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Research article

Camel milk; A potent superfood for diabetes complications

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Abstract

Currently, camel milk has been considered around the world due to awareness of its unique health benefits. Camel milk is considered a superfood with special nutrients and therapeutic values. In diabetes or hyperglycemia, the cells may not respond properly to insulin or defects in insulin secretion by the pancreas, therefore glucose level of blood is excessive. Chronic hyperglycemia is associated with dysfunction in the eyes, heart, nerves, kidneys, liver, and blood vessels. Insulin and oral hypoglycemic drugs are used for diabetes, but a high percentage of patients cannot use allopathic drugs and rely on natural alternative healings. Furthermore, coagulation of oral insulin in an acidic environment neutralizes and decreases the efficacy of insulin. Camel milk contains insulin-like proteins and may be an effective alternative for insulin to treat type 1 and 2 and gestational diabetes. Camel milk may prepare about 60% of the insulin in diabetic patients and reduce blood sugar and required insulin doses of about 30% - 35% in type 1 diabetes patients. This milk is believed to be a suitable hypoglycemic agent in improving long-term glycemic control in experimental animals and diabetic patients, as well as improving diabetes risk factors such as liver and kidney failures and cardiovascular challenges. It appears that more scientific studies are needed to confirm the efficacy of processed camel milk on diabetes. This review represents scientific studies on how camel milk as a superfood can be effective in diabetes.

Introduction

Camels are the fifth largest dairy animals in the world after cow, buffalo, goat, and sheep; producing approximately 2.91 million tons of milk per year, which is equivalent to 0.36% of the world's milk production [1]. Age, geographical area, pregnancy, nutrition, seasonal changes, health, and genetics affect the composition of camel milk [2]. The average fat content of camel milk was 3.82%, protein 3.35%, and lactose 4.12 %. Also in another study, the chemical composition of camel milk including 3.4% protein, 3.5% fat, 4.4% lactose, 0.79% ash, 7.9% total solids, and 87% water was reported [3]. The average fat is 1.2 and 6.4 % and the amount of short-chain fatty acids is low; But the levels of long-chain fatty acids, linoleic acid, and unsaturated fatty acids which are important for nutrition and health, are high (Zibaee, et al. 2015). Triacylglycerols of camel milk contain 66.1% saturated fatty acids and 30.5% unsaturated fatty acids. The unsaturated to saturated fatty acids ratio in camel's milk is more favorable compared to cows and other mammalians [4].

Camel milk has a high amount of unsaturated fatty acids, immunoglobulin, insulin-like protein, and protective enzymes like lactoferrin and lysozyme [1]. Camel milk contains insulin-like protein and may help to heal diabetes of type 1 and 2 and gestational diabetes. According to the studies, camel milk contains insulin-like proteins that do not form a coagulum in the acidic condition of the stomach, can be absorbed from the intestine, and may be an effective alternative for insulin to treat type 1 and 2 and gestational diabetes. Raw camel milk has immune-modulatory effects on the pancreas beta-cells, increases insulin secretion, and reduces insulin resistance in type 1 diabetes patients [5]. It contains small-size immunoglobulins which strengthen the immune system [6]. In addition, camel milk reduces blood cholesterol, avoiding psoriasis disease, healing inflammation, and improving

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cardiovascular issues. Camel milk may be effective as a unique superfood in many health issues of humans [7-9].

Anti-diabetic effects of camel milk

Type 1 diabetes is a serious disease with many complications that are increasing worldwide. Three-quarters of the world's population cannot use allopathic medicines and therefore have to rely on medicines made from natural products of animals and plants [6]. Camel milk contains insulin-like proteins, which do not form a coagulum in the acidic media of the stomach that can be an effective alternative for insulin [10]. Camel milk improves glycemic control and decreases insulin resistance in diabetes patients [11]. It is detected high amount of insulin in camel milk (about 52 units.litre^{-1}), causes to reduction in blood sugar and insulin requirements [12]. The presence of fat micelles in camel milk covers insulin and transfers it to the circulatory system in diabetic patients [13]. Camel milk improves obesity, inflammation, wounds, and oxidative stress damage as diabetes complications [14]. Therefore, camel milk and some of its active compounds influence pancreatic β-cells and insulin receptor function in the insulin-sensitive tissues, therefore increasing insulin secretion [15]. Daily drinking of camel milk may meet about 60% of the insulin in diabetic patients [16]. The whey proteins of camel milk with anti-oxidative activity enhance immune cell proliferation and diabetic wound healing by increasing glutathione synthesis and improving the function of the cellular antioxidant defense system [5,17].

The beneficial immune-stimulating effects of camel's whey proteins as natural antioxidants have been reported to accelerate the healing process of diabetic wounds in laboratory animals [5]. Therefore, camel milk is safe in long-term glycemic control that significantly reduces the required insulin doses in diabetic patients of type 1 [5] and type 2 [6].

Mechanism of anti-diabetic effects

The effects of camel milk on diabetes included; its effect on insulin synthesis, secretion, and insulin receptor function. Also, direct effects on insulin receptor function and glucose transport in the insulin-sensitive tissues, direct and/or indirect effects on insulin secretion by the pancreatic ß-cells, and the normal activity of the pancreatic ß-cells [15]. Insulin-like proteins (52 units/liter) in camel milk are related to the lactation period and the storage condition, that transfer to the circulatory system [18].

The bioactive proteins of camel milk are effective by direct or indirect action on specific pathways controlling insulin synthesis and secretion by the pancreatic ß-cells. Hormones like glucagon and glucose-dependent insulinotropic polypeptides, such as Gastric Inhibitory Polypeptide (GIP) and Glucagon-Like Peptide-1 (GLP-1), as well as enzymes such as the endoprotease dipeptidyl peptidase IV (DPP-IV) and its proteolytic effects on GIP and GLP-1, have a key role in the control of insulin synthesis and secretion by the pancreas. The non-coagulation of camel milk in the stomach and the protective effects of small Igs of camel milk on pancreatic ß-cells have also been suggested to explain the hypoglycemic effects of camel milk [15,19].

Among whey proteins, iron-binding glycoproteins of camel milk (lactoferrin) have an important role in insulin function and the signaling of insulin receptors and insulin resistance that influence diabetes disorders such as inflammation and obesity [15]. The known metabolic pathway through the PI3-kinase / Akt insulin activating axis controls the expression and transport of GLUT4 to the plasma membrane, and this is an important step in the transport and utilization of glucose by insulin-sensitive tissues through its receptor [20].

However, camel milk proteins may increase insulin secretion by the following mechanisms: (1) stimulation of glucose-mediated insulin secretion, (2) inhibition of glucagon secretion by pancreatic α-cells, and (3) inhibition of major enzymes such as dipeptidyl Peptidase IV (DPP-IV), which indirectly controls insulin secretion [15].

These effects, together with the inhibitory effects on DPP-IV and the positive pharmacological effects on GI and GLP-1 receptors, may explain the cellular and molecular reasons for the beneficial effects of camel milk on the management of diabetes mellitus [21]. In addition, the potential target selection of insulin-sensitive tissues and their regulation by camel milk compounds may also be possible by positive regulating of GLUT activity, thereby increasing glucose uptake [15].

The small size Igs of camel's milk may potentially induce regulatory cells by interacting with host cell proteins, ultimately reducing the regulation of the immune system and preserving pancreatic ß-cells. The high concentration of antioxidants in camel's milk is effective in reducing body fat in the individual with type 1 diabetic patients, as insulin receptors become more sensitive to available insulin [15].

Camel milk against diabetes complications

There are serious acute problems due to high blood sugar like diabetic ketoacidosis and non-ketotic hyperosmolar coma. Chronic hyperglycemia causes long-term damage and dysfunction of various organs; eyes, kidneys, nervous system, heart, and blood vessels in the body. However, control of sugar metabolism can be improved through diet and exercise with or without antidiabetic drugs, which significantly reduces the risk of these complications [15]. The effects of camel milk have been proven to improve the pathophysiological aspects of diabetes, such as insulin resistance, obesity, inflammation, wound healing, and oxidative damage [22].

Liver disease and decreased liver enzyme levels are common in people with diabetes mellitus. The researchers observed a significant improvement in liver enzyme function in diabetic rats treated with camel milk compared to cow and buffalo milk [6]. Camel milk plays an important role in controlling the level of microalbuminuria in type 1 diabetic patients [23]. The level of microalbuminuria in patients with type 1 diabetes treated with camel's milk decreased after 24 hours. A significant reduction in microalbuminuria has been reported after adding camel's milk to the diet for 6 months [21].

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Delayed wound healing occurs in diabetic patients and is one of the most serious complications associated with diabetes. Milk whey proteins accelerate wound healing in diabetics by increasing the immune response of injured tissue cells and reducing some of the complications of diabetes [24]. Recent studies suggest that camel milk increases antioxidant activity in the body and has therapeutic effects in the treatment of diseases caused by oxidative stress [15]. Some of the effects of camel milk whey proteins or their peptide fragments have been attributed to the antioxidant activity of camel's whey proteins, which increase the proliferation of immune cells and accelerate the wound healing process in diabetes [24]. Increased oxidative stress may lead to diabetes mellitus and the development of vascular and neurological complications [25]. Hyperlipidemia and hypercholesterolemia happen with diabetes and increase the risk of cardiovascular disease [26]. The high degree of oxidative stress may lead to the development of vascular complications caused by diabetes mellitus. Thus, diabetes is associated with cardiovascular diseases [5]. Probiotic and bioactive peptides obtained from proteolytic activity in camel milk have hypocholesterolemic properties. The interaction between its milk's bioactive peptides decreases cholesterol [6]. Cholesterol-lowering peptides also prevent cholesterol absorption by electrostatic and hydrophobic reactions or through decreasing cholesterol solubility [6]. These friendly bacteria deconjugate bile salts and inhibit cholesterol reabsorption, thus reducing cholesterol absorption in the intestine [27] Also, probiotics make short-chain fatty acids in the gut from the fermentation of carbohydrates that affect cholesterol synthesis and transfer from plasma to the liver [28].

Studies on the anti-diabetic properties of camel milk

The researchers found that consuming 500 mL of camel milk daily reduced glucose and required insulin dose by 30% to 35%, But it does not affect the concentration of blood lipids [3]. Camel milk also reduced cholesterol and triglycerides in type 2 diabetic patients and rats [29]. Consumption of camel's milk could increase serum insulin levels in type 2 diabetic patients, but fasting blood sugar, blood lipid, and blood pressure changes were insignificant in camel's and cow's milk may help to control type 2 diabetic patients [30].

In this experiment, type 2 diabetes cases, of the same age (10 people per treatment) were given 500 mL camel milk daily in the morning and evening for two months, and patients did not drink any other milk. After milking, camel's milk and cow's milk were first pasteurized at 70 for 15 minutes and stored in the refrigerator. After two months, the results showed that camel milk reduced insulin requirements in diabetic patients [30].

Twenty-one patients with type 1 diabetes consumed 500 mL of camel milk daily for six months in one experiment. Lipid factors such as LDL and triglycerides the required insulin dose and albuminuria were reduced. Urine albumin level before treatment with camel milk was about 93.5 u/kg, and after treatment was approximately 60.64 u/kg. However, the required insulin amount before treatment with camel milk was 41.6 u/day and after treatment with camel milk reached 28.32 u/day [31] (Table 1).

In this case, 54 diabetic patients aged 17 to 22 years were selected, and the first group took insulin according to their routine. Group 2 consumed 500 mL of camel milk daily for 68 weeks, and some were considered healthy controls [10]. Fresh milk samples were cooled and frozen until used in patients. The results showed that consuming camel milk reduced the need for insulin [10]. In this experiment, after two years, a significant reduction in insulin requirements (46.15%) occurred in type 1 patients consuming camel milk; However, the required insulin reached zero in three cases. A significant decrease in HbA1c level (7.81% to 5.44%) was observed as a glycemic control index in the camel milk receiving group. A significant increase in peptide C may improve pancreatic beta-cell function, which increased from 0.18% to 0.24% after one year of camel milk supplementation. In this test, patients' fasting insulin levels, an indicator of insulin resistance, also decreased [32] (Figures 1,2).

In this experiment, two groups of 15 people with type 1 diabetes aged 18 to 19 years and between 2 and 15 years old with diabetes consumed 500 mL camel milk in the morning and evening for a year under similar conditions. Their blood

Table 1: The effect of camel milk on blood parameters of diabetic patients [31].

	Before using camel milk	After using camel milk
HBA1 (%)	9.54 ± 0.44	8.65 ± 0.38
Insulin dose (u/day)	41.61 ± 3.08	28.32 ± 2.66
Mean plasma glucose (mg/dl)	128.7 ± 1.17	125.46 ± 1.24
Microalbuminuria (mg/dl)	119.48 ± 1.68	22.52 ± 2.68
Total cholesterol (mg/dl)	77.22 ± 0.03	76.32 ± 0.04
HDL (mg/dl)	26.82 ± 0.02	26.28 ± 0.03
LDL (mg/dl)	65.18 ± 0.14	45.54 ± 0.1
VLDL (mg/dl)	6.84 ± 0.02	6.3 ± 0.02
Triglyceride (mg/dl)	92.7 ± 0.18	31.5 ± 0.17
C-peptide (nmol/l)	0.18 ± 0.14	0.24 ± 0.17
Plasma insulin (pmol/l)	127.08 ± 2.86	130.63 ± 3.86

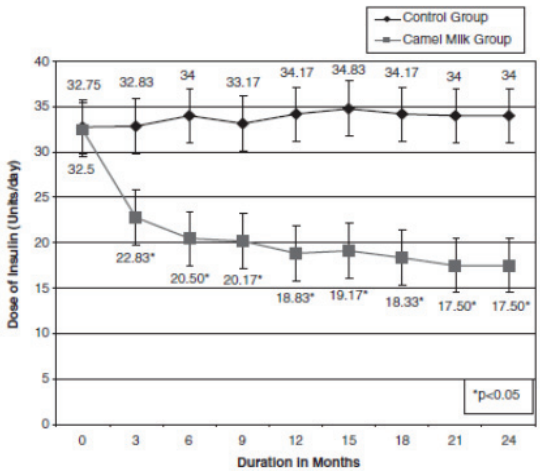

Figure 1: Average of required insulin dose in the control group and the group receiving camel milk over two years [32].

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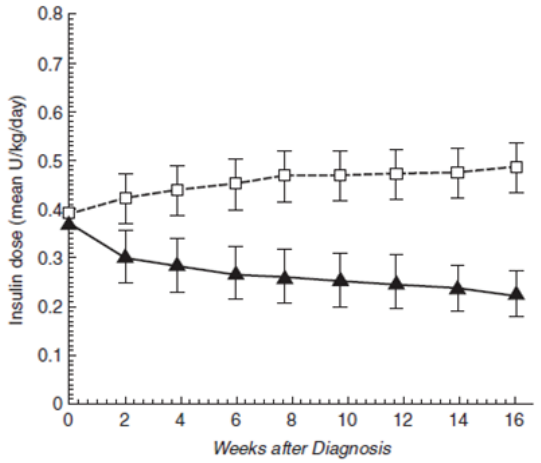

Figure 2: Mean dose of insulin required in the control group and the group receiving camel milk over 16 weeks [14].

conditions were checked every day for two months. The raw camel milk was collected weekly and stored in the refrigerator [33]. The results showed that the required insulin dose was reduced by 46%, from 75 to 42 u/day. Fasting blood sugar decreased by 67% from 286 to 95 mg / dL. Blood postprandial sugar fell by 65% , from 264 to 93 mg / dL. HbA1c decreased by 37% from 7.3 to 4.6; Thus, camel milk as therapeutic insulin can regulate blood sugar and improve carbohydrate metabolism in type 1 diabetics in the absence of insulin. For this purpose, camel milk can be used on an empty stomach or after each meal and prevent other risk factors for diabetes [33]. In one experiment, the effects of camel milk on risk factors and blood sugar control in type 1 diabetic cases were investigated. In this experiment, 500 mL raw camel milk was used for three months in type 1 diabetic patients, which reduced blood sugar from 115 to 100 and the required insulin from 41 to 30 u/day. LDL also decreased significantly from 92 to 72, and total cholesterol and triglycerides reduced insignificant ly [34]. 20 patients with type 2 diabetes were considered in two groups. One group was fed daily raw camel milk for three months, and one group was fed sterilized cow milk. Patients did not consume any other dairy during these three months [35]. After three months, camel milk reduced insulin resistance, and HbA1c and significantly decreased blood sugar. Still, blood lipid parameters such as LDL, HDL, and triglycerides did not change and were almost the same in both groups. The results showed that although changes in fasting blood glucose and lipid profiles in the camel milk group were not significant compared to cow milk; However, regular consumption of camel milk significantly reduced blood sugar and long effect insulin dose in type 2 diabetes patients [35].

250 mL diluted kefir and yogurt, or camel dough was used daily for eight weeks in diabetic patients with the same conditions [36]. The results showed that IL6 and TNF decreased and glucose metabolizing hormone GIP and GLP1 increased significantly. GLP - 1 levels increased with shubat in type 1 diabetic mice, which may be due to the probiotic action on the release of GLP - 1. An increase in IL6 levels and a decrease in TNF were also observed with fermented products or shubat [16]. Among other studies on fermented camel milk [37,38] some presented that there was no effect on TNF with fermented milk in diabetic cases [36]. Camel milk was able to lower blood sugar and postprandial blood sugar, HbA1c, and HOMA - IR in type 2 diabetes patients; But had no effect on glucose tolerance; Therefore, peptide C levels were higher with the consumption of fermented camel milk. Proper function of the pancreatic islets and stimulation of endogenous insulin secretion was observed by 250 to 500 mL shut [36].

Another study investigated the effect of camel milk on glucose metabolism in type 2 diabetic patients in the Raika community, India. In this study, 28 males of the Raika and non-Raika communities were divided into diabetic and non-diabetic groups. 500 mL of raw camel milk was given daily to the diabetic group for three months, and the non-diabetic group consumed boiled cow's milk [32]. In the diabetic group, improvement in blood glucose was observed. HbA1c levels decreased, and insulin levels improved. Improvements in fasting blood sugar and blood sugar were observed two hours after taking camel milk, which shows the hypoglycemic effect of camel milk. In the diabetic group, insulin levels decreased significantly at 0, 60, and 120 min after camel milk supplementation, suggesting that camel milk plays a crucial role in controlling insulin resistance [32]. Overall results showed that in type 2 diabetic patients, camel milk reduced fasting blood sugar, postprandial blood sugar, HbA1c, and insulin resistance [32].

In this experiment, 24 patients with type 1 diabetes were randomly selected. Group 1 (n = 12) received routine or usual care (diet, exercise, and insulin), and group 2 (n = 12) received 500 mL of camel milk daily in addition to regular care for three months. After three months of treatment with camel milk, the results showed a significant improvement in fasting blood sugar and a significant reduction in insulin requirements. The quality of life of diabetic patients improved [12]. In 92% of patients in group 2, a 30% reduction in insulin dose was observed; But no changes were observed in the lipids profiles, plasma insulin, and C-peptide [12].

In another study, the effects of camel milk on long-term glycemic control in type 1 diabetes were studied in a 52-week study. During the study period, 12 patients were under routine, or usual diabetes treatment (diet, exercise, and insulin), and 12 patients consumed 500 mL of raw camel milk per day in addition to the standard treatment [39]. In the camel milk group, a significant decrease in HbA1c, mean blood glucose, and required insulin dose was observed compared to the beginning of the study [12]. For two years, this study evaluated camel milk's efficacy, safety, and acceptance as adjunctive insulin therapy in type 1 diabetes patients. Twenty-four patients with type 1 diabetes were divided into two groups. The first group (12 patients) received routine care, i.e., diet, exercise, and insulin; the second group (12 patients) received 500 mL camel milk and common or usual care. In the camel milk group, mean blood glucose, hemoglobin A1c, and insulin dose decreased. Insulin requirements in 3 people were also reduced to zero [32]. The average dose of required insulin before consuming camel›s milk in type 1 diabetes patients was 41.16 ± 10.32 u/

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day. This amount gradually decreased to 30.06 ± 12.06 u/day three months after treatment [12].

The effectiveness of camel milk as a drug treatment in young type 1 diabetes patients was evaluated for 16 weeks. Fifty-four type 1 diabetic patients (mean age 20 years) were divided into two groups of 27 members. The first group (control) was under regular treatment (diet, exercise, and insulin), and the second group, in addition to conventional therapy, was treated with 500 mL camel milk. After 16 weeks, they observed a significant difference between the control group and the camel milk group [10]. After 16 weeks, fasting blood sugar and daily insulin requirements decreased. In addition, a combination of camel milk and insulin reduced postprandial blood glucose levels in type 1 diabetic patients by 52% compared with camel milk alone (30% reduction) or insulin alone (12% reduction) [10,40].

The effect of camel milk insulin on the lipid profile of type 1 diabetic patients was evaluated compared to insulin injection alone or camel milk. After three months, triglyceride and cholesterol levels decreased by 9% and LDL by 7% in type 1 diabetic patients who received insulin injections (control group). Reverse reductions of threefold for triglycerides and twofold for cholesterol and LDL were reported in diabetic patients treated with camel>s milk. Also, a significant decrease in triglyceride, cholesterol (approximately 45%), and LDL (about 30%) was shown in the diabetic patients treated with insulin and camel milk together compared with the control group. There was also a significant increase in HDL levels in patients treated with insulin and camel>s milk, from 41 mg/dL to 49 mg/dL in patients treated with the mixture [41].

Significant improvement in fasting blood sugar, postprandial blood sugar, and HbA1c were observed. There was a substantial decrease in insulin requirements in the group receiving insulin and camel milk compared to other groups; Therefore, camel milk and insulin were effective supplements in managing type 1 diabetes [41].

In this experiment, 50 mL of raw camel milk per day was used in each diabetic rat. High concentrations of insulin in camel milk activate the lipoprotein lipase, and raw camel milk causes favorable changes in the lipid profile of diabetic mice by acting on lipid metabolic pathways, reducing the risk of heart disease and clogged arteries [42]. The atherogenic index decreased in camel milk-fed diabetic rats, leading to a decrease in the ratio of LDL to HDL and an increase in HDL. High levels of vitamin C in camel's milk also play an essential role in reducing peroxides in the blood, glucose, cholesterol, triglycerides, and LDL in diabetic cases [42].

Camel milk prevents collagen glycosylation due to reduced glucose availability. Also, camel milk vitamin C can effectively produce hydroxyproline, which is involved in collagen structure [43].

This study gave 40 mL/kg/day of raw camel milk for 100 days. Camel milk contains components that can increase erythropoietin production (a hormone that increases the production of red blood cells in the bone marrow). High antioxidants and vitamin C concentrations in camel milk also reduce diabetic-induced blood hemolysis by preventing lipid peroxidation in cell membranes [44]. Camel milk normalizes uterine tissue history during pregnancy in people with diabetes toward normal and improves neonatal growth [44]. Fasting blood sugar levels significantly decreased due to insulin-like protein in camel milk, which is not degraded in the stomach, and the presence of IGF-1, which stimulates the energy substrate by reducing lipolysis and stimulating glucose oxidation [44].

Increased lipid profile, increased antioxidant enzymes, and normalization of liver enzymes and kidney health factors were observed with camel milk [45].

Consuming camel's milk can reduce hyperlipidemia, which is also associated with the risk of developing diabetes mellitus. In this study, total levels of cholesterol, triacylglycerol, free fatty acids, phospholipids, LDL, and VLDL were significantly reduced compared to normal levels in the plasma and tissue (e.g., liver, kidney, and heart); Plasma HDL was improved considerably in diabetic rats after treatment with camel milk for 45 days [46].

The effect of camel milk powder on diabetes

Since fresh camel milk is not available for all people globally, most clinical trials are on fresh camel milk, and information on the antidiabetic effects of camel milk powder is rare. There is only one study on using camel milk powder for diabetes [47] (Table 2).

In one trial, type 2 diabetic patients, 35 years - 68 years, without gastrointestinal issues were divided into two groups. They received camel milk powder and cow milk powder two times daily, 10 g each for four consecutive weeks. 14 and 13 participants received camel milk powder and cow milk powder after breakfast and dinner [47].

The results showed a significant decrease in fasting blood glucose in patients fed camel milk powder and a nonsignificant reduction in 2-hr postprandial blood glucose [47]. Previous studies confirmed the hypoglycemic effects of camel milk. There was a significant decrease in fasting blood glucose in type I diabetes and type II diabetes. The patients' insulin content and insulin resistance (HOMA-IR) were not influenced.

The total cholesterol decreased in the camel milk powder group after 4 weeks, but there were no significant effects on the total triglyceride, LDL-C/HDL-C before and after the

Table 2: Composition of camel and cow milk powder [47].

Factors (%)	Camel milk powder	Cow milk powder
Fat	32.6	28.2
Total protein	30.3	25.1
Whey protein	8	4.5
Casein	20.8	20.2
Carbohydrates	37.1	42
H_2O	4.3	2.1

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consumption of camel milk powder [47]. Among a few studies on type II diabetic patients, one study obtained the same results [48], but Ejtahed, et al. [30] reported different results in lipid profiles. A decrease in total cholesterol and HDL-C by camel milk indicates decreased vascular risk. After 4 weeks, there was a significant decrease in the inflammatory cytokines IL-6 in the camel milk powder group [47]. Camel milk has more excellent antioxidant and immunomodulatory activities than other whey proteins [15]. Defects in the immune systems and increasing oxidative stress destroy the pancreatic beta-cells [49]. And camel milk or camel milk whey proteins reduce the proinflammatory IL-1β, IL-6, and TNF-α [22].

There was a noticeable decrease in serum resistin and lipocalin-2 (adipokines) in camel milk powder which improved diabetes [47]. After 4 weeks of applying 10 g camel milk powder, two times daily, there was a decrease in fasting blood glucose, 2-hr postprandial blood glucose, and total cholesterol. Camel milk powder exhibited antidiabetic activity in type 2 diabetic patients [47].

Heat processing on the anti-diabetic properties of camel milk

In this experiment, skimmed milk was heated at 65, 75, 85, and 100 °C for 10, 20, and 30 min. Heating at 65 for 30 min had no significant effect on lysozyme and lactoferrin, but immunoglobulin G was significantly affected in three kinds of milk. In contrast, 69% was lost in camel milk [50]. Antimicrobial agents of camel milk were more heat resistant than the other two kinds of milk [50]. Researchers reported no effect on the whey proteins, alpha-lactalbumin, and beta-lactoglobulin in cow and camel milk at 63 for 30 min; Camel milk proteins are even more resistant to 100 °C. At 100 °C for 30 min, total lysozyme activity was eliminated in cow and buffalo milk; But 94% of the lysozyme activity of camel milk was destroyed [50] (Figure 3).

Pasteurization at 71 °C for 9 s maintained 75% of immunoglobulin. Camel milk had a high loss of immunoglobulin G at 85 ° C for 30 min and was similar to 85 and 100 °C. But 75 ° C in 30 min caused a substantial loss in the activity of this enzyme [50]. Camel milk whey proteins were higher and more resistant than the other two kinds of milk [50,51].

The effect of temperature processing of camel milk on the therapeutic efficacy of diabetic rats was investigated [52]. After eight weeks, the results showed that the highest reduction in blood glucose levels was related to raw camel milk. Also, the therapeutic activity of camel milk was eliminated after heating at 100 °C (boiled camel milk). Heat, cold, and freeze-drying treatments have reduced the concentration of insulin in camel milk, reducing camel milk's efficiency in lowering blood glucose levels [52].

The insulin-like protein activity of camel milk is reduced by boiling [53]. Heating camel milk to 100 °C, reduced alpha-lactalbumin and immunoglobulin G more than in cow's milk, and lactoferrin was completely denatured [50]. Raw camel milk, pasteurized and refrigerated for 2 to 4 days and

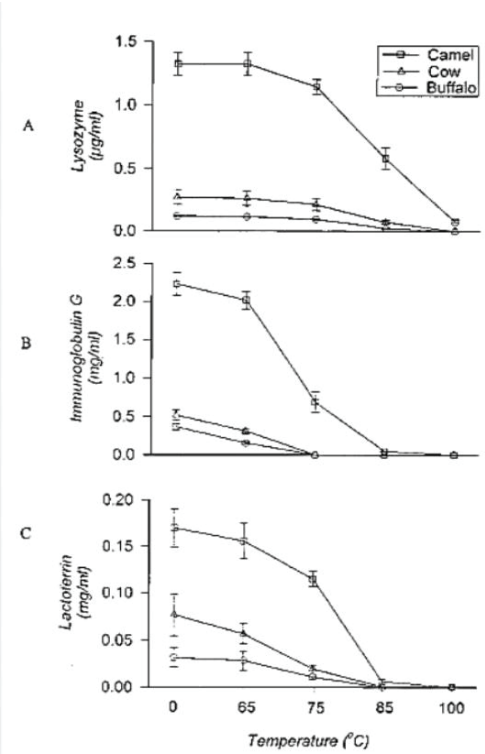

Figure 3: Effect of heat treatment on lysozyme, immunoglobulin G, and lactoferrin in camel, cow, and buffalo milk [50].

freeze-dried decreased triglyceride, LDL, and VLDL levels and increased HDL compared with the diabetic group [52]. Thus, raw, pasteurized, refrigerated, freezer, and freeze-dried milk reduced LDL, VLDL, and increased HDL, reducing the risk of heart diseases [52]. Also, the atherogenic index decreased due to a significant decrease in the LDL to HDL ratio in the groups fed raw, pasteurized, refrigerated, frozen, and freeze-dried camel milk compared to the control [52].

Fifty camel milk samples were divided into different sections and studied in raw, pasteurized forms at 62.3 for 30 min and in the microwave at 10, 20, 30, 40, and 50 seconds at 2450 MHz. The results showed that pasteurization with these conditions is insufficient for the microbial count, but 40 seconds in the microwave is enough to reduce the microbial load. Both methods have the opposite effect on the bioactive components of camel milk, such as insulin, immunoglobulin G, vitamin C, and glutathione, which lead to an increase in malondialdehyde [54]. Camel milk microwave treatment has promising results in microbiological quality that heating camel milk in the microwave for 10 seconds had a reducing effect on Ecoli; Microwave heating is more promising and less damaging than conventional heat treatment to preserve camel milk components [54]. This experiment's pasteurized and microwave temperatures did not affect insulin or anti-diabetic effects. Pasteurization, freeze-drying, and storage at 4 degrees for four days and freezing at 20 degrees below zero resulted in a significant reduction in insulin levels [54].

The insulin level of camel milk

In an experiment, colostrum and camel milk samples were tested for insulin levels during the first five months of

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lactation [55]. The results showed that the highest insulin level was 1856.8 ± 804 .4 µmol / mL at 0 hours after calving in the first lactation, which was constant after two weeks to 5 months with no significant difference according to the sampling time; About 55.1 ± 33.2 µmol / mL, which was higher in blood than in colostrum and milk but had no correlation with blood. The insulin amount in camels receiving concentrate was higher than in those grazing naturally [55]. The concentration of insulin in the colostrum at the time of zero lactation was the highest, reaching 367.5 ± 286.1 µmol / mL in 24 hours, which is 20% of the initial rate. After 24 hours, the insulin concentration gradually decreases to 101.3 ± 65.6 µmol / mL after seven days and remains constant for two to 5 months [55-58].

The amount of insulin in the collected milk in lactation 1 and 2 was higher than in other lactations; the most elevated amount was in lactation two about 61.8 ± 16.1 µmol / mL, which was not significantly different from the amount in lactation 1; However, the lowest rate was for lactation 4, 15.7 ± 10.3 µmol / mL, which was not substantially different from lactation 3.

Conclusion

In most studies, the beneficiary impacts of raw camel milk on diabetes proved; to improve risk factors like cardiovascular challenges, and hepatic and renal failures due to diabetes. Consuming camel milk for 180 days lowers triacylglycerol and LDL in diabetes (type 1), and a 1% decrease in cholesterol diminishes the cardiac disease risks by about 2% to 3%. More trials are required to prove the efficacy of processed camel milk like making powder for diabetes complications and CVDs. The number of evidence shows that the milk of camel is safe without any side effects and effective for diabetic persons for long-term hypoglycemic effects.

References

1. Alavi F, Salami M, Emam-Djomeh Z, Mohammadian M, Watson R, Collier R, Preedy V. Nutraceutical properties of camel milk. 451-468. In: Nutrients in Dairy and Their Implications on Health and Disease. Academic Press, Elsevier. 2017; 490.

2. Zibaee S, Hosseini SM, Yousefi M, Taghipour A, Kiani MA, Noras MR. Nutritional and Therapeutic Characteristics of Camel Milk in Children: A Systematic Review. Electron Physician. 2015 Nov 20;7(7):1523-8. doi: 10.19082/1523. PMID: 26767108; PMCID: PMC4700900.

3. Kanha HA AI. Compositional, technological, and nutritional aspect of dromedary camel milk. International Dairy Journal. 2010; 20(12): 811-821.

4. Gorban AM, Izzeldin OM. Fatty acids and lipids of camel milk and colostrum. Int J Food Sci Nutr. 2001 May;52(3):283-7. doi: 10.1080/713671778. PMID: 11400477.

5. Aqiba AI. Kulyar A, Muhammad FA, Ashfaq Kh, Bhutta ZA, Shoaib M. Camel milk insuline: Pathophysiological and Molecular Repository. Trends in Food Science and Technology. 2019; 88: 497-504.

6. Shori AB. Camel milk as a potential therapy for controlling diabetes and its complications: A review of in vivo studies. J Food Drug Anal. 2015 Dec;23(4):609-618. doi: 10.1016/j.jfda.2015.02.007. Epub 2015 Mar 27. PMID: 28911476; PMCID: PMC9345463.

7. Mihic T, Rainkie D, Wilby KJ, Pawluk SA. The Therapeutic Effects of Camel Milk: A Systematic Review of Animal and Human Trials. J Evid Based Complementary Altern Med. 2016 Oct;21(4):NP110-26. doi: 10.1177/2156587216658846. Epub 2016 Jul 18. PMID: 27432772.

8. Mohammadabadi T. Camel milk as an amazing remedy for health complications; A review article. Basrah Journal of Agricultural Science. 2020; 33(2).

9. Mohammadabadi T. Camel Milk lactoferrin: Special agent against bacterial infections. World J Pharm Sci. 2021; 9(3): 155-159.

10. Mohamad RH, Zekry ZK, Al-Mehdar HA, Salama O, El-Shaieb SE, El-Basmy AA, Al-said MG, Sharawy SM. Camel milk as an adjuvant therapy for the treatment of type 1 diabetes: verification of a traditional ethnomedical practice. J Med Food. 2009 Apr;12(2):461-5. doi: 10.1089/jmf.2008.0009. PMID: 19459752.

11. Sboui A, Khorchani T, Djegham M, Agrebi A, Elhatmi H, Belhadj O. Anti-diabetic effect of camel milk in alloxan-induced diabetic dogs: a dose-response experiment. J Anim Physiol Anim Nutr (Berl). 2010 Aug 1;94(4):540-6. doi: 10.1111/j.1439-0396.2009.00941.x. Epub 2009 Nov 11. PMID: 19906135.

12. Agrawal PP, Swami SC, Beniwal R, Kochar DK, Sahani MS, Tuteja FC. Effect of camel milk on glycemic control, risk factors and diabetes quality of life in type-1 diabetes: A randomized prospective controlled study. Journal of Camel Practice and Research. 2003;10(1):45–50.

13. Shamsia SM. Nutritional and therapeutic properties of camel and human milks. Int. Journal Genet Mol Biol. 2009; 1: 52.

14. Agrawal RP, Saran S, Sharma P, Gupta RP, Kochar DK, Sahani MS. Effect of camel milk on residual beta-cell function in recent onset type 1 diabetes. Diabetes Res Clin Pract. 2007 Sep;77(3):494-5. doi: 10.1016/j.diabres.2007.01.012. Epub 2007 Feb 22. PMID: 17320238.

15. Ayoub MA, Palakkott AR, Ashraf A, Iratni R. The molecular basis of the anti-diabetic properties of camel milk. Diabetes Res Clin Pract. 2018 Dec;146:305-312. doi: 10.1016/j.diabres.2018.11.006. Epub 2018 Nov 16. PMID: 30452940.

16. Shori A. Comparative study of chemical composition, isolation and identification of micro-flora in traditional fermented camel milk products: Gariss, Suusac, and Shubat. Journal of the Saudi Society of Agricultural Sciences. 2012; 11(2):79–88.

17. Ebaid H, Abdel-Salam B, Hassan I, Al-Tamimi J, Metwalli A, Alhazza I. Camel milk peptide improves wound healing in diabetic rats by orchestrating the redox status and immune response. Lipids Health Dis. 2015 Oct 24;14:132. doi: 10.1186/s12944-015-0136-9. Erratum in: Lipids Health Dis. 2017 Feb 20;16(1):43. PMID: 26498022; PMCID: PMC4619484.

18. Abdulrahman AO, Ismael MA, Al-Hosaini K, Rame C, Al-Senaidy AM, Dupont J, Ayoub MA. Differential Effects of Camel Milk on Insulin Receptor Signaling - Toward Understanding the Insulin-Like Properties of Camel Milk. Front Endocrinol (Lausanne). 2016 Jan 27;7:4. doi: 10.3389/fendo.2016.00004. PMID: 26858689; PMCID: PMC4728290.

19. King GL. The role of inflammatory cytokines in diabetes and its complications. J Periodontol. 2008 Aug;79(8 Suppl):1527-34. doi: 10.1902/jop.2008.080246. PMID: 18673007.

20. Haeusler RA, McGraw TE, Accili D. Biochemical and cellular properties of insulin receptor signalling. Nat Rev Mol Cell Biol. 2018 Jan;19(1):31-44. doi: 10.1038/nrm.2017.89. Epub 2017 Oct 4. PMID: 28974775; PMCID: PMC5894887.

21. Meena S, Rajput YS, Pandey AK, Sharma R, Singh R. Camel milk ameliorates hyperglycaemia and oxidative damage in type-1 diabetic experimental rats. J Dairy Res. 2016 Aug;83(3):412-9. doi: 10.1017/S002202991600042X. PMID: 27600979.

22. Badr G, Ramadan NK, Sayed LH, Badr BM, Omar HM, Selamoglu Z. Why whey? Camel whey protein as a new dietary approach to the management of free radicals and for the treatment of different health disorders. Iran J Basic Med Sci. 2017 Apr;20(4):338-349. doi: 10.22038/IJBMS.2017.8573. PMID: 28804604; PMCID: PMC5425915.

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DOI: https://dx.doi.org/10.17352/jfsnt.000048

23. Khan AA, Alzohairy MA, Mohieldein AH. American Journal of biotechemistry and molecular biology. 2013; 3 1: 151-158.

24. Ebaid H, Salem A, Sayed A, Metwalli A. Whey protein enhances normal inflammatory responses during cutaneous wound healing in diabetic rats. Lipids Health Dis. 2011 Dec 14;10:235. doi: 10.1186/1476-511X-10-235. PMID: 22168406; PMCID: PMC3254143.

25. Moreno-Navarrete JM, Ortega FJ, Bassols J, Ricart W, Fernández-Real JM. Decreased circulating lactoferrin in insulin resistance and altered glucose tolerance as a possible marker of neutrophil dysfunction in type 2 diabetes. J Clin Endocrinol Metab. 2009 Oct;94(10):4036-44. doi: 10.1210/jc.2009-0215. Epub 2009 Jul 7. PMID: 19584176.

26. Ashraf A, Mudgil P, Palakkott A, Iratni R, Gan CY, Maqsood S, Ayoub MA. Molecular basis of the anti-diabetic properties of camel milk through profiling of its bioactive peptides on dipeptidyl peptidase IV (DPP-IV) and insulin receptor activity. J Dairy Sci. 2021 Jan;104(1):61-77. doi: 10.3168/jds.2020-18627. Epub 2020 Nov 6. PMID: 33162074.

27. El-Zahar KM, Hassan MFY, Al-Qaba SF. Protective Effect of Fermented Camel Milk Containing Bifidobacterium longum BB536 on Blood Lipid Profile in Hypercholesterolemic Rats. J Nutr Metab. 2021 Oct 29;2021:1557945. doi: 10.1155/2021/1557945. PMID: 34745660; PMCID: PMC8570886.

28. Kawase M, Hashimoto H, Hosoda M, Morita H, Hosono A. Effect of administration of fermented milk containing whey protein concentrate to rats and healthy men on serum lipids and blood pressure. J Dairy Sci. 2000 Feb;83(2):255-63. doi: 10.3168/jds.S0022-0302(00)74872-7. PMID: 10714858.

29. Kotb-El-Sayed MI, Al-Shoeibi ZY, Abd El-Ghany AA, Atef ZA. Effects of Camels Milk as a Vehicle for Insulin on Glycaemic Control and Lipid Profile in Type 1 Diabetics. American journal biochemistry biotechnology. 2011;7(4):179–89

30. Ejtahed HS, Niasari Naslaji A, Mirmiran P, Zraif Yeganeh M, Hedayati M, Azizi F, Moosavi Movahedi A. Effect of camel milk on blood sugar and lipid profile of patients with type 2 diabetes: a pilot clinical trial. Int J Endocrinol Metab. 2015 Jan 22;13(1):e21160. doi: 10.5812/ijem.21160. PMID: 25745496; PMCID: PMC4338669.

31. Agrawal RP, Dogra R, Mohta N, Tiwari R, Singhal S, Sultania S. Beneficial effect of camel milk in diabetic nephropathy. Acta Biomed. 2009 Aug;80(2):131-4. PMID: 19848050.

32. Agrawal RP, Sharma P, Gafoorunissa SJ, Ibrahim SA, Shah B, Shukla DK, Kaur T. Effect of camel milk on glucose metabolism in adults with normal glucose tolerance and type 2 diabetes in Raica community: a crossover study. Acta Biomed. 2011 Dec;82(3):181-6. PMID: 22783713.

33. Abdalla KO, Fadlalla AA. Effects of Sudanese Dromedary's CQamel Raw Milk on Insulin Doses and Carbohydrate Metabolism in Type 1 Diabetic Patients. Journal Biomolecular Research and Therapeutics. 2018; 7:159.

34. Agrawal RP, Swami SC, Beniwal R, Kochar DK, Sahani MS, Tuteja FC. Effect of camel milk on glycemic control, lipid profile, and diabetes quality of life in type 1 diabetes: a randomised prospective controlled cross over study. Indian Journal of Animal Sciences. 2003; 73(10):1105–10.

35. Fallah ZH, Ejtahed S, Mirmiran HS, Naslaji NP, Movahedi AM, Eslami A, Azizi F. Effect of Camel Milk on Glycemic Control and Lipid Profiles of Diabetic Patients. Iranian Journal of Endocrinology and Metabolism. 2017; 19:(4).

36. Fallah Z, Feizi A, Hashemipour M, Namazi N, Azarbayejani L, Kelishadi R. Effect of Fermented Camel Milk on Obesity Measures and Blood Pressure of Adolescents with Metabolic Syndrome. Journal of Pediatrics Review. 2019; 7(3):181-189.

37. Hamed H, Chaari F, Ghannoudi Z, ElFeki A, Ellouz SC, Gargouri A. Beneficial effects of fermented camel milk by lactococcus lactis subsp cremoris on cardiotoxicity induced by carbon tetrachloride in mice. Biomed Pharmacother. 2018 Jan;97:107-114. doi: 10.1016/j.biopha.2017.10.057. Epub 2017 Nov 6. PMID: 29080450.

38. Quan S, Tsuda H, Miyamoto T. Angiotensin I-converting enzyme inhibitory peptides in skim milk fermented with Lactobacillus helveticus 130B4 from camel milk in Inner Mongolia, China Journal Science Food Agriculture. 2008; 88: 2688- 2692.

39. Agrawal RP, Sahani MS, Tuteja FC, Ghorui SK, Sena DS, Gupta R, Kochar DK. Hypoglycemic activity of camel milk in chemically pancreatectomized rats an experimental study. International Journal of Diabetes in Developing Countries. 2005; 25:75-79.

40. Al-Numair KS. Type II diabetic rats and the hypolipidemic effect of camel milk. Journal of Food, Agriculture and Environment. 2010; 8:77e81.

41. El-Sayed MK, Al-Shoeibi ZY, Abd El-Ghany AA, Atef ZA. Effects of camel's milk as a vehicle for insulin on glycaemic control and lipid profile in type 1 diabetics. American Journal of Biochemistry Biotechnol. 2011; 7:179-89.

42. Kebir NE, Aichouni A, Zahzeh T. Raw camel milk properties on alloxan-induced diabetic wistar rats. The Romanian Journal of Diabetes Nutrition and Metabolic. 2017; 24(1):041-047.

43. Al-Numair K, Chandramohan SG, Alsaif MA. Effect of camel milk on collagen abnormalities in streptozotocin diabetic rats. African Journal of. Pharmacy and Pharmacology Pharmacol. 2011; 5:238e43.

44. Ateeq MK, Qureshi AS, Usman M, Shahid RU, Khamas WA. Effect of orally administered camel milk in alloxan® induced albino rats: long term study on maternal uterus and neonates selected organs. Pakistan Veterinary Journal. 2019; 29261 /2018.114

45. Mansour AA, Nassan MA, Saleh OM, Soliman MM. PROTECTIVE EFFECT OF CAMEL MILK AS ANTI-DIABETIC SUPPLEMENT: BIOCHEMICAL, MOLECULAR AND IMMUNOHISTOCHEMICAL STUDY. Afr J Tradit Complement Altern Med. 2017 Jun 5;14(4):108-119. doi: 10.21010/ajtcam.v14i4.13. PMID: 28638873; PMCID: PMC5471457.

46. Sboui A, Djegham M, Khorchani T, Hammadi M, Barhoumi K, Belhadj O. Effect of camel milk on blood glucose, cholesterol and total proteins variations in alloxan-induced diabetic dogs. The 'International Journal of Diabetes and Metabolism. 2010; 18:5-11.

47. Zheng Y, Wu F, Zhang M, Fang B, Zhao L, Dong L, Zhou X, Ge S. Hypoglycemic effect of camel milk powder in type 2 diabetic patients: A randomized, double-blind, placebo-controlled trial. Food Sci Nutr. 2021 Jun 29;9(8):4461-4472. doi: 10.1002/fsn3.2420. PMID: 34401094; PMCID: PMC8358379.

48. Wang SY, Liang JP, Song NN, Shao WJ, Heng H. Effect of raw camel milk in type 2 diabetes animal models and patients: Ten months randomised study. Journal of Camel Practice and Research. 2009; 16(1):107–113.

49. Newsholme P, Keane KN, Carlessi R, Cruzat V. Oxidative stress pathways in pancreatic β-cells and insulin-sensitive cells and tissues: importance to cell metabolism, function, and dysfunction. Am J Physiol Cell Physiol. 2019 Sep 1;317(3):C420-C433. doi: 10.1152/ajpcell.00141.2019. Epub 2019 Jun 19. PMID: 31216193.

50. Elagamy E. Effect of heat treatment on camel milk proteins with respect to antimicrobial factors: a comparison with cows' and buffalo milk proteins. Food Chemistry. 2000; 68: 227-232.

51. El-Agamy EI. Camel Milk. Handbook of Milk of Non-Bovine Mammals. 2006; 297–344.

52. Manal S, Eman AM. Evaluation of Therapeutic Efficiency of Camel Milk on Alloxan-induced Diabetic Rats. Journal of American Science. 2014; 10(2):53-60.

53. Agrawal RP, Beniwal R, Kochar DK, Tuteja FC, Ghorui SK, Sahani MS, Sharma S. Camel milk as an adjunct to insulin therapy improves long-term glycemic control and reduction in doses of insulin in patients with type-1 diabetes A 1 year randomized controlled trial. Diabetes Res Clin Pract. 2005 May;68(2):176-7. doi: 10.1016/j.diabres.2004.12.007. Epub 2005 Feb 24. PMID: 15860247.

Citation: Mohammadabadi T, Jain R (2024) Camel milk; A potent superfood for diabetes complications. Food Sci Nutr The 10(1): 035-043.
DOI: https://dx.doi.org/10.17352/jfsnt.000048

54. Alkaladi A, Mohamed A, Kamal R. Application of microwave as an alternative home pasteurization method for camel milk; microbiological, physiochemical, and biochemical study. 2011.

55. Soliman N, Elmetwaly HA. Milk insulin content of Egyptian lactating camels. International journal of food and nutritional science. 2018; 7: 2.1-8.

56. Agrawal RP, Budania S, Sharma P, Gupta R, Kochar DK, Panwar RB, Sahani MS. Zero prevalence of diabetes in camel milk consuming Raica community of north-west Rajasthan, India. Diabetes Res Clin Pract. 2007 May;76(2):290-6. doi: 10.1016/j.diabres.2006.09.036. Epub 2006 Nov 13. PMID: 17098321.

57. Agrawal RP, Beniwal R, Kochar DK, Tuteja FC, Ghorui SK, Sahani MS, Sharma S. Camel milk as an adjunct to insulin therapy improves long-term glycemic control and reduction in doses of insulin in patients with type-1 diabetes A 1 year randomized controlled trial. Diabetes Res Clin Pract. 2005 May;68(2):176-7. doi: 10.1016/j.diabres.2004.12.007. Epub 2005 Feb 24. PMID: 15860247.

58. Mohammadabadi T. The camel milk lactoferrin against different viral infections and COVID-19. Journal of Global Biosciences. 2021; 10(10):9009-9017.

Citation: Mohammadabadi T, Jain R (2024) Camel milk; A potent superfood for diabetes complications. Food Sci Nutr The 10(1): 035-043.
DOI: https://dx.doi.org/10.17352/jfsnt.000048