indicate that donkey milk possesses purported medicinal values that can combat human ailments [43,46,47] and is used in the cosmetics industry to make skin

care products such as soaps and body lotions [22,40,48,49]. The claimed therapeutic benefits of donkey milk are largely attributed to its high lysozyme concentration, an antimicrobial protein known to inhibit a broad spectrum of pathogenic microorganisms [50]. In addition to lysozyme, donkey milk also contains lactoferrin, another antimicrobial protein that works synergistically with lysozyme [50]. Moreover, donkey milk is believed to have a skin-regeneration effect and slows the aging process due to its possession of high contents of vitamins A, B2, C, and E, which exhibit antioxidant activities [51]. The vitamins found in donkey milk are readily absorbed due to the presence of unsaturated fatty acids such as omega-6, which make the skin become elastic and prevent certain skin diseases [50].

Because of the claimed therapeutic benefits, donkey milk is sold at a very high price (240 Pula (23.2 US$) per liter) in Botswana (Table 5). This suggests that although the amount of milk produced by donkeys is significantly lower than that of cows, the production of donkey milk can represent a feasible and lucrative business opportunity. People interested in the donkey milk business may focus on niche markets for their products.

3.2.2. Handling, processing, marketing, and use of donkey milk

The respondents in the study area are of the opinion that donkey milk has medicinal values (Table 5). Some of the claimed medicinal benefits include its use in the treatment of asthma, cancer, joint problems (rheumatism), arthritis, diabetes (to control blood sugar level), ear and eye infections, and chest ailments, and for gut cleansing. They also asserted that donkey milk has an aphrodisiac quality. One respondent claimed that his family enjoys good health, fertility, and longevity due to their consumption of donkey milk. This respondent stated that donkey milk contains high proportions of unsaturated and short-chain fatty acids, which assist in dissolving fat deposits in the arteries, thereby reducing the risk of stroke and chronic heart disease. In essence, donkey milk is used to reduce atherosclerosis. He further noted that donkey milk helps male erection, i.e., specifically in addressing erectile dysfunction in men.

In the study area, farmers do not pasteurize donkey milk (Table 5). They believe that pasteurization of donkey milk destroys micronutrients, especially the lysozyme content and thereby reduces its medicinal value. Available literature shows that pasteurization (63°C/30 min and 72°C/15 sec) of donkey milk reduces its lysozyme content by 7-25% [52]. A report by Meena et al. [53] indicated that heat processing of donkey milk (68°C/2.5 min) reduces the lysozyme activity from 45,640 U/mL in raw milk to 40,526 U/mL. An increase in heat intensity to 75°C/10 min significantly decreases the lysozyme activity to 31,130 U/mL [53]. Moreover, it was reported that the lysozyme activity can be significantly reduced (60.79%) by more intense heat treatments such as 80°C for 10 minutes compared with raw donkey milk [54]. The lysozyme content of donkey milk ranges from 0.67 to 3.74 g/L [55]. On the other hand, the lactoferrin content of donkey milk ranges from 0.07 to 0.37 g/L [41]. A report by Ozturkoglu-Budak [56] indicated that lactoferrin completely disappears in donkey milk at heat treatments higher than 65°C. It was reported that the nutritional and functional qualities of donkey milk can be retained to a better extent with non-thermal processing methods such as high-pressure processing and ultrasonication than the conventional thermal processing methods [53].

Table 5. Storage, transportation, processing, marketing, and utilization of donkey milk: The case of a commercial donkey farm at Werda village.

Variables	Response*
Storage of milk after milking	Store the milk in aluminum milk cans and put the can inside a wet hole in the ground, which was filled with water
Containers used to store milk	Aluminum milk cans
Cleaning of milk containers	Wash the milk containers with sunlight liquid soap and hot water
Source of water used for cleaning milk containers	Get potable water from Werda Water Utilities
Do you sell donkey milk?	Yes
What is the price of one liter of donkey milk?	240 BWP/1 L**
Where do you sell the milk?	Individual customers, retailers in Gaborone (Main Mall, BBS Mall, Westgate Mall, and the Airport), Molepolole, Francistown, Mahalape, Palapye, Serowe, Kasane, Maun, Gantsi, Letlhakalane, Hukuntsi, Tsabong, Werda, Mafikeng (RSA), Bloemfontein (RSA) and Middleburg (RSA)
Major customers of your donkey milk	Individual consumers (niche market) and retailers in Botswana and South Africa
Transportation of milk from the farm to the market	Frozen milk is transported from Werda to Gaborone (400 km) by car
Containers used to transport milk to the market	Five-liter plastic bottles
Mode of storage of milk at the market	Put milk in a cooler box
Uses of donkey milk	Donkey milk is used for small children and elderly people Give donkey milk to children for good health and make them strong They drink the milk when they are sick To treat lung diseases Donkey's milk makes you energetic and strong
Is donkey milk processed into dairy products?	No, but the farmer produces soap and body lotion from donkey milk
Do you pasteurize the milk before sale?	No. When you boil the milk, all the medicinal properties are destroyed The milk is consumed raw
Does donkey milk have medicinal value?	Yes It is used to treat asthma, cancer, joint problems (rheumatism), arthritis, and diabetes (to control blood sugar level), has an aphrodisiac effect. Treatment of ear and eye infection To clear the gut For chest ailment

**The responses in Table 5 are based on a case study and information obtained from one commercial donkey dairy farm in Werda village, which is a farm with over 200 donkeys. This is the only farm that produces and sells donkey milk in the study area. The exchange rate of US Dollar to Botswana Pula at the time of the survey (June 2018) was 1 US$ = 10.345 BWP.*

Botswana's Food Control Act 1993 [57] prohibits the sale of any food that is adulterated or unfit for human consumption, which includes raw milk if it is contaminated with harmful substances. This general prohibition against selling unsafe food implies strict control over the sale of raw milk directly to consumers, which can pose public health risks. Botswana's standard for raw milk [58] stipulates that raw milk should be kept at 4°C or below within two hours of milking and maintained at this temperature until further processing. It further states that milk must be handled, stored, and transported under hygienic conditions and obtained from approved sources, and this has to be verified by the Department of Veterinary Services. Moreover, selling and consumption of raw donkey milk can potentially cause public health risks. Thus, the respondents' perception of the medicinal value of raw donkey milk has to be considered cautiously since these claims have not been supported by clinical evidence. It should also be noted that we did not evaluate the safety/efficacy of donkey milk and do not imply treatment of diseases.

In the study area, a particular farmer maintains a herd of over 200 donkeys, which he uses for milk production. He mentioned that he primarily produces this milk for sale to consumers in the capital city, Gaborone, and other regions of the country. Based on his account, it typically takes 2-3 days for the milk to be sold out at the market outlets. The selling points in Gaborone include Main Mall, Botswana Building Society (BBS) Mall, and Westgate Mall, where the milk is sold under the shade of a big umbrella locally referred to as a *Gazebo,* as well as at the Sir Seretse Khama International Airport. He mentioned that he sells one liter of donkey milk for 240 BWP. The pricing of donkey milk considers the costs of labor, production, and transportation costs.

The farmer in Werda sells donkey milk to the general public (for direct human consumption) and to make cosmetics (soap and body lotion) (Figure 4) from the milk, which they sell as skin care products. He believes that donkey milk has nutritional and medicinal values. This producer believes that it is possible to make cheese from donkey milk although they are not involved in cheesemaking currently.

After milking, the donkey milk is frozen and then transported to Gaborone by bus at night, which is 400 km from Werda. They use 5 L plastic bottles to transport the milk. The frozen milk is put in a bag and given to the driver. The driver is paid 100 BWP to deliver the milk to Gaborone. Upon arrival, the agents at Gaborone collect the milk and take it to the processing site, where it is defrosted and packaged into 250 mL sealable plastic bottles. The processing is done at their home in Gaborone. Before dispensing the milk into 250 mL bottles, they filter the milk using a cheesecloth that has been put in boiling water.

After repackaging, the milk is frozen again. The milk is then taken to the selling point and put in a cooler box. They sell the milk in four places in Gaborone (Main Mall, BBS Mall, Westgate Mall, and at the Airport), Molepolole (1), Francistown (3), Mahalapye (1), Palapye (3), Serowe (2), Kasane (1), Maun (1), Gantsi (1), Letlhakalane (1), Hukuntsi (1), Tsabong (1), Werda, Mafikeng (RSA) (1), Bloemfontein (RSA) (1), and Middleburg (RSA) (1). The farmer supplies the milk to some of these places upon request. The South African customers come to Werda and get the milk. This farmer also produces freeze-dried donkey milk in capsule form (300 mg/capsule) and sells 60 capsules for 250 BWP. This is a convenient method of providing donkey milk. He said that he provides the milk to a niche group of people (i.e., people who are able and willing to pay).

In recent years, a dairy donkey farming system has been developed in Portugal, Italy, Spain, Greece, France, and Belgium, mostly in marginal areas of these countries [31]. Salimei and Fantuz [31] reported that larger farms in Italy produce freeze-dried donkey and horse milk. Aspri *et al*. [20] reported that the problems associated with donkey milk are that its market has not developed, and it is

a "niche product," which is often sold on farms. Besides, the cost of donkey milk per liter is high due to the low milk yield and the rarity of the product.

A B

Figure 4. Soap (A) and body lotion (B) made from donkey milk by the commercial donkey farm considered in the case study (Source: photo by Eyassu Seifu).

4. Conclusions

Donkeys are important in the livelihoods of farmers in the study areas. In the study areas, donkeys are used for various purposes, including transportation of water and firewood, ploughing, riding for entertainment and cattle post patrols, meat and milk production, breeding, transporting game meat post-hunting, and ferrying children to school using donkey carts. Despite their significant socio-economic contributions and their vital role in the livelihoods of farmers in the study areas and nationally in particular, donkeys have received minimal attention and are generally overlooked compared to other livestock species in the country. There is a growing interest in donkey products, particularly donkey milk, which is noted for its purported medicinal properties and cosmetic uses. Thus, it is essential for all stakeholders to focus on fully harnessing the benefits of this important animal. By enhancing the management, nutrition, and health of these animals, it is possible to significantly increase the productivity of the donkeys from their current status. The findings of the study indicated that there is no cultural stigma associated with the production and consumption of donkey products, such as meat and milk, in the study areas. This presents a favorable opportunity to develop and improve the donkey meat and milk industries within the country. All farmers interviewed expressed (n =25) a willingness to engage in the donkey milk business, provided they receive a stable price for the milk. It should be noted that, given the limitations of the study (small sample size, purposive sampling, case-specific study, and absence of microbiological data to verify some of the claims made by the respondents), the results should be interpreted cautiously.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

The authors declare no conflict of interest related to the manuscript.

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