Innovative Solutions for Food Security: The Role of Camels in Sustainable Development

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ABSTRACT

Camels, often dubbed "the ships of the desert", are increasingly recognized as vital contributors to sustainable animal production. With the global population on the rise and protein demand escalating, camels emerge as highly effective ruminants capable of meeting these challenges. They produce a range of valuable products, including nutritious and therapeutic items such as meat, milk, hair, and cosmetics. Furthermore, camels provide significant income for nomadic herders. Their meat is noted for its health advantages, including lower fat and cholesterol levels, as well as enhanced water retention. Camel milk is rich in vitamins and minerals, boasting antibacterial properties that add to its therapeutic benefits. Despite this, the marketing of camel products remains limited, with herders primarily selling their goods at the village level. To fully realize camels' potential in sustainable animal production, it is essential to improve production systems and pursue genetic advancements.

Keywords: Camels, milk, meat, hides, marketing

INTRODUCTION

As global warming and desertification progress, the world's deserts are expanding. Camels are uniquely adapted to serve as the primary livestock for sustainable agricultural and animal production in these challenging environments. With droughts becoming more prevalent and the productivity of other livestock declining, camels are increasingly viewed as a viable solution to the growing protein demand. In desert regions, communities depend heavily on camels for meat, milk, hides, and transportation, earning them the designation of "The Ship of the Desert."

The expanding human population intensifies food insecurity, making the availability of nutritious food at reasonable prices crucial for maintaining social stability and preventing mass migration. Sustainable production practices that adapt to climate challenges are vital for agricultural progress. Current protein sources from large and small ruminants, poultry, and fish are insufficient. Therefore, exploring innovative local food sources is paramount for achieving food security. Camel breeding has flourished in desert and rural areas, as camels have evolved over millennia to produce quality meat, milk, and hides in some of the harshest climates. Given their unique physiology and the ongoing effects of climate change, camels are excellent candidates for sustainable production. Their products can enhance food availability in arid regions, provide significant income for nomadic herders, support rural livelihoods, and contribute to economic development, ultimately integrating these communities into the global economy.

Camel Products

Camel Meat

The acceptance of camel meat as a food source is increasing globally. According to Faye and Esenov (2005), camels have considerable potential to satisfy future dietary needs. Camel meat is particularly economically viable in arid areas (Patil, 2011). Studies indicate that camel muscles are

low in fat and high in water retention, making camel meat a healthy option with excellent processing qualities (Babiker and Yousif, 1990). Kadim et al. (2008) emphasized the dietary benefits of camel meat, while Kadim et al. (2014) noted its lean quality, low cholesterol, and high protein content. Research by Adam and Abugroun (2015) found no significant differences in microbial growth or sensory attributes, such as flavor and tenderness, between camel and beef meat. This makes camel meat suitable for those with health concerns like diabetes and high cholesterol, as well as health-conscious consumers. Abrhaley and Leta (2017) classified camel meat as a functional food, believed to aid in treating various health issues. With increasing interest in camel meat, further research on its characteristics and quality improvement is essential (Al-Owaimer et al., 2014; Maqsood et al., 2015a, b; Abdel-Naeem et al., 2016). Generally, meat from younger camels is viewed as healthier due to its lower fat and cholesterol levels (Abdel-Raheem et al., 2019). Over the past two decades, camel meat products like burgers and canned corned camel have emerged in various markets (Farah and Fisher, 2004; Zaki, 2017). However, in Egypt, detailed chemical analyses of camel meat are limited, particularly in Upper Egypt (Abdel-Raheem et al., 2019).

Camel Milk

Camels have unique adaptations that allow them to produce milk even when other livestock struggle to survive (Han, 2005). Female camels can yield five to ten times more milk than cows under comparable conditions, thanks to their high daily yields and extended lactation periods (Field, 2005). Camel milk is rich in vitamins (A, B2, C, and E) and minerals (sodium, potassium, copper, magnesium, and zinc) (Al-Humaid et al., 2010). Its composition includes low fat (1.5-3%) and low protein (2.5%), along with a longer shelf life and a higher ratio of β-casein to κ-casein. The absence of Lysozyme C and β-lactoglobulin, combined with the presence of whey acidic protein, further distinguishes camel milk. Ongoing research into its antibacterial and therapeutic properties emphasizes the need for more studies on its unique nutritional profile (Patil, 2011). Camel milk has lower levels of β-lactoglobulin (Merin et al., 2001; Al-Alawi and Laleye, 2011) and β-casein (Al-Alawi and Laleye, 2011), which may correlate with fewer allergic reactions (El-Agamy et al., 2009). Recent studies by Shori (2017) and Mohammed (2018) suggest that camel milk could be a valuable source of probiotics in dairy products. Ayyash et al. (2018) noted that Lactobacillus spp. from camel milk show promise as starter cultures in the dairy industry. Consequently, camel milk products are becoming increasingly available worldwide, including raw and fermented forms, as well as processed items like ice cream, Halomy cheese, freeze-dried milk, butter, and chocolate (Konuspayeva and Faye, 2016; Berhe et al., 2017; Elnemr et al., 2020).

Camel Hides, Hair, and Cosmetic Products

Camel hides are typically of lower quality but are utilized in the production of shoes, saddles, and containers for water and milk (Khan et al., 2003). Adult camels generate between 1 to 3 kg of hair each year, which is used to make ropes, bags, mats, and carpets. Finished products made from camel hair are particularly popular with tourists. Blends of camel hair with materials such as silk, polyester, and wool have been developed for textiles (Patil, 2011). Additionally, camel bones are valued as a cost-effective substitute for ivory, leading to various small bone items crafted in cottage industries. Tourists often favor items made from camel hides and bones (Patil, 2011). Furthermore, components derived from camel milk are being investigated for their potential application in cosmetics, especially regarding anti-aging properties (Adlerova et al., 2013). Kula (2016) noted that camel milk is rich in α-hydroxy acids, which can improve skin texture and help treat conditions like dermatitis, acne, psoriasis, and eczema.

Camel Medical Products

Camel milk and urine have been used as traditional medicinal remedies in several regions of Asia and Africa for centuries. Recently, there has been a surge of scientific interest in the therapeutic benefits of these camel products. As reported by Abdel Gader and Alhaider (2016), there is substantial evidence from laboratory and limited clinical studies that camel milk, often in combination with

camel urine, can effectively manage various medical conditions, including diabetes, cancer, food allergies, autism, viral hepatitis, and infections caused by viruses, bacteria, and parasites. Camel products may also provide cardiovascular benefits.

Research by O'hag et al. (2000) demonstrated that camel lactoferrin significantly inhibits the infection of human cells by hepatitis C virus genotype 4. Maghraby et al. (2005) found that camel milk effectively eliminated *Schistosoma mansoni* in infected mice, indicating its anti-parasitic properties. The immune-boosting effects of camel milk were highlighted by Shabo et al. (2005), who showed its efficacy against viral and bacterial infections.

Studies suggest that camel milk enhances antioxidant activity in the body, offering therapeutic benefits against diseases related to oxidative stress (Al-Hashem, 2009; Ayadhi and Elamin, 2013). According to a review by Shori (2015), in vivo studies concluded that camel milk can significantly lower blood glucose levels and reduce insulin requirements, helping to mitigate complications associated with diabetes, such as high cholesterol, liver and kidney issues, oxidative stress, and delayed wound healing. Camel milk has also demonstrated notable antiulcer properties (Habib et al., 2013).

Recent findings by Ayyash et al. (2018) underscored the health advantages of camel milk, particularly its antioxidant properties and potential for angiotensin-converting enzyme (ACE) inhibition and anti-proliferative activity. Camel lactoferrin shows greater antiviral efficacy against HCV compared to lactoferrin from other species (El-Fakharany et al., 2013). Additionally, camel milk casein has shown promising effects against HCV, while camel whey protein aids healing by enhancing the immune response in wounded tissues (Badr, 2013).

Research conducted by Al-Yousef et al. (2012) and Romli et al. (2017) suggested that camel urine possesses significant anti-cancer and immune-modulating properties in vitro, potentially inducing apoptosis in cancer cells. Evidence provided by Hosseini et al. (2015) demonstrated camel milk's effectiveness in cancer control and treatment, while Alebie et al. (2017) reviewed its therapeutic applications against cancer.

Further investigations have shown that camel urine exhibits antifungal and antibacterial properties and can protect the liver from Carbon Tetrachloride (CCl_4)-induced damage (Al-Bashan, 2011; Alzahrani and Alharbi, 2011). Additionally, camel urine has antimetastatic effects on breast cancer cells (Romli et al., 2017).

According to Singh et al. (2017) and Ali et al. (2019), ongoing research continues to explore the therapeutic potential of camel products as natural adjuvants for various human diseases. A recent review by Mohammadabadi (2020) suggested that camel milk could effectively address numerous health issues, particularly those related to cardiovascular health. Consequently, camel products serve not only as nutritional sources but also as valuable remedies for various health conditions. Further studies are necessary to understand the molecular mechanisms underlying their effects on diseases and immune system support.

Marketing of Camel Products

Faye (2014) pointed out that while camelids play a minor role among domestic herbivores, they are widespread across arid regions of the Old World, significantly contributing to the agro-ecosystem balance in those areas. Currently, due to inadequate marketing infrastructure and resources (such as transport costs), herders often sell their camels locally within villages. For example, the FAO (2010) highlighted that camel wool from Mongolia has qualities appealing to hobbyists in the United States. A development project involving an NGO aims to establish a value chain linking women in southern Mongolia who spin camel wool into yarn with American knitting enthusiasts.

The consumption of camel milk in households is shaped by various factors, such as pastoralists' access to markets, the number of milking camels, seasonal climate fluctuations, community requirements, and cultural practices (Gebremichael et al., 2019). Milk sourced from remote mountainous and desert areas often does not reach urban markets and is consumed locally. Additionally, transporting a few animals to distant markets can be impractical, as producers typically sell based on immediate cash needs. Aujla et al. (2013) highlighted the need for regulatory reforms in livestock and camel marketing systems to improve profits for producers and attract investments aimed at enhancing camel farming for poverty reduction and food security. Improving efficiency is vital to

maximize benefits for producers and stakeholders in the milk and meat value chains (Kuria et al., 2011).

In larger urban areas, camel milk is available, usually sold as pure milk or mixed with cow and buffalo milk, particularly during shortages of the latter (Yaqoob and Nawaz, 2007). In 2006, Lokhit Pashu-Palak Sansthan, a local NGO, initiated efforts to explore new income-generating avenues from camels beyond their traditional transportation role. This initiative included promoting camel milk as a diabetes treatment, creating camel milk ice cream, assessing wool for market potential, producing paper from camel dung, and forming savings groups for camel breeders (FAO, 2010). In Mauritania, Tiviski dairy, a private company, buys milk from pastoral herders in the southern region, chills it, and transports it to its facility in the capital, Nouakchott. This company specializes in camel milk, serving semi-nomadic herders (London et al., 2010), and produces high-quality pasteurized milk and other dairy products, including camel cheese, for which they are seeking regulatory approval for export to the European Union, a potentially lucrative market. According to an FAO estimate (2011), the global market for camel milk could be worth billions of dollars in the near future as it enters European markets as a health food. However, camel milk consumption remains limited in Egypt, primarily found in some desert regions.

In terms of the camel meat industry, better data collection and dissemination could unlock more opportunities. Accurate data is essential for attracting potential investors. There are opportunities to market camel meat to health-conscious consumers (Warfield and Tume, 2000). Developing brands could also enhance the camel meat market, particularly as branded meats gain popularity in the food service industry. Typically, camel meat sells more slowly in markets, making it crucial for the industry to implement extended shelf-life technologies, such as vacuum packaging and modified atmosphere packaging, to preserve freshness (Kadim et al., 2014).

Improvement of Camel Production Systems

The economic potential of camel products, including milk and meat, plays a significant role in fulfilling the protein needs of both rural and urban populations. Additionally, camel hides and fibers provide vital raw materials for the textile sector. The camel industry also employs a significant workforce in agriculture and promotes productivity improvements in developing countries through various research and development efforts (Salehi and Birjandi, 2009; Rahanjam and Kor, 2009; Mirzaei, 2012).

Enhancing camel husbandry practices can greatly support nomadic herders and camel breeders who depend on camel rearing for their livelihoods. Traditional camel farming shows considerable variability, indicating substantial opportunities for productivity enhancements. Success stories in milk and meat production demonstrate the potential for modernizing camel farming systems (Breulmann et al., 2007). The expansion of the camel milk market is closely linked to the establishment of dairy plants capable of processing camel milk, such as the Tiviski factory in Mauritania (Mohammed, 2003). The use of milking machines is on the rise in larger farms across regions like the Emirates, Saudi Arabia, and Central Asia, with camels adapting well to automated systems without compromising udder health (Ayadi et al., 2013). Under intensive management, camels can produce 15-20 liters of milk per day for lactation periods extending up to 18 months, underscoring their value as farm animals (Raziq et al., 2008). Numerous intensive camel dairy farms have emerged globally, serving both local and international markets (Gossner et al., 2014).

The integration of camel products into national and global economies is progressing steadily (Faye, 2008). Camels not only enhance food security but also generate employment, reduce poverty, and support economic diversification. To fully realize their potential, a deeper understanding of the unique genetic traits of camels is essential. Genetic enhancements are critical for effectively utilizing camels while preserving their genetic diversity, presenting both challenges and opportunities for the efficient use of this unique species (Al Abri and Faye, 2019).

International and Egyptian Strategies for Sustainable Camel Production

Development initiatives aimed at camel breeding are particularly significant for Sahelian countries in sub-Saharan Africa, which host substantial camel populations. Collaborative research

networks, including RESARDEC (Sahelian Network Research and Development of Camel Livestock), involve countries such as Mauritania, Mali, Niger, and Chad. These initiatives are crucial for international organizations and address livestock challenges in arid regions, with support from entities like ICARDA (International Center for Agricultural Research in Dry Areas) and various camel development networks.

There is notable variation in production among individuals of the same breed, as well as across different breeds and regions. Understanding this variation can guide future strategies for improving production. It is essential to recognize and utilize the true potential of camels, transforming traditional practices into modern enterprises while conserving valuable genetic resources. Integrating camel products—such as milk and meat—into the food supply chain is vital, as demonstrated in Egypt, where annual camel meat consumption ranges from 40,000 to 60,000 tons. The globalization of camel products and the growing presence of expatriates from southern countries necessitate that these products compete in quality to meet global market standards. Currently, there are few innovative products available, which offer limited value to rural producers.

In Egypt, there is a growing interest in enhancing camel breeding, particularly within research institutes focused on desert environments, like the Desert Research Center. Their international project, "Promotion des systèmes camelins innovants et des filières locales pour une gestion durable des territoires sahariens (PROCAMED)," aims to develop innovative camel breeding systems for sustainable local industry growth and effective management of Saharan territories. This project takes a holistic approach to livestock development, emphasizing the crucial role of camels in adapting to climatic and economic changes (Badawy et al., 2013).

Recently, Askar (2019) coordinated another initiative called the "National Campaign for Camel Productivity (NCPCP, 2017-2019)," funded by the Academy of Scientific Research and Technology (ASRT). This project, led by the DRC in collaboration with several Egyptian universities, focuses on addressing challenges in camel production. It employs high-yielding lactating camels in semi-intensive systems and utilizes machine milking to improve both milk production and quality. The NCPCP has successfully added value to camel milk by creating high-quality dairy products such as cheese, butter, ice cream, yogurt, and pasteurized milk.

CONCLUSION

While camels are often regarded as marginal animals worldwide, their capacity to produce milk, meat, and wool in harsh conditions provides significant benefits to producers and nutritional advantages to consumers. Camels are transitioning from being seen merely as "ships of the desert" to becoming essential elements of modern farming systems. Their role as productive livestock is increasingly relevant in the context of climate change. With the backing of various developmental organizations and collaboration among camel scientists and policymakers, there is considerable potential for enhancing camel production on a global scale.

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الملخص العربي

حلول مبتكرة للأمن الغذائي: دور الإبل في التنمية المستدامة

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تعتبر الإبل "سفينة الصحراء" مفتاح المعجزة الذي يمكن أن يلعب دورًا مهمًا في استدامة الإنتاج الحيواني. في الوقت الحاضر وفي المستقبل القريب، مع النمو السكاني المتزايد مع زيادة الطلب على البروتين، تعد الإبل أفضل الحيوانات المجترة إنتاجية والتي يمكن أن تحل مشكلة الطلب المتزايد على البروتين الحيواني. لأن الإبل يمكن أن توفر العديد من المنتجات "المنتجات الصحية والعلاجية" مثل اللحوم واللبن والشعر ومستحضرات التجميل. بالإضافة إلى ذلك، فهي مصدر غني للدخل للرعاة الرحل. ومن المعروف أن لحوم الإبل منتج صحي، وتتميز بمحتوى أقل من الدهون والكوليسترول، وسعة أعلى للاحتفاظ بالمياه. كما أن لبن الإبل غني بالمعادن والفيتامينات بالإضافة الي الخصائص المضادة للبكتيريا التي تمنح حليبها خاصية علاجية. في الواقع، لا يتم تسويق منتجات الإبل بالنظام المتطور بشكل جيد. حيث يفضل الرعاة توزيع منتجات الإبل على مستوى القرية. في الواقع، تحتاج الإبل إلى تطوير نظام الإنتاج والخضوع للتحسين الوراثي للاستفادة من إمكاناتها في استدامة الإنتاج الحيواني.

الكلمات الدالة: الإبل، لبن، لحم، التسويق