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Review Article

The unique effects of camel milk as adjunctive super food on the health

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ABSTRACT

Currently, the importance of camel milk has been emphasized around the world base on its health properties. Recently, consumers' interest in camel milk has been largely due to awareness of its special health benefits. Camel milk is a unique source of nutrients and is considered as a super food with medicinal values. Smaller size of nobodies of camel milk enhances the immune and anti-inflammation responses. Also higher amount of zinc in the camel milk has key role for maintenance of normal function of immune system. Camel milk has hypoglycemic effects which may be beneficial in the healing of diabetes due to presence of insulin like protein. Camel milk vitamin C as strong anti-oxidant is higher than cow milk. Also camel milk has the highest amount of lactoferrin with anti-viral and anti-bacterial properties against infections. Camel milk has unique benefits for human health and plays an important role in improving diabetes, gastrointestinal disorders, food allergies, hepatitis, cancer, cardiovascular disease, hypertension and autism. Also it has antioxidant, anti-inflammatory, antimicrobial, immune stimulant and allergenic properties. Therefore, camel milk is recommended as adjunctive super food for healthy complications.

Key words: Camel Milk, super food, health

INTRODUCTION

Camel milk is a unique source of nutrients. It contains fat, cholesterol, lactose, proteins, minerals and vitamins. Calcium, magnesium, iron, copper, zinc and vitamins C in camel milk are higher than cow milk. Smaller size of camel milk nobodies stimulates the immune responses and prevent food allergy (Shabo & Yagil, 2005). Also camel milk contains no *β*-lactoglobulin and low *β*-casein as allergic proteins (Shabo & Yagil, 2005). Protective proteins of camel milk including lactoferrin, lactoperoxidase, lysozymes, immunoglobulins, N-acetyl-§-glycosaminidases and peptidoglycan recognition (Shabo & Yagil, 2005).

It is proved that antibodies of camel milk could be effective against cancer cells, HIV, Alzheimer's and hepatitis C (Shabo & Yagil, 2005; Habib *et al.*,

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2013). Vitamin C of camel milk is about 40 to 50 mg/kg in compared to cow milk (10 mg/kg).
Camel milk exhibits hypoglycemic effects, due to insulin like protein, which can be beneficial for diabetic cases and their complications and heart failures (Shori, 2015). Also camel milk has the greatest amount of lactoferrin against viral and bacterial infections (Mohammadabadi et al., 2018). Camel milk has unique benefits for human health and plays a special role in improving diabetes, gastrointestinal disorders, food allergies, hepatitis, cancer, cardiovascular disease, hypertension and autism. Also it has anti-inflammatory, antimicrobial and immune stimulant properties (Alhaji et al., 2020).Camel milk lactic acid bacteria are important probiotic for the gut health (Yateem *et al.,* 2008). This review represents camel milk as adjunctive therapeutic supplement according to the scientific researches.

Anti-microbial effects

Camel milk contains various protective proteins with antimicrobial and immunological properties (Farah, 1993). Camel milk Igs combat autoimmune diseases by strengthens the immune system (Muylderman *et al*., 2001) and protects the body against microbial and viral infections (Galali & Al-Dmoor, 2019). Lysozymes that invade pathogens and damages the bacterial cell wall and enhances immune system (Conesa *et al.,* 2008). Lysozymes are usually specialized in enhancing immunity against pathogens but immunoglobulins are related to body infections (Jilo, 2016).

Lactoferrin that inhibit microbial growth (Gizachew *et al.,* 2014). Camel milk contains lactoferrin much more than other ruminant milk (95 to 250 $ml.dl^{-1}$) which may inhibit the infectious microbe's growth (Morin *et al.,* 1995).The N-lobe of lactoferrin is proved to be responsible for camel milk antimicrobial activity (Sharma et al., 2013).

Lactoperoxidase of camel milk is about 2.23 ± 0.01 $U.ml^{-1}$ of milk (Galali and Al-Dmoor, 2019) has bactericidal activity on gram negatives bacteria. Peptidoglycan recognition protein which only is found in the camel milk, stimulate the host's immune response (Gizachew *et al.,* 2014) which acts as protective antibiotic protein and inactivate the pathogenic bacteria by binding to the peptidoglycan structures of the bacterial cell wall (Abd El-Salam and El-Shibiny, 2013).

Camel whey proteins such as lysozyme, LF, LPO, and some Igs have antibacterial effects against gram-positive and negative bacteriaand viruses. They inhibited *Lactococcus lactis*, *Escherichia coli, Staphylococcus aureus* and rotavirus. *Salmonella typhimurium* growth prevented due to bacteriostatic effect of LF by binding to necessary iron for bacterial growth (Badr et al., 2017). Lactoferrin has the most antiviral activity between all components of camel milk. The casein macropeptide derived from hydrolysis of κ-casien has antimicrobial function and inhibit bacterial and viral adhesion, improve the *Bifidobacteria* growth modulate immunity (Dziuba and Dziuba, 2014).

It is indicated that camel milk has beneficial effects on tuberculosis patients and improvement of symptoms with multidrugs resistance (Alwan and Tarhuni, 2000). In addition, immunoglobulins of camel milk may be effective on Crohn's disease due boosting the immune system (Kaskous *et al.,* 2016). Lactoferrin of camel milk as strong anti-virus agent inhibits the virus entry into the host cells. Lactoferrin and Immunogloloulins of camel milk have the most therapeutic properiteis (Rasheed, 2017).

The high lactoferrin of camel milk inhibit virus entry and its innatiory drug against HCV infections (Redwan & Tabll, 2007). In addition, camel milk inhibits the replication of virus DNA of hepatitis B (Saltanat *et al.,* 2009) and HCV entry and replication more than lactoferrin of human, bovine, and sheep. Camel lactoferrin neutralizes intracellular HCV and reduce HCV replication in infected cells (Badr et al., 2017).

Milk lactoferrin can modulate immune responses to viral infections by binding to virus particles or receptors and may acts against viral attacks and reduce the severe infections, so it could be an adjunct treatment for more severe cases of COVID-19 (Mohammadabadi &Hussain, 2021).

Anti-diabetes effects

Content of camel milk insulin (52 units/liter and mean is 40.5 ± 10.7 μU/ ml) is greater than cow milk (16.32±5.98 micro u/ ml) but lower than human milk insulin (60.23±41.05 micro u/ml), (El Agamy 2006). Camel milk insulin might be microencapsulated by nanolipids of camel milk (Malik et al., 2012), therefore, it doesn't coagulate in the acidic condition of the stomach and is protected from proteolysis in the intestine in comparison to other mammalian (Abdel Galil et al., 2016). Insulin like proteins of camel milk will be available for absorption in the intestine (Mohamad *et al*., 2009).

Camel milk improves diabetes complications such as wounds, kidney and liver failures and oxidative stress (Agrawal *et al.,* 2007). Camel milk controls the blood glucose by some mechanisms including effect on insulin receptors activity, increasing of the signaling in the insulin-sensitive tissues, effect on the pancreatic beta-cells function, inhibition of glucagon receptors, activation of GLUT4 in the

cells, inhibition of DPP-IV enzyme and activating of GIP/GLP-1 and increase insulin secretions (Ayoub *et al*., 2018). Raw camel milk in type 1 diabetes patients caused to increase insulin secretion, reduce required insulin (about 30–35%), preparing 60% insulin in the diabetic patients, reduce insulin resistance, therefore reduce blood sugar and improve the glycemic control (Fallah et al 2019). Camel milk has positive effects on incretins hormones, inflammatory cytokines and boosting immune functions in diabetes subjects (Ebaid et al 2014). The anti-oxidative activity and anti-microbial properties of camel milk whey proteins enhances the proliferation of immune cells, improve the wound healing process during diabetes, improves kidney and liver function and cardiovascular challenges in type 1 and 2 diabetes mellitus (Molitch *et al.,* 2004; Aqiba *et al.,* 2019). Therefore, even if camel milk has significant effects in decreasing of blood glucose and improve diabetes problems, but more scientific studies are needed to confirm the effectiveness of camel milk for the treatment of diabetes.

Autism

Camel milk decreases oxidative stress and improve behaviors of autistic cases by alteration of antioxidant enzymes and nonenzymatic antioxidant. Also using of camel milk in autistic subjects elevated motor skills, language and social communication and behavior (Panwar *et al.,* 2015) (Al-Ayadhi & Elamin, 2013).

High amount of vitamin C, copper, zinc, iron and magnesium as strong antioxidants is found in the Camel milk (Kaskous, 2016). Recovering of the autistic cases by camel milk could contribute to decreasing oxidative stress due to these antioxidants (Al-Ayadhi & Elamin 2013). Camel milk has inflammation-inhibiting and hypoallergenic properties and smaller size of antibodies of which may treat gastrointestinal failures and improve some autistic behaviors (Rasheed, 2011).Badr et al (2017) reported camel whey protein exhibits higher antioxidant activities than bovine whey proteins in decreasing of lipid peroxidation and considerably increase glutathione levels in the tissues and reduces inflammation and oxidative stress. Also, proteins hydrolysates of camel milk have greater antioxidant activity compared to bovine milk proteins (Maqsood et al., 2019).

Food allergies and skin issues

Camel milk is proper protein source for allergic children to cow's milk (Panwar *et al.,* 2015) due to lacks β−lactoglobulin and low amount of β-casein and improved severe food allergies (Restani *et al.,* 1999). Additionally, immunoglobulin's camel milk improves allergic reactions to foods. About 25% of allergic cases to cow milk, had allergies to camel milk (Katz *et al.* 2008). Lactose intolerance cases can digest camel milk with minimal symptoms (Kaskous, 2016).

Camel milk contains α-hydroxyl acids which shed skin dead cells and have important role to wrinkles, spots and dryness of skin (Panwar *et al.,* 2015). In addition, liposomes of camel milk are beneficial for cosmetic ingredient (Choi *et al.,* 2013). High vitamin C in the camel milk has protective and healer activity on skin issues against free radicals; wrinkles and dryness (Jilo & Tegegne, 2016). Some bioactive peptides of camel milk are as natural anti-oxidants (Salami *et al.,* 2011; Yagil, 2017).

Anti-cancer and anti-inflammatory factor

High amounts of immunoglobulins and lactoferrins are antitumor due to increasing RNA synthesis and the inhibition of protein kinases (Galali & Al-Dmoor, 2019). It is proved that camel milk stops cancer cells through the activation of apoptotic pathways (Galali & Al-Dmoor, 2019). It inhibited the proliferation of cancer cells by 50% via activation of caspase-3 mRNA (Korashy *et al.,* 2012) and inhibitory activity of DNA damage (Habib *et al.,* 2013). Camel milk lactoferrin reduced cancer growth by 56% (Habib *et al.,* 2013). Camel milk can remove cancer cells of hepatic, colon, lung, glioma cells and leukemia Gader and Alhaider (2016) and destroy tumor cells (Levy *et al.,* 2013). Camel milk lactoferrin is able to reduce carcinogenesis by altering activating proteins,induction of cell apoptosis, and activation of natural killer cells (Keykanlu et al., 2016).

Gut disorders

Lactose-intolerant patients easily digest camel milk (Mullaicharam, 2014). The reason is high concentration L-Lactate in camel milk in compared to cow milk that is rich in D-Lactate (Baubekova *et al.,* 2015). Cardoso et al (2010) determined camel's milk can be consumed by lactose intolerant patients without undesirable responses. Reactions to camel's milk were milder, in compared to cow's milk. This increase of β-galactosidase production by the colonic flora increases the amount of lactic acid and reduce short-chain fatty acids, hydrogen and carbon dioxide, and symptoms (Cardoso et al 2010).

Camel milk seems more easily metabolized and has less effect on lactose intolerance problem than cow milk (Cardoso *et al*, 2010). One reason is maybe camel milk produces less casomorphine, which would cause more exposing of lactose to lactase for digestion (Racinet *et al*, 2013).

High amount of anti-inflammatory proteins of camel milk has proper effects on the stomach and intestinal issues. Camel milk has anti-diarrhea properties in the children due to high level anti-rotavirus antibodies (Yagil, 2013). High β-LG, Half-cystine, lactoferrin, casein macropeptide, α-LA, glycomacropeptide and antimicrobial peptides of camel milk promote the proliferation of *Bifidobacterium* species and inhibit gastrointestinal bacterial infections (Kakous, 2016**).**

Cardiovascular diseases

Maybe, the interaction between bioactive peptides of camel milk and cholesterol cause to hypocholesterolemic effects (Li and Papadopoulos, 1998). The presence of orotic acid is responsible for the lowering of cholesterol amount by camel milk (Kaskous, 2016). Reduction of 1% in cholesterol reduces the risk of cardiovascular diseases by 2–3% (Manson et al., 1992). The administration of camel milk for 45 days significantly decreased hyperlipidemia; total cholesterol, triacylglycerol's, free fatty acid, LDL, and VLDL in plasma, liver, heart and kidney towards normal levels (Al-Numair 2010). Also camel milk for 5 weeks had significant decrease in the total cholesterol from 6.17 to 4.35 m mol.l^{-1} (Shori, 2015). Hypocholesterolemic effect of fermented camel milk or Gariss reported by Ali *et al.,* 2013). Using of camel milk for 6 months, the reduced LDL and triacylglycerol's in type 1 diabetic case (Agrawal *et al.*, 2009).

Probiotic bacteria may interfere with cholesterol absorption from the intestine by de conjugating bile salts and preventing reabsorption (Alhaji et al., 2010). Hypocholesterolaemic peptides have been result in cholesterol reduction by binding to cholesterol or by reducing the micellar solubility of cholesterol and inhibiting cholesterol absorption (Nagaoka et al., 2001).

Casein hydrolysates produced by Bb12 culture or trypsin significantly reduced cholesterol levels (24–87%). Fermented camel milk has inhibitory peptides of angiotensin I-converting enzyme (ACE) that which produced by proteolytic digestion of casein and whey protein that regulate blood pressure (Alhaji et al., 2010).

Camel milk as raw, fresh and pasteurized form has an important role in the healing of human serious diseases, because it containing protective proteins such as lactoferrin, immunoglobulins and lactoperoxidase. Camel milk is effective on diabetes, food allergies, cancer, hepatitis, autism and enhances the immune system. It needs to do more studies to prove therapeutic efficacy of camel milk.

Table 1. The published researches on some health effects of camel milk

	Dose, Case, populations, period	Results	References
Anti-diabetic	500 ml raw camel milk, 24 humans for 3 months type I diabetes	significant improvement in fasting blood sugar and HbA1c significant reduction in insulin requirement no statistically significant changes in lipid profile, plasma insulin and c peptide	Agrawal et al (2003)
	500 ml raw camel milk, 24 humans, 52 weeks type I diabetes	improvement in fasting blood sugar and HbA1c significant reduction in the mean doses of insulin Fasting plasma insulin and C-peptide levels did not change Anti-insulin antibody titers were less than 10% even after 1 year	Agrawal et al (2005)
	500 ml raw camel milk, 24 human 6 month type 1 diabetes	significant improvement in the micro albuminuria A significant reduction in the mean dose of insulin	Agrawal et al (2009)
	500 ml camel milk, 24 type 1 diabetics, 2-year	decrease in mean blood glucose, hemoglobin A1c, levels and insulin doses insulin requirement in 3 subjects reduced to zero	Agrawal et al (2011)
	500 ml raw camel milk,54 type 1 diabetics 16-week (average age 20 years)	fasting blood sugar, HbA1c serum anti-insulin, urinary albumin excretion , daily insulin dose and C-peptide levels were markedly higher in the camel milk group	Mohamad et al (2009)

	500 ml raw camel milk, 50 type 1 diabetes for three months	significant improvements in FBG PBG HbA1c % significant reduction in insulin requirement significant decrease in FBG, PBG and HbA1c% significant decrease in TGs , Tc and LDLc significant increase in HDLc Nausea, flatulence and mild diarrhea was reported by four patients	El Sayed et al (2011)
	30 type 1 diabetic patients have been evaluated for 12 months. 0.5 L/day of raw dromedary's camel milk that was consumed by 250 ml twice/day in the morning and evening.	significant reduction in insulin dosages fasting blood sugar was reduced by 67% postprandial blood sugar was reduced by 65%	Abdalla et al.,2018
	20 patients with T2DM 20 to 70 years of age, 500 mL camel milk for two months. Camel milk was pasteurized at 70°C for 15 minutes, preserved in a refrigerator at 4°C,	Mean of insulin concentration was significantly increased No significant differences were shown in fasting blood sugar, lipid profile, and blood pressure There was significant increase in insulin resistance (HOMA-IR) Insulin concentration was significantly increased in the camel milk group A significant reduction was shown in systolic blood pressure only in the cow milk group	Ejtehad et al (2015)
	adolescents (fulfilling MetS criteria, aged 11–18 years) 250 mL fermented camel milk for 8 weeks	The study also resulted in non-significant mean reduction in DBP nonsignificant mean reduction in IL6 and nonsignificant increase in glucose metabolizing hormones such as GIP and GLP1 . Nonsignificant decrease was observed in TNF The changes of FBS, fasting insulin, and insulin resistance indices were not statistically significant	Fallah et al (2019)
Autism	60 subjects with ASD, especially those with known allergies or food intolerances, aged 2–12 years. 500 mL of camel milk in their children's regular daily diet for a period of 2 weeks.	Plasma GSH levels were significantly increased following 2 weeks of camel milk consumption. In addition, plasma levels of SOD demonstrated no significant differences glutathione peroxidase, superoxide dismutase, and myeloperoxidase significantly increased 2 weeks after camel milk consumption. There was a significant elevation of myeloperoxidase in children fed on camel milk, showed less oxidative stress at the end of two weeks, antioxidant activity increased and improvement in behavioral and cognitive tests observed	Al-Ayadhi and Elamin (2013)
	Autistic kid that diagnosed at 3 years of age, camel milk was used at 9 years of age. for 6 consecutive years.	Daily consuming 4 oz of camel milk, rapid improvement in behavior and motor skills observed. by increasing the camel milk to 8 oz, pragmatic language and vocabulary skills were improved and other academic skills were above average.	Adams (2013)

		Consumption of camel milk continued that was associated with improvements in autism symptoms for 6 consecutive years.	
	A 4-year-old girl suffering from autism disease, after 40 days of drinking camel milk, her autism symptoms disappeared; A 15-year-old boy was healed after a 30-day intake of camel milk from his illness (autism);	autism symptoms disappeared; they were observed to be quieter and less self-injurious. camel milk significantly improved symptoms of autism severity	Yagill (2013)
	In a hostel for autistic youths, 21-year-olds consumed camel milk for 2 weeks		
Anti hepatitis	an early clinical study on 18 HCV-positive patients who were given natural camel milk	88% showed improvements in alanine aminotransferase (ALT) and/or aspartate aminotransferase (AST). In addition, 50% of the patients showed marked improvement in fatigue (personal communication).	Redwan and Tabll (2007)
Skin care	The application of camel milk crème containing 40% raw camel milk when 20 patients with psoriasis were treated with 2 x camel milk crème for 4 weeks, daily	very good results in psoriasis patients Itching, skin redness and dryness reduced	Wernery, (2006)
Lactose intolerance	Twenty-five patients (six males, between 2 and 68 years old) with clinical and laboratorial diagnosis of lactose intolerance , 250 mL camel's milk.	Except for two patients, who had mild reactions to the maximum dosage of camel's milk the acceptance was excellent. Also, most of the patients showed significant clinical reactions when drinking very low amounts of cow's milk	Cardoso et al (2010)
Food allergy	clinical study on 35 children aged 6–126	Children could safely consume camel milk as an alternative without any reaction	Ehlayel et al. (2011)

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