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Review Article

The unique medicinal properties of camel products: A review of the scientific evidence

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الملخص

استُخدمت ألبان وأبوال الإبل كعلاجات في مناطق معينة من آسيا وأفريقيا منذ أزمنة قديمة، ولكن حديثا فقط أبدى العلماء اهتماما باستكشاف تلك المزاعم العلاجية لمنتجات الإبل. يشير عدد من الأدلة المخبرية وبعض الدراسات السريرية إلى أن ألبان الإبل وحدها، وفي بعض الحالات ممزوجة مع أبوال الإبل فعّالة في علاج حالات سريرية متنوعة مثل داء السكري، والسرطان، وحساسية الأطعمة، ومرض التوحد، والتهاب الكبد الفيروسي ومجموعة أخرى من الإصابات الفيروسية والبكتيرية والطفيلية. بالإضافة إلى ذلك، تم اكتشاف عدد من الآثار العلاجية المحتملة لألبان وأبوال الإبل على جهاز القلب والأوعية الدموية، وبخاصة عملها المضاد للصفائح الدموية والمذيب للفايبرين. العرض الحالي يمثل ملخصا موجزا للأدلة العلمية المساندة لهذه الآثار العلاجية.

الكلمات المفتاحية: ألبان الإبل؛ لبن الإبل والسكري؛ لبن الإبل والسرطان؛ غلوبولين الإبل المناعي؛ لاكتوفيرين

Abstract

Camel milk and urine have been used as medicines in certain parts of Asia and Africa since ancient times, but only recently have scientists shown interest in exploring the claimed therapeutic benefits of camel products. Significant evidence, drawn from laboratory and limited clinical studies, has shown that camel milk on its own and occasionally mixed with camel urine is effective in the management of diverse clinical conditions such as diabetes mellitus, cancer, food allergy, autism, viral hepatitis and a host of other viral, bacterial and parasitic infections. In addition, a number of potential benefits of camel milk and urine on the cardiovascular system, particularly their antiplatelet and fibrinolytic actions, have been demonstrated. The current review presents a concise summary of the scientific evidence to support these therapeutic actions.

Keywords: Camel immunoglobulins; Camel lactoferrin; Camel milk and cancer; Camel milk and diabetes

Abbreviations: CM, camel milk; DM, diabetes mellitus; HEPG2, hepatocellular carcinoma cell line; HCT 116, colon carcinoma cell line; U251, human glioma cell line; Cyp1a1, cytochrome P450 1a1 gene; LF, lactoferrin; HCV, hepatitis C virus

Introduction

The one-humped camel (*Camelus dromedaries*) is a unique animal that survives and reproduces under severe climatic conditions of heat and drought that do not suit the survival of other species of domestic mammals. For desert dwellers in Asia and Africa, the camel continues to be vital to daily life as a source of food and a means of transportation, and just as importantly, its milk and urine have been used as medicines for diverse ailments since ancient times.[1,2] However,

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beginning in the early 1980s, more orthodox publications began identifying specific diseases and medical conditions that have been treated by camel milk or urine, including cancer,[3] chronic hepatitis,[4] hepatitis C infection[5,6] and peptic ulcers.[7] Even more recently, it has been reported that camel milk has cured severe food allergies in children who were unresponsive to conventional treatments[8] and diabetes mellitus.[9] Furthermore, camel milk is endowed with anti-malignant,[10] antiplatelet[11] and anti-thrombotic properties[12] in addition to a host of anti-bacterial and viral properties,[13,14] suggesting, among other things, the existence of a very strong immune system, which was recently shown to be equipped with unique light-chain-only antibodies.[15]

These claimed therapeutic actions have recently been the subject of numerous studies, and there is now mounting scientific information detailing the constituents of camel milk and urine as well as their therapeutic components. These revelations lend scientific evidence to support the current practice of using these camel products for their therapeutic benefits. The following review summarizes the current knowledge in these areas.

Anti-diabetic action of camel milk

Diabetes mellitus (DM) is characterized by abnormally high blood glucose levels, resulting from low insulin secretion and/or increased insulin resistance.[16] DM and its complications have become a main focus of interest for researchers worldwide due to their close association with the risk of cerebrovascular and cardiovascular disorders, which were noted in 68% of diabetes-related deaths among patients aged 65 years or older.[17,18] Today, the management of DM remains a great challenge for treating physicians.

In addition to the conventional diabetic management strategies of diet, insulin, oral hypoglycaemic drugs, and exercise, diabetes has also received attention because of the current wide interest in alternative therapies for chronic incurable diseases. In this respect, there is mounting evidence that camel milk (CM) consumption is effective in the control of DM in both humans[9,19–21] and experimental animals.[22,23] Strong support for this notion comes from camel breeders in India who consume CM regularly and who have zero incidence of DM compared to 5.5 percent in other communities in which CM is not consumed.[20] Additional support comes from the more recent finding that the consumption of CM by type I diabetic patients resulted in a 30–35% reduction in the daily insulin requirements, with significant decreases in both blood glucose levels and micro-albuminuria.[9]

These benefits can be related in part to the unique composition of CM, which is rich in insulin, insulin-like proteins,[24] minerals, immunoglobulins[25] and trace elements with anti-inflammatory properties. Additionally, CM possesses antioxidants and free radical scavengers.[26–28] Further, camel insulin possesses unique features that make it different from human and other animal insulin and more effective when orally administered. Camel insulin, unlike the insulin contained within other animal and human milks, is contained within micelles and is thus protected from digestion and proteolysis in the upper gastrointestinal tract; it has also been proposed that camel insulin is encapsulated in nanoparticles that facilitate its absorption and easy passing to the blood stream.[24] An added advantage of camel milk consumption by diabetic patients was discovered in recent renal functional and genetic studies in diabetic animals showing that camel milk has renal protection actions that prevent the renal damage associated with diabetes, as it attenuates the biochemical and morphological features of diabetic nephropathy in these diabetic animals.[26] It is also plausible that the antioxidant action of CM prevents the manifestations of metabolic syndrome, including hyperglycaemia, hyperlipidaemia, and insulin resistance. This, in turn, would inhibit the pathophysiological processes underlying the microvascular complications of DM, including retinopathy, nephropathy or cardiovascular complications that heighten the mortality and morbidity of the disease.[9,21,28]

The above findings lend strong support to the beneficial effect of CM as a nutritional supplement and therapeutic adjuvant in the management of DM. In addition to the established hypoglycaemic benefit, CM treatment is expected to achieve the nephrologists' goal of renal protection.

Anti-cancer action of camel milk

The claimed anti-cancer action of camel products is widely accepted by local healers who use of a mixture of camel milk and urine in the treatment of patients suffering from a variety of cancers, including breast, nasopharyngeal, lung and others. This, in addition to the difficulties faced by modern medicine in finding a lasting cure for cancer, prompted the current flurry of studies attempting to find evidence to support these claimed anti-cancer actions of camel milk and urine and eventually succeed in identifying the anti-malignant component in camel milk or urine that could ultimately lead to the discovery of an effective anti-cancer drug.

In a series of *in vitro* experiments, a research group led by Dr Fatin Khorshid succeeded in demonstrating that lyophilized camel urine stopped the growth of tumour cells implanted into experimental animals and the growth of malignant cell lines including hepatocellular carcinoma (HEPG2), colon carcinoma (HCT 116), human glioma (U251) cells, lung cancer cells and leukaemic cells. She suggested that this anti-cancer action could be both a direct cell cytotoxicity and cutting blood supply to tumour cells, i.e., anti-angiogenic action.[29–32] The latter action of camel urine was recently confirmed by our group. In a series of recent experiments we have demonstrated that both camel urine[33] and milk,[34] each on its own, inhibited inflammatory angiogenesis in the murine sponge implant angiogenesis model. Further support for the anti-cancer action of camel urine comes from the observations of Alhaider et al.[35] that camel urine causes significant inhibition of the expression of the gene encoding carcinogen-activating enzyme Cyp1a1 at the mRNA level in cancerous liver cells. Similar, apoptotic anti-cancer action has also been demonstrated in camel milk.[36] To date, the exact nature of the anti-malignant constituents in camel milk or urine have not been identified, although the iron binding, multi-tasking and multi-functional protein lactoferrin (LF) is believed to be a possible candidate.[37]

Interestingly, studies in patients with colorectal cancer found that the administration of LF along with chemotherapy resulted in better prognosis than chemotherapy alone[38] and that LF inhibited the growth of adenomatous colorectal polyps in human patients.[39] In line with these revelations, LF has also been shown to be directly cytotoxic against cancer cells by inducing the inhibition of the proliferation of cancer cells and their subsequent programmed cells death (apoptosis).[40] Detailed evidence drawn from laboratory and clinical studies on the actions of LF, which were reviewed recently,[41] have confirmed that the ingestion of LF resulted in the inhibition of tumour growth and induced apoptosis and the metastasis of tumour cells by both anti-angiogenic and cytotoxic actions. However, almost all of these studies were performed using the commercially available bovine LF, with the exception of a few in which camel LF was used.[27] Therefore, further research is needed to confirm these findings using camel LF, which is reported to be more potent than bovine LF.[27]

Finally, it is becoming clear that the local healers' practice of prescribing milk along with urine has a double advantage as both products are endowed with anti-cancer actions; additionally, the milk disguises the identity and taste of the urine and makes its consumption palatable to the patient.

Chronic hepatitis and hepatitis C infection

The early observations of Sharmanov et al., in 1982[4] were the first to suggest an anti-viral action of camel milk when they found that camel's milk was more effective than mare's milk in improving and normalizing the clinical and biochemical status of patients with chronic active hepatitis. Later observations using camel urine therapy in patients with Bilharzial liver disease supported this finding, as significant improvement was noted in the clinical condition of these patients with marked resolution of the ascites and morphological changes of the cirrhotic liver.[42] Subsequent studies have shown that camel lactoferrin markedly inhibits hepatitis C virus genotype 4 infection of human peripheral blood leukocytes and that the incubation of human leucocytes with camel LF followed by their infection with HCV prevented the entry of the virus into the cells. The conclusion was that the direct interaction between the HCV and camel LF led to complete inhibition of virus entry into the cells; in this respect camel lactoferrin proved to be a more potent anti-viral agent than bovine and human lactoferrins.[5] Additionally, camel milk administration clears *Schistosoma Mansoni* from infected mice, thereby indicating a further beneficial anti-parasitic action of camel milk.[43]

Food allergies and other therapeutic benefits of camel milk

In addition to the diseases described above, numerous small studies have reported diverse therapeutic benefits of camel milk. For example, a group of children with severe food (mainly milk) allergies who failed to respond to all modern therapies recovered fully after the daily administration of camel milk.[8] This finding confirms further the unique immune properties of camel milk, which are also believed to be the basis for its efficacy in the treatment of viral and bacterial infections.[14] Relevant to the immune properties of camel milk, camel whey protein was shown to be effective in enhancing wound healing in the diabetic mouse model by mobilizing a wide range of cellular immune responses as well as cytokines.[44,45]

Camel milk supplementation was reported to cause significant improvement in the clinical symptoms and investigative tests of patients suffering from drug-resistant tuberculosis.[46] Similar therapeutic benefit was also shown in children with autism (autism spectral disorders, ASD).[47–49] The consumption of CM by sufferers of autism resulted in the disappearance of autism symptoms in some cases or caused significant improvement in these symptoms; patients became quieter and less destructive and showed better emotional expression and communication.

Finally, recent studies from our laboratory have shown that camel milk and urine possess potent cardiovascular actions. In separate *in vitro* experiments, it was shown that camel urine has potent platelet blocking properties similar to the actions of the widely used anti-platelet drugs, aspirin and clopidogrel.[11] An earlier study[50] has shown that lactoferrin isolated from sheep and human lactoferrin inhibit thrombin-induced aggregation; however, we could not confirm this observation using human lactoferrin. Our ongoing efforts are approaching the identification of the probable dual-platelet inhibitor in camel urine.

Conversely, camel milk was also shown to have potential thrombolytic action, as it causes marked reduction in plasma fibrinogen in diabetic rats.[12] The significance of this observation, added to the observed antiplatelet action mentioned above, provides strong support for the claimed anti-cancer properties of camel milk and urine, as the inhibition of coagulation and fibrin formation would hinder the spread and growth of metastatic tumour cells. These and other reported benefits of camel milk and urine were drawn from small laboratory studies and should trigger engagement in larger controlled trails in patients.

The possible therapeutic candidate(s) in camel milk

Judging by the currently accumulated scientific evidence, there are two possible candidates: *Lactoferrin* and *Camel Immunogloloulins*.

Lactoferrin

Camel milk is rich in lactoferrin with potent antimicrobial and anti-inflammatory properties, including bacterial inhibition (*Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, clostridium and Helicobacter pylori)*, antiviral effects (*HBC,CMV, herpes simplex virus-1, and human immunodeficiency virus (HIV, the virus responsible for AIDS)*), antifungal effects (*Candida albicans)*, immunosupportive and immunomodulating functions (*regulates the maturation and activation of neutrophils and macrophages)*, the maturation and function of lymphocytes *(antioxidant and anti-inflammatory)* and anti-cancer actions.[27,37]

Camel immunoglobulins

The medicinal properties of both camel milk and urine could also be related to the gamma globulins and other immune components, including immunoglobulins, present in both products.[25,51] For example, half of the circulating antibodies in camel blood consist of only two heavy chains and no light chains.[15] Because of their reduced size, one-tenth the size of human antibodies, these antibodies can readily pass to the milk of the lactating camel, can pass the blood brain barrier, can be filtered in urine, and are readily absorbed from the gut into the general circulation of consumers of camel milk and/or urine. In addition, the single antigen-binding domains (VHH) of these heavy-chain antibodies—also known as *nanobodies—may* have applications in cancer diagnosis and therapy and biosensor development.[52] Recently, the unique features of the camel immune system and its possible health benefits to humans has been put into practical use by a Belgian biotechnology company (Ablynx nv, Technologiepark, 219052, Ghent/Zwijnaarde, Belgium) that is using animals of the camelid family (camels and Llama) as the source of targeted immune therapy for cancer and other autoimmune disease such as multiple sclerosis and Alzheimer's disease.

Additionally, it is important to add that reports of the therapeutic benefits associated with bovine milk consumption add credibility to the idea that camel milk would have similar benefits. Bovine milk proteins are known to serve as precursors for numerous biologically active peptides encrypted within major milk proteins, and these are activated by gastrointestinal digestion or food processing.[53] Bovine milk peptides have also been shown to exhibit antimicrobial, antioxidant, antithrombotic, antihypertensive, and immunomodulatory actions.[54,55]

As to the cardiovascular action of camel urine[11,56] mentioned above, the identity of the dual human platelet inhibitor with actions similar to both aspirin and clopidogrel is being studied, and these efforts are approaching their conclusion in our centre. Although this platelet inhibitory activity was observed in camel urine, earlier studies identified this activity in camel plasma,[57,58] where it was thought to be a natural defence mechanism against thrombotic disease, which camels are at risk to develop due to excessive exposure to environmental heat and drought.[59]

Finally, while knowledge about camels was traditionally restricted to limited geographical areas, particularly Asia, Africa and Australia, the use of camel's milk as a nutrient and for its health benefits was further confined to only certain Asian and African countries. Cow's milk, conversely, has been consumed worldwide. However, as cross-cultural migration of humans increased during the 20th century, knowledge about camels and their milk started to reach countries beyond Asia and Africa. This culminated in 2013 when the European Community licenced the importation of camel milk from the United Arab Emirates (UAE). The main and perhaps only current supplier of camel milk is the Dubai-based Emirates Industry for Camel Milk and Products (EICMP), which manufactures its trademark camel milk, *Camelicious*, which is now on sale in numerous European countries, particularly The Netherlands, Denmark and England. Another chocolate manufacturer, Al Nassma, is selling its camel milk chocolate in London's world-famous upscale department store Harrods. This increased popularity of camel milk among Europeans is likely due to the prior knowledge of the unique nutritional value and possible health benefits of camel milk compared to the more widely consumed cow's milk.

Conclusion

The long-standing practice of using camel milk and urine for medicinal purposes in the Middle East, parts of Africa and Asia, and the former Soviet Union was without scientific rationale for centuries. However, based on the existing information about bovine milk as a functional food, camel milk, in a similar way, could serve not only as a source of nutrients but also as a source of bioactive agents with therapeutic properties. The current scientific evidence for the therapeutic actions of camel milk continues to unfold, and efforts are underway to more precisely identify the therapeutic constituents. Thus, the camel is already proving to be 'a goldmine' for researchers.

Conflict of interest

The authors declare no conflict of interest in the conduct of this research.

Authors' contributions

We confirm that both the authors (AG and AA) whose names feature in this article have contributed equally and substantially to the conception of this study, provided research material, read and revised this review manuscript critically and gave approval to the final draft and are responsible for the contents and the submission of the manuscript for publication.

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