RESEARCH ARTICLE Indian Journal of Animal Research, Volume 59 Issue 7: 1149-1154 (July 2025)

Camel Urine Characteristics and its Bioactive Molecules on Potential Impacts against Diseases and Pathogenic Microorganisms

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10.18805/IJAR.BF-1908

ABSTRACT

Background: Camel urine (CU) traits varied depending on hydration status, dietary intake, physiological and health conditions. The CU impacts against diseases and pathogenic microorganisms were greatly differed.

Methods: The camel urine can be explored from virgin and mature healthy females and males under different management conditions. Urine sample quantity, storage and camel characteristics in addition to country of study were indicated in the article. Effects of different forms of camel urine including fresh urine, enzymatic hydrolysed form, a lyophilized form, bioactive fraction (prophet medicine fraction; PMF) of camel urine were explored *in vivo* and *in vitro* in different experiments to explore their antimicrobial properties. The articles concerning fresh camel urine and its fractions against pathogenic microorganisms and diseases were collected from PubMed, SciencDirect and Google Scholar databases.

Result: The results indicated antibacterial, antifungal and antiviruses activities of camel urine in addition to hepatoprotective, gastroprotective and anti-cancer effectives. Camel urine and its fractions has a distinctive ability to kill bacteria, viruses and fungi. The compounds of camel urine aid in recovery like metabolites, hormones, corticosteroids and urea. In addition, camel urine was reported as anticancer, gastroprotective, hepatoprotective, antiplatelet and antiapoptotic agent. Collectively, it could be concluded that camel urine and its fractions have a wide range against pathogenic microorganisms and diseases with the potential hygienic procedure.

Key words: Bioactive molecules, Camel urine, Diseases, Microorganisms, Pathogen.

INTRODUCTION

Camels are crucial to the nomadic lifestyle, providing essential resources for survival. The importance of camels in the livestock industry varies greatly across different countries, depending on factors including the camel breeds, management systems and the environmental conditions (Faye, 2020; Chamekh *et al.,* 2020). Camels provide various products that have been used for sustenance and trade including milk, meat, urine, wool and fertilizer (Kishore *et al.,* 2024; Mohammed and Mahmoud 2011; Mohammed and Alshaibani 2024a,b). These products have played significant roles in the economies and cultures of many regions around the world (Mohammed *et al.,* 2024a,b,c,d).

Camel urine secretion is a fascinating aspect of camel physiology to adapt to the harsh environmental conditions (Iglesias Pastrana *et al.,* 2022). Camels produce highly concentrated urine to conserve water in arid environments (El-Hady *et al.,* 2023). Camel urine contains a high concentration of solutes, including salts, urea and uric acid to minimize water loss. The kidneys are highly efficient at reabsorbing water and solutes resulting in production of concentrated urine (El-Hady *et al.,* 2023). Furthermore, the camels exhibit behavioral adaptation as avoiding the hottest parts of the day and seeking shade to minimize water loss. The amount of camel urine secreted and its specific characteristics can vary depending on hydration status, dietary intake and health conditions (Amina *et al.,* 2024a,b). Collectively, camel urine secretion is a remarkable sign of camel adaptation to harsh environments, which is highly concentrated for their survival in the desert environments (Hoter *et al.,* 2019). Camel urine has been used for centuries as traditional medicine in the Middle East and North Africa due to its potential therapeutic properties. The traditional uses of camel urine were included for treatment of diseases, antimicrobial, anti-inflammatory and antioxidant activities (Al-Ghumlas *et al.,* 2023) (Fig 1).

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How to cite this article: Mohammed, A.A. and Alshaibani, N. (2025). Camel Urine Characteristics and its Bioactive Molecules on Potential Impacts against Diseases and Pathogenic Microorganisms. *Indian Journal of Animal Research.* **59(7):** 1149-1154. doi: 10.18805/IJAR.BF-1908.

Submitted: 22-10-2024 **Accepted:** 19-12-2024 **Online:** 07-01-2025

Several studies have shown that camel urine contains a variety of bioactive compounds, including peptides, amino acids and minerals. These compounds may have therapeutic potential effects (Salamt *et al.,* 2021). Because of the limited scientific evidences, the possible side effects and the ethical considerations, further rigorous scientific research studies are needed to validate the efficacy and safety of camel urine for treating diseases. Therefore, it's essential to consult with a healthcare professional to use camel urine for medicinal purposes (Abuelgasim *et al.,* 2018). Collectively, this review is designed to collect and interpret data concerning camel urine and its form against diseases and pathogenic microorganisms.

MATERIALS AND METHODS

The article was approved by the research committee of King Faisal University [Ref. No. KFU-REC-2024-AUG-EA050]. The articles concerning unique anatomical features of camel kidney, chemical composition of camel urine, amino acids of camel urine, camel urine against antimicrobial activities, hepatoprotective, gastroprotective and anti-cancer activities of camel urine and others were collected from PubMed, SciencDirect and Google Scholar databases to write the review article. Therefore, our targets were to highlight key aspects of camel urine secretion and composition and it is effect against diseases and pathogenic microorganisms.

RESULTS AND DISCUSSION

Unique anatomical features of camel kidney and urine formation

The kidney's size is approximately 850 cm^3 and weighs about 1000 grams in adult camel. Camel kidneys are brown and bean-shaped having a smooth surface and covered by a thin fibro-muscular capsule (Bello *et al.,* 2013). The kidney is divided into an outer brown region called the renal cortex and an inner red region called the renal medulla. The medulla is about four times thicker than the cortex (Abdalla and Abdalla, 1979). The structural and functional unit of the kidney is called the nephron responsible for filtering blood and removing waste products (Imran 2024). The kidney is particularly responsible for regulating water balance and electrolytes in cases of dehydration and rapid rehydration. The camel kidney also plays a crucial role in recycling nitrogen, which is a remarkable feature in camels that explains their ability to survive on low-quality diets.

Several unique anatomical features of camel kidneys contribute to their ability to produce concentrated urine (Abdalla and Abdalla 1979). Henle loop is significantly longer in camels than in many other mammals as in the kangaroo rat (Schmidt-Nielsen and O'Dell, 1961). This extended Henle loop allows for a greater concentration gradient, enabling the kidneys to reabsorb more water and solutes. In addition, the ascending limb of the Henle Loop is also thicker in camels, which increases its ability to actively transport sodium and chloride ions out of the tubule (Alvira-Iraizoz *et al.,* 2021). This contributes to the creation of a hyperosmotic environment in the medulla, facilitating water reabsorption. The medulla of the camel kidney is significantly thicker than in many other mammals (Schmidt-Nielsen, 1964). This allows for a longer countercurrent multiplier system and a greater ability to concentrate urine. The collecting ducts in camel kidneys are highly specialized to reabsorb water in response to the hormone vasopressin. This hormone increases the permeability of the collecting ducts to water, allowing for further water reabsorption. Another unique feature of camel kidneys is the presence of folds in the pelvis providing a large surface area. These folds provide a close association between the renal pelvis and the medulla, facilitating the recycling of urea (Abdalla, 2020). Collectively, these unique anatomical features enable camel kidneys to produce highly concentrated urine, minimizing water loss and conserving precious resources in arid environments.

Chemical composition of camel urine

Camel urine is a complex fluid with a unique compo-sition that reflects their adaptations to arid environments (Al-Numair *et al.,* 2022), which varies according to hydration status, dietary intake, sex, age, physiological and health status (Bollard *et al.,* 2005; Schreier *et al.,* 2013; Vogt *et al.,* 2016) (Fig 2). The volume of camel urine was varied from 1.8L to 6.0L according to weather, which increased during colder weather compared to hotter one. The urine had a yellow color and a specific gravity ranged from 1.045 to 1.056. The pH of camel urine is slightly alkaline, ranging from 8.2 to 9.2 compared to pH 5 of human urine. This alkaline pH is likely caused by the high amount of potas-sium salts it contains (Yagil and Berlyne, 1976). The high concentration of solutes (organic nitrogen, urea, creatinine, creatine, uric acids, ammonia, organic acids, amino acids, vitamins, hormones and electrolytes) in camel urine is a key adaptation to their desert environments (Read, 1925). Camel urine contains about 10-folds more mineral salts versus human urine. In addition, an average of 1.08 per cent of hippuric was found in camel urine. This helps to conserve water by minimizing urine volume while still eliminating waste products. Further research is still needed to fully understand the chemical composition of camel urine and its potential therapeutic applications (Salamt *et al.,* 2021). However, it is clear that this complex fluid plays a crucial role in the survival of camels in harsh desert environments.

Amino acids of camel urine

Amino acids (AAs) are the building blocks of proteins and there are more than 100 amino acids. Twenty of these amino acids are particularly important for creating proteins in our bodies. The AAs were classified into essential, semi-essential and nonessential amino acids (Abdalla *et al.,* 2017). The main essential amino acids are leucine, isoleucine, lysine, phenylalanine, methionine, tryptophan,

threonine, Arginine, valine and histidine. Tyrosine cysteine are semi-essential AAs because they may be synthesized from phenylalanine and methionine, respectively. The main nonessential AAs are asparagine, aspartic acid, alanine, glycine, proline, serine, glutamine and glutamic acid (Seif *et al.,* 2016). Camel urine is known to contain a high amount of amino acids (Abdalla *et al.,* 2017).

Camel urine has been shown to inhibit the bacterial growth (Sumia *et al.,* 2016). This could be attributed to glutamic acid high value, which can inhibit some pathogenic bacterial growth as *Staphylococcus aureus*, *Klebsiella pneumonia*, *Listeria monocytogenes, Salmonella typhimurium* and *Esherichia coli*. Leucine value in CU reflex its potential ability to control blood sugar level in diabetic patient. Leucine stimulates insulin synthesis by serving as both metabolic fuel and allosteric activator of glutamate dehydrogenases to enhance glutaminolysis in pancreatic beta cells. Leucine has been shown also to regulate gene transcription and protein synthesis in pancreatic islet β-cells *via* both motor-dependent and independent pathways at normal levels. Long-term exposure to leucine has been found to improve the insulin-producing function of beta cells in people with diabetes by increasing the activity of specific genes involved in metabolism (Yang *et al.,* 2010).

Camel urine against antimicrobial activities

There is growing curiosity about using camel urine to treat infectious diseases (Yehia *et al.,* 2020). Camel urine has been explored in traditional medicine and recent scientific studies as a potential source of antimicrobial compounds (Ali *et al.,* 2019; Amina *et al.,* 2024a,b). Compounds with antimicrobial properties found in camel urine has been reported. The chemical compounds found in camel urine with antimicrobial activity include urea, uric acid, peptides, organic acids and minerals (Khedr and Khorshid, 2016). Urea and uric acid have been shown to exhibit antimicrobial properties against a wide range of bacteria and fungi. In addition, the peptides in CU can disrupt the cell membranes of microorganisms. Organic acids in CU including lactic and acetic acids can contribute to its antimicrobial activity. Besides, certain minerals as zinc and copper can have antimicrobial properties. Furthermore, some other studies suggested that camel urine might have immune-modulating properties, helping to enhance the body's natural defenses against infections. While the research on the antimicrobial properties of camel urine is still ongoing, the findings suggest that it could be a potential source of natural antimicrobial agents. Further studies are

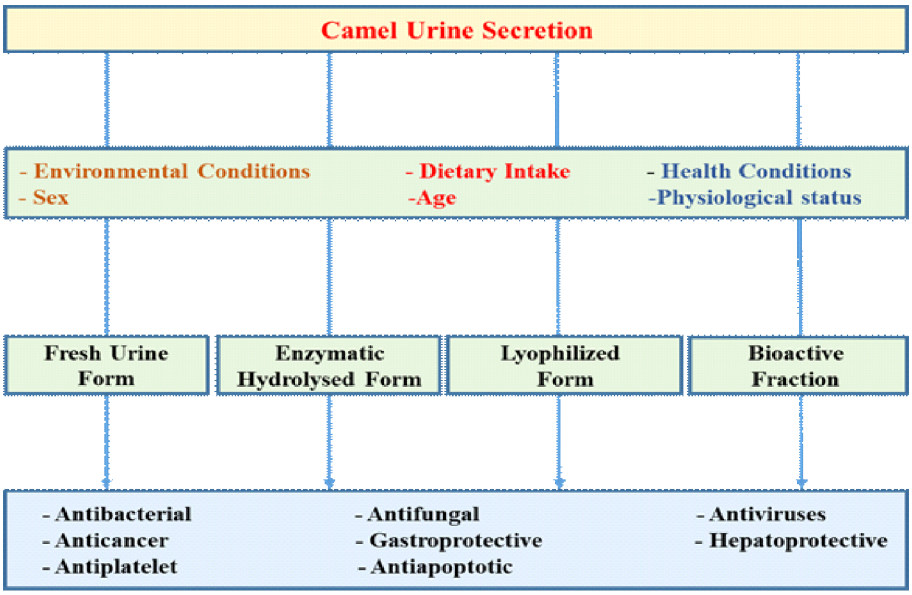


Fig 1: Factors effecting on camel urine secretion and its efficacy against pathogens and diseases.

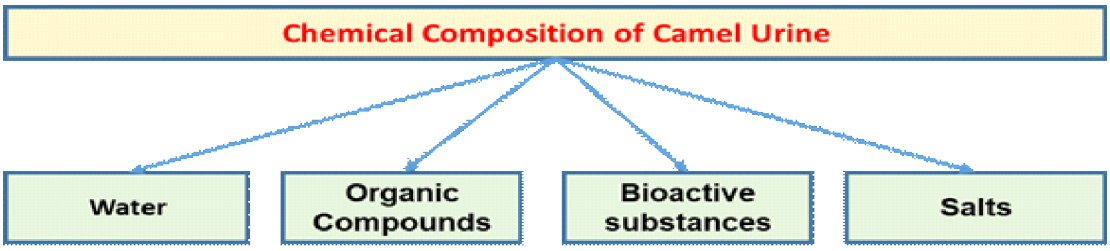


Fig 2: Chemical composition of camel urine.

needed to fully understand the mechanisms of action and to evaluate the safety and efficacy of camel urine-derived compounds for therapeutic applications.

While there is growing interest in the antimicrobial properties of camel urine, more research is still needed to fully understand its mechanisms of action and potential applications. The composition of camel urine can vary depending on factors such as the camel's diet, health and environmental conditions. This can make it challenging to standardize the production of camel urine-based products for medicinal use. Further studies are also required to assess the safety and potential toxicity of camel urine and its derivatives.

Hepatoprotective, gastroprotective and anticancer effectives of camel urine

Camel urine, especially in the Arabian Peninsula, has been consumed as a traditional remedy. Bedouins has been reported to drink approximately 100 ml of camel urine daily, either alone or mixed with camel milk (Al-Yousef *et al.,* 2012). Camel urine has been explored in traditional medicine and scientific studies for various health benefits, including hepatoprotective, gastroprotective and anti-cancer properties (Salamt *et al.,* 2021).

Camel urine has been explored for its potential hepatoprotective properties. Several studies have suggested that certain compounds in camel urine could contribute to hepatoprotective properties. Camel urine contains antioxidants that can help neutralize harmful free radicals and reducing oxidative stress on the liver (Mahmoud *et al.,* 2019; Al-Ghumlas *et al.,* 2023). Certain compounds in camel urine may have anti-inflammatory properties, which can help protect the liver from damage caused by inflammation (Al-Numair *et al.,* 2022). In addition, some studies suggest that camel urine may stimulate the growth of new liver cells, aiding in liver regeneration after injury (Ajiboye *et al.,* 2022; Hora and Wuestefeld 2023). While these findings are promising, more research is needed to fully understand the mechanisms behind the hepatoprotective effects of camel urine and to determine its safety and efficacy for treating liver diseases (Mahmoud *et al.,* 2019; Iglesias Pastrana *et al.,* 2022).

Camel urine exhibits a significant protection against a peptic ulcer. Some components in camel urine might enhance the protective mucus layer in the stomach, shielding it from damage against endogenous and exogenous ulcerogenic agents (Hu *et al.,* 2017). In addition, camel urine may help reduce the production of gastric acid, potentially protecting against ulcer conditions (Iglesias Pastrana *et al.,* 2022). The anti-inflammatory properties of camel urine may benefit the gastrointestinal tract. The healing properties of camel urine is attributed to the presence of antioxidants (Hu *et al.,* 2017). Trace elements present in camel urine such as zinc and magnesium were found to reduce oxidative stress and help prevent the tissue injury caused by a toxic agent (Shazia *et al.,* 2012).

Camel urine has been claimed to have health benefits for cancer patients. The Saudi Center for Medical Research revealed the possibility of producing a medical capsule containing camel urine for cancer treatment due to various promising therapeutic effects of camel urine in cancer cells (Ghamdi and Khorshid, 2012; Romli *et al.,* 2017). The CU anticancer effects were explored either *in vitro* or *in vivo* (Salamt *et al.,* 2021). The obtained results of studies concerning CU as anticancer agent were doubtful (Tharwat *et al.,* 2023). It has been suggested that camel urine might inhibit the growth and proliferation of cancer cells (Romli *et al.,* 2017). Some studies have indicated that camel urine may induce apoptosis, or programmed cell death in cancer cells *in vitro* (Al-Mutairi *et al.,* 2021). Camel urine samples with a <0.5 Osm/L osmolarity demonstrated significant antiproliferative effects in Caki-1 cells. There were two out of ten tested samples showed antiproliferative effects, suggesting that the bioactive compounds responsible for this activity might be present in specific camel urine samples or under certain conditions (Iglesias Pastrana *et al.,* 2024). Certain compounds in camel urine could potentially target specific signaling pathways involved in cancer development (Amina *et al.,* 2024a,b). Although the results of some findings were promising, several rigorous scientific studies are required to establish the definitive efficacy and safety of camel urine for anticancer purposes. In addition, there might be a risk of zoonotic infection from consuming camel urine (Al Zahrani *et al.,* 2023).

CONCLUSION

Camel urine was collected from different camel breeds and it was given different potential impacts against pathogens and diseases. Different forms of camel urine were given to patient people with hyperglycemic, hyperlipidemic, cancer, kidney and liver malfunctions and pathogen infections. The results gave wide ranges of camel urine activities against pathogens and diseases including antibacterial, antifungal and antiviruses activities in addition to hepatoprotective, gastroprotective and anti-cancer effectives. Further studies are required for improvement camel urine usage against pathogens and diseases in addition to the bioactive constituents against pathogens and diseases. Furthermore, further studies are also required to assess the safety and potential toxicity of camel urine and its derivatives.

ACKNOWLEDGEMENT

The authors want to thank and acknowledge Deanship of Scientific Research, King Faisal University, Saudi Arabia for funding and support (KFU242532).

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Conflict of interest

There is no conflict of interest for authors to declare.

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