Boffin Access

Open Access Journal | Volume: 1.1

Biomedical Research and Reviews

ISSN 2631-3944

Effect of Camel Milk on Lipid Metabolism in Type 1 Diabetic Patients

Kamal Omer Abdalla[1*]
Ahmed Abdalla Fadlalla[2]
Mohammed A. Abdellah Ahmed[3]

[1]Department of Biochemistry, Faculty of Medicine and Health Sciences, University of Gadarif, Sudan
[2,3]Department of Pediatrics, Faculty of Medicine & Health Sciences, University of Gadarif, Sudan

Abstract

Treatment of lipid abnormalities and hypercholesterolemia associated with diabetes and non-diabetes is a medical dilemma as current lipid-lowering drugs cause serious and sometimes fatal side effects. There have been a few attempts to explore natural medicines to unravel this dilemma. This study has investigated the efficacy of *Sudanese Camelus dromedary's* raw milk on lipid metabolism in 30 type 1 diabetic patients for 12 month. The patients were randomly divided into two groups. Control group (N=15 patients), received usual medical care and study group (N=15 patients), received the same medical care as for group 1, in addition to 0.5 L/day of raw *dromedary's* camel milk that was consumed by 250 ml twice/day in the morning and evening. Camel milk has proven very effective in improving lipid metabolism in the subjects who received it. It significantly reduced the bad lipids i.e. total cholesterol by 35% (from 138 ± 52 mg/dl to 89.5 ± 29.5 mg/dl; $P < 0.0001$), low density lipoprotein by 78% (from 121.5 ± 56.5 mg/dl to 27 ± 16 mg/dl; $P < 0.0001$), very low density lipoprotein by 33% (from 20.97 ± 10.05 mg/dl to 13.5 ± 5.5 mg/dl; $P = 0.0121$) and triglycerides by 33% (from 100 ± 51 mg/dl to 67.5 ± 27.5 mg/dl; $P = 0.0121$). At the meantime camel milk significantly raised the "good cholesterol" the HDL by 236.5% (from 63 ± 37 mg/dl to 212 ± 72 mg/dl; $P < 0.0001$). This was in contrast to the lipid parameters of the subjects who did not received camel milk as their lipid parameters did not improve. It seems that *dromedary's camel* milk works well with the body's own restorative and regenerative mechanisms to overcome any metabolic aberrations in lipid metabolism that might resulted from diabetes mellitus and from other factors. Camel milk is very well tolerated and it is absolutely safe for human uses. Thus, *dromedary's* camel milk can safely be used as an alternative medicine to treat lipid abnormalities and hypercholesterolemia associated with diabetes or that resulted from other factors. The mechanism by which dromedary's camel milk effectively improves lipid metabolism in type 1 diabetic patients needs further studies.

Keywords

Diabetes; Lipid; Metabolism; Camel; Milk

Introduction

DM is defined as a state of chronic hyperglycemia associated with insulin deficiency and dysfunction of carbohydrate metabolism [1-4]. Dysfunction of carbohydrate metabolism leads to the dysfunction of lipids, proteins and nucleic acids metabolism [1]. Large sector of people in the world especially in the developed world suffer lipid abnormalities [2]. On the other hand, most of the diabetic patients, especially insulin-dependent diabetic adults develop lipid dysfunctions, in particularly hypercholesterolemia [2]. For instance, approximately 53% of the USA adults have lipid abnormalities [5] and the prevalence of dyslipidemia in the USA continues to increase, with the majority of U.S. adults now affected by some form of lipid abnormalities. The association between increased low-density lipoprotein cholesterol (LDL-C) and increased risk for cardiovascular events is well established, with treatment focusing on LDL-C lowering. Other lipid abnormalities are also associated with increased cardiovascular risk (eg: low high-density lipoprotein cholesterol [HDL-C], High Triglycerides [TG] and high non-HDL-C) [5]. Several lipid-lowering medications like "Atorvastatin" known commercially as Lipitor can cause serious side effects that include: digestive problems, blood sugar problems, muscle aches and stiffness, muscle injury, kidney damage, liver damage and brain toxicity [6]. This drug also causes impotency [7]. Moreover, lipid lowering agents interact reversely with several drugs and fruits (i.e. grapefruits) and have been associated with serious biochemical abnormalities of many organs [6]. Brain hemorrhage was seen in a female dog treated for 3 months at 120 mg Lipitor/kg/day. Brain hemorrhage and optic nerve vacuolation were seen in another female dog that was sacrificed in moribund condition after 11 weeks of escalating doses up to 280 mg Lipitor/kg/day. There have been post marketing reports of fatal and non-fatal hepatic failure in patients taking statins, including atorvastatin [6]. Increases in HbA1c and fasting serum glucose levels have been reported with HMG-CoA reductase inhibitors, including Lipitor. In a 2-year carcinogenicity study in rats at dose levels of 10, 30 and 100

Article Information

DOI: 10.31021/brr.20181102
Article Type: Research Article
Journal Type: Open Access
Volume: 1 **Issue:** 1
Manuscript ID: BRR-1-102
Publisher: Boffin Access Limited

Received Date: 16 May 2018
Accepted Date: 15 June 2018
Published Date: 25 June 2018

*Corresponding author:

Abdalla KO
Department of Biochemistry
Faculty of Medicine and Health Sciences
University of Gadarif
Sudan
Tel: +249-119246534
Fax: +249-4481-42578
E-mail: kamalabdalla03@gmail.com

Citation: Abdalla KO, Fadlalla AA, Ahmed MAA. Effect of Camel Milk on Lipid Metabolism in Type 1 Diabetic Patients. Biomed Res Rev. 2018 Jun;1(1):102

mg Lipitor/kg/day, 2 rare tumors were found in muscle in high-dose females: in one, there was a rhabdomyosarcoma and in another, there was a fibrosarcoma. Lipitor is contraindicated for usage during pregnancy and lactation since its safety has not been established during those periods [8]. Till now, there is no drug that has been shown safe to treat lipid abnormalities or to modify the course of diabetic complications [1,2,4,10,9,11]. These force scientists to search for safer alternative therapies for lipid abnormalities and to DM and its complications either as complementary or alternative to existing treatment. An alternative to current treatments of lipid abnormalities associated with diabetes and non-diabetes is *Camelus dromedary's* raw milk [1-4,10]. There have been a few attempts to explore natural medicines to unravel the side effects dilemma of current treatment of lipid dysfunction [1,4]. For many centuries people in the Wilderness, Africa, Middle East and Asia have been using dromedary's camel raw milk to treat various difficulties to treat human diseases [2]. This study investigated the efficacy of *Camelus dromedary's* raw milk on lipid metabolism in 30 type 1 diabetic patients for 12 months.

Study Area and the Study Group

This study was conducted in Gadarif Pediatrics' Teaching Hospital in Gadarif State that is located in the East of Sudan. All children with diabetes or diabetic complications in the state are referred to this hospital. Thirty type 1 diabetic patients were recruited randomly in this study. Baseline data for all the patients were similar in demographic characteristics and variables. The 30 type 1 diabetic patients were divided into two groups, control and study group. Each group consisted of 15 patients; 4 males and 11 females with age range of 13.5 ± 5.5 years old for the both groups and periods of diabetes onset in the of range 8.5 ± 6.5 years. The category of the patients was dictated by the inclusion and exclusion criteria of the study and patients' commitment. Baseline characteristics of participants of the study are presented in table 1. Before commencing the study, all the patients underwent 2 month period of frequent monitoring of their blood sugar, strict diet, and exercise and insulin treatment with the aim to reach euglycemia. After the monitoring period has completed, the control group (N=15 patients), received usual medical care i.e. heath advices, diet, exercise and insulin, and the study group (also N=15 patients), received the same medical care as for group 1, in addition to 0.5L/day of *camelus dromedary's* raw milk that was consumed by 250 ml twice/day in the morning and evening. Patients with any acute metabolic complications like hypoglycemia, ketoacidosis, cardiovascular diseases, renal, heart or acute infections were excluded from the study.

The ethical committee of the Faculty of Medicine and Health Sciences, University of Gadarif, Sudan has approved the protocol of the study. Verbal and written consents were obtained from the participants before their inclusion in the study. Data collection forms were designed including personal data, clinical data, and laboratory findings (Table1).

Materials and Methods

Study Design and Analysis

This is a randomized twelve-month open case control parallel design study. Serum total cholesterol, HDL, LDL, VLDL and triglycerides were measured at the beginning of the study and every 15 days till the end of the study for all the 30 type 1 diabetic patients for 12 month period. Any patients who refused to participate in the study, not fully committed to all stages of the study period or missed during the follow-up have been excluded.

Variables	Control Group (N=15)	Study Group (N=15)
Age (years)	13.5 ± 5.5	13.5 ± 5.5
Male/Female	4/11	4/11
Duration of DM onset	8.5 ± 6.5	8.5 ± 6.5

Table 1: Baseline characteristics of participants of the study

Data Statistical Analysis

Data have been analyzed using SPSS Version 16.01. Descriptive analysis for the personal, clinical and laboratory findings and outcomes have been achieved. The two groups (control and the study groups) have been compared with each other using Mann-Whitney U test after Satterthwaite correction. The variables have been compared at the 12 month to that at start of the study using Wilcoxan matched pair test with cut off value being decided at $p<0.05$.

Collection of *Dromedary's* Camel Milk

Camel milk samples were collected weekly with hand milking in the morning from healthy dromedary's camels that feed on natural grazing in Albutana Rural Area that is located in the North of the Gadarif State. The milk was collected in sterile screw bottles that were kept in cool boxes. On arrival to the hospital, the milk samples were kept in refrigerator and distributed by 0.5 L/day to each of the 15 members of the study group.

Biochemical Investigations

To assess the effect of the dromedary's camel raw milk on lipid metabolism in the 30 type 1 diabetic patients, serum total cholesterol, HDL, LDL, VLDL and TAGs were measured at the beginning of the study and every 15 days for the 30 type 1 diabetic patients for 12 months. The lab tests were performed in duplicates using blood sera, and the mean values for all the analyses were calculated accordingly. Venous patients' blood samples were drawn in plain tubes (BioSystems, USA), blood samples were left to clot and centrifuged for 5 minutes by 5000/ rpm in REMI centrifuge (China) to obtain the sera. All the lab tests were performed according to the approved protocol of the study. Kit reagents for measurement of serum total cholesterol, HDL, LDL, VLDL and TAGs values for in vivo use in the clinical laboratory from BioSystems S.A. (Costa Brava 30, 08030 Barcelona, Spain) were used to measure the lipid parameters according to the manufacturer's instructions. Standard spectrophotometric method using Biosystems BTS 310 Photometer Chemistry Analyzer (Barcelona, Spain) was used to measure the total cholesterol, LDL and TAGs. Spectrophotometer JEN WAY 6305, UK Chemistry Analyzer was used to measure the HDL values. VLDL values were calculated based on the Friedewald equation by dividing triglycerides' values by five.

Results

Results of Total Cholesterol

The mean value of the serum total cholesterol level for the control group at the beginning of the study was 110 ± 55 mg/dl while the mean value of total cholesterol level for the control group at the end of the study was 130 ± 47 mg/dl. These results showed no significant differences in serum total cholesterol levels between the values at the beginning of the study and the values at the end of the study in subjects who did not receive camel milk. (Table 2) shows the results of the serum total cholesterol levels (mg/dl) in the control group at the beginning of the study and during the study period of the study.

The mean value of the serum total cholesterol for the study group before consumption of the camel milk was 138 ± 52 mg/dl, while the mean value of the serum total cholesterol for the study group after consumption of the camel milk was 89.5 ± 29.5 mg/dl. Statistical analysis of the total cholesterol levels for the study group before and after consumption of the camel milk showed significant difference ($P < 0.0001$). These results showed reduction in the total cholesterol levels for the study group by 35% since month 4 of the camel milk consumption. Table 3 shows the results of the serum total cholesterol levels (mg/dl) in the study group before (I) and after consumption of the camel milk (II).

Results of High Density Lipoprotein

The mean value of serum HDL level for the control group at the beginning of the study was 103.5 ± 74.5 mg/dl, while the mean value of HDL level for the control group by the end of the study was 111 ± 72 mg/dl. These results showed no significant differences in the serum HDL level between the values at the beginning of the study and

Patients	Total cholesterol levels (mg/dl) at the beginning of the study period		Total cholesterol levels (mg/dl) during the study period		
	Month 1	Month 2	Month 1	Month 2	Month 3-12
1	132 ± 6.5	145 ± 3	151 ± 3	139 ± 5	131 ± 4
2	143 ± 3.5	150 ± 4	155 ± 2.5	118 ± 4	122 ± 11
3	165 ± 3	172 ± 2.5	160 ± 3	178 ± 2.5	122 ± 28
4	131 ± 15	162 ± 14	158 ± 13	185 ± 12	134 ± 27
5	96 ± 3.5	99 ± 3	101 ± 5	123 ± 2	142 ± 1
6	87 ± 4	65 ± 7	78 ± 3.5	133 ± 4	85 ± 3
7	110 ± 6	116 ± 4	128 ± 2	132 ± 3	130 ± 5
8	92 ± 12	120 ± 14	89 ± 4	91 ± 12	177 ± 11
9	98 ± 9	117 ± 12	123 ± 1	121 ± 3	129 ± 9
10	112 ± 1	129 ± 3	145 ± 4.5	142 ± 5	113 ± 5
11	102 ± 7	117 ± 6	132 ± 10	152 ± 8	166 ± 2
12	119 ± 4	128 ± 2	142 ± 5	167 ± 9	172 ± 7
13	55 ± 8	63 ± 6	65 ± 3	74 ± 2	83 ± 5
14	93 ± 7	111 ± 2	128 ± 9	98 ± 4	113 ± 7
15	78 ± 4	97 ± 2	115 ± 7	103 ± 3	89 ± 5

Table 2: Results of serum total cholesterol levels (mg/dl) in the control group at the beginning of the study and during the study period

Patients	Period					
	Month 1	Month 2	Month 1	Month 2	Month 3	Month 4-12
1	79 ± 3.5	86 ± 2	84 ± 3	78 ± 3	69 ± 3.5	60 ± 2
2	162 ± 2	164 ± 3	116 ± 6	111 ± 8	85 ± 4	69 ± 3
3	142 ± 3	144 ± 4	129 ± 6	118 ± 5	98 ± 2	93 ± 0.7
4	86 ± 6	87 ± 1	96 ± 0.9	88 ± 7	86 ± 4	78 ± 4
5	197 ± 6	190 ± 5	111 ± 4	106 ± 4	105 ± 3	86 ± 5
6	166 ± 1	165 ± 2	113 ± 6	105 ± 4	134 ± 6	88 ± 6
7	152 ± 4	150 ± 3	152 ± 7	146 ± 5	123 ± 5	116 ± 4
8	155 ± 1.5	154 ± 2	149 ± 3	133 ± 2	108 ± 0.0	108 ± 0.5
9	154 ± 4	156 ± 1	155 ± 5	137` ± 7	137 ± 4	119 ± 3
10	145 ± 2	133 ± 5	138 ± 3	131 ± 2	123 ± 5	109 ± 1
11	93 ± 4	99 ± 5	131 ± 3	104 ± 1	100 ± 4	91 ± 3
12	136 ± 6	133 ± 7	127 ± 5	115 ± 2	100 ± 1	94 ± 1
13	128 ± 0.0	128 ± 0.5	101 ± 7	93 ± 6	88 ± 3.5	78 ± 2
14	145 ± 4	140 ± 3	119 ± 12	100 ± 9	97 ± 8	89 ± 6
15	146 ± 3	149 ± 5	101 ± 7	78 ± 5	74 ± 4	71 ± 2

Table 3: Results of serum total cholesterol levels (mg/dl) in the study group before (I) and after (II) consumption of the camel milk

the values at the end of the study in subject from control group. Table 4 shows the results of serum HDL levels (mg/dl) in the control group at the beginning of the study and during the study period.

The mean value of the HDL for the study group before consumption of the camel milk was 63 ± 37 mg/dl while the mean value of the HDL for the study group after consumption of the camel milk was 212 ± 72 mg/dl. Statistical analysis of the HDL levels for the study group before and after consumption of the camel milk showed significant difference ($P < 0.0001$). These results showed an increase in the mean value of the HDL level for the study group by 236.5% after 3-4 months of the camel milk consumption. Table 5 shows the results of the serum HDL levels (mg/dl) in the study group before and after consumption of the camel milk.

Results of the Low Density Lipoprotein

The mean value of serum LDL level for the control group at the beginning of the study was 73 ± 41 mg/dl, while the mean value of the LDL level for the control group by the end of the study was 66 ± 34 mg/dl. These results showed no significant differences in the serum LDL levels between the values at the beginning of the study and the values at the end of the study in subjects from control group. Table 6 shows the results of the lipid metabolism parameters levels of the control group at the beginning of the study and by the end of the study.

The mean value of the LDL for the study group before consumption of the camel milk was 121.5 ± 56.5 mg/dl while the mean value of the LDL for the study group after consumption of the camel milk was 27 ± 16 mg/dl. Analysis of the LDL levels before and after consumption of the camel milk in the study group showed significant difference ($P < 0.0001$). These results showed a reduction in the LDL levels for all individuals of the study group by 78% after 3 months of camel milk consumption. Table 7 shows the summary of the effects of the dromedary's raw camel milk on the lipid metabolism.

Results of Very Low Density Lipoprotein

The mean value of serum VLDL level for the control group at the beginning of the study was 17 ± 5.6 mg/dl, while the mean value of VLDLs for the control group by the end of the study was 26 ± 6.4 mg/dl. These results showed no significant differences in the VLDL levels between the values at the beginning of the study and the values at the end of the study in the control group. Table 6 shows the results of the lipid metabolism parameters levels of the control group at the beginning of the study and by the end of the study.

The mean value of the serum VLDL level for the study group before consumption of the camel milk was 20.15 ± 10.05 mg/dl while the mean value of the serum VLDL level for the study group after consumption of the camel milk was 13.5 ± 5.5 mg/dl. Analysis

Patients	HDL levels at the beginning of the study		HDL levels during the study period		
	Period				
	Month 1	Month 2	Month 1	Month 2	Month 3-12
1	52.5 ± 3	75 ± 4	95 ± 2	102 ± 5	112 ± 0.5
2	79 ± 26	131 ± 2	134 ± 4	130 ± 0.5	131 ± 0.0
3	75 ± 1	77 ± 0.5	78 ± 11	78 ± 13	105 ± 0.0
4	67 ± 2	55 ± 4	78 ± 4	52 ± 26.5	105 ± 1.5
5	36 ± 2	37 ± 7	36 ± 5	40 ± 1	36.5 ± 2
6	85 ± 4	90 ± 5	94 ± 2	78 ± 25.5	131 ± 5
7	29 ± 7	29 ± 6	32 ± 1	37 ± 1	39 ± 0.5
8	27 ± 2	31 ± 3	29 ± 1.5	37 ± 2	39 ± 1
9	31 ± 6	29 ± 1	38 ± 4	37 ± 1	39 ± 1
10	178 ± 4	170 ± 1	168 ± 1	166 ± 8.5	183 ± 9
11	32 ± 2.5	28 ± 3	32 ± 2	52 ± 3.5	59 ± 2
12	41 ± 4	49 ± 1	43 ± 3	67 ± 11	89 ± 2
13	39 ± 5	47 ± 1	46 ± 0.0	50 ± 3	56 ± 2
14	29 ± 7	36 ± 2	40 ± 2	47 ± 3	52 ± 1
15	40 ± 2	38 ± 2	41 ± 0.5	56 ± 3	61 ± 2

Table 4: Results of serum HDL levels (mg/dl) in the control group at the beginning of the study and during the study period

Patients	Period					
	I		II			
	Month 1	Month 2	Month 1	Month 2	Month 3	Month 4-12
1	53 ± 13	79 ± 3	105 ± 20	184 ± 18	210 ± 13	237 ± 10
2	79 ± 3	73 ± 6	105 ± 26	158 ± 22	198 ± 9	217 ± 11
3	79 ± 10.5	100 ± 9	53 ± 20	93 ± 18	126 ± 15	156 ± 13
4	53 ± 7	67 ± 5	105 ± 24	154 ± 16	199 ± 13	225 ± 11
5	27 ± 4	35 ± 1	99 ± 29	158 ± 26	179 ± 13	206 ± 12
6	78 ± 6	89 ± 5	110 ± 30	210 ± 25	235 ± 13	261 ± 9
7	53 ± 1.5	56 ± 2	201 ± 16	234 ± 15	253 ± 16	284 ± 14
8	37 ± 4	45 ± 3	34 ± 22	78 ± 19	110 ± 15	140 ± 18
9	54 ± 1	52 ± 3	98 ± 23	145 ± 22	180 ± 15	210 ± 20
10	39 ± 1.5	42 ± 2	79 ± 22	123 ± 17	154 ± 19	192 ± 16
11	75 ± 3	68 ± 3.5	114 ± 15	145 ± 16	189 ± 14	218 ± 12
12	73 ± 1	75 ± 2	45 ± 22	89 ± 16	130 ± 10	151 ± 9
13	36 ± 4	29 ± 3.5	79 ± 23	165 ± 22	192 ± 12	216 ± 10
14	53 ± 1	55 ± 2	102 ± 22	167 ± 12	199 ± 8	214 ± 7
15	35 ± 5	44 ± 3	89 ± 13	136 ± 14	182 ± 12	207 ± 15

Table 5: Results of serum HDL levels (mg/dl) in the study group before (I) and after (II) consumption of the camel milk

Lipid Metabolism Parameters	Levels at the beginning of the study	Levels by the end of the study	*P* value	Comments
Total Cholesterol	110 ± 55	130 ± 47	*P > 0.05*	No improvement
HDL	103.5 ± 74.5	111 ± 72	*P > 0.05*	No improvement
LDL	73 ± 41t	66 ± 34	*P > 0.05*	No significant difference
VLDL	17 ± 5.6	26 ± 6.4	*P > 0.05*	No improvement
TAGs	85 ± 27	130 ± 32	*P > 0.05*	No improvement

Table 6: Comparison of the lipid metabolism parameters levels (mg/dl) of the control group at the beginning of the study and by the end of the study

of the VLDL levels for the study group before and after consumption of the camel milk showed significant difference (P = 0.0121). These results showed reduction in the VLDL levels for the study group by 33% after 3 months of the camel milk consumption. Table 7 shows the summary of the effects of the dromedary's raw camel milk on the lipid metabolism.

Results of Triglycerides

The mean value of the serum TAGs level in the control group at the beginning of the study was 85 ± 27 mg/dl, while the mean value of the TAGs in the control group by the end of the study was 130 ± 32 mg/dl. These results showed no improvement in the TGs values compared to its values at the beginning of the study. Table 6 shows the results of the lipid metabolism parameters levels of the control group at the beginning of the study and by the end of it.

The mean value of the serum TAGs level for the study group before consumption of the camel milk was 100 ± 51 mg/dl while the mean value of the TAGs level for the study group after consumption of the camel milk was 67.5 ± 27.5 mg/dl. Analysis of the TAGs levels for the study group before and after consumption of the camel milk showed

S. no	Lipid metabolism parameters	Serum level of lipid metabolism parameters before the beginning of consumption of the camel milk	Serum level of lipid metabolism parameters after 12 month of consumption of the camel milk	*P* value	Effects after 12 month of camel milk consumption
1.	**Total cholesterol**	138 ± 52 mg/dl	89.5 ± 29.5 mg/dl	$P < 0.0001$	Reduction in total cholesterol level by 35%
2.	**HDL**	63 ± 37 mg/dl	212 ± 72 mg/dl	$P < 0.0001$	Increase in HDL level by 236.5%
3.	**LDL**	121.5 ± 56.5 mg/dl	27 ± 16 mg/dl	$P < 0.0001$	Reduction in LDL level by 78%
4.	**VLDL**	20.97 ± 10.05 mg/dl	13.5 ± 5.5 mg/dl	$P = 0.0121$	Reduction in VLDL level by 33%
5.	**TGs**	100 ± 51 mg/dl	67.5 ± 27.5 mg/dl	$P = 0.0121$	Reduction in TGs level by 33%

Table 7: Summary of the effects of the *dromedary's* raw camel milk on the lipid metabolism

significant difference (P = 0.0121). These results showed reduction in the TAGs levels for the study group by 33% after 4 months of the camel milk consumption. Table 7 shows the summary of the effects of the dromedary's raw camel milk on the lipid metabolism.

Discussion

The main treatment of type 1 diabetes mellitus is insulin replacement via parenteral routes which is far from satisfactory. In addition to many drawbacks of parenteral insulin treatment of DM [1,4] exogenous insulin cannot wholly replace the indigenous insulin and meet all the body's need for the insulin. And this might be the main reason of lipid abnormalities and other metabolic aberrations in type 1 diabetic patients who use parenteral insulin therapy, although they might have controlled blood sugars. Insulin is a key hormone in the regulation of intermediary metabolism; it organizes the use of fuels for either storage or oxidation [12-16]. Through these activities, insulin has profound effects on both carbohydrate and lipid metabolism, and significant influences on protein and mineral metabolism. Consequently, derangements in insulin signaling have widespread and devastating effects on many organs and tissues [24]. Metabolic pathways for utilization of fats and carbohydrates are well integrated. Considering insulin's profound effects on carbohydrate metabolism, it stands to reason that insulin also has important effects on lipid metabolism, including that insulin promotes synthesis of fatty acids in the liver [16].

Treatment of lipid abnormalities and hypercholesterolemia associated with diabetes and non-diabetes is a medical dilemma as current lipid-lowering drugs cause serious and sometimes fatal side effects. There have been a few attempts to explore natural medicines to unravel this dilemma. For many centuries people in the Wilderness, Africa, Middle East and Asia have been using dromedary's camel milk to treat various incurable human diseases. This study has investigated the effects of Sudanese dromedary's camel milk on the doses of insulin to obtain euglycemia and lipid profile in 30 type 1 diabetic patients with ages between 8-19 years old who were randomly recruited in this study in Gadarif State, Diabetic Centre of Gadarif Pediatrics' Teaching Hospital in Gadarif city that is located in the East of Sudan. Twenty two (22) of the patients are females and 8 are males. The 30 patients were divided randomly into 2 equally groups (control and the study group by 15 patients, 4 male and 11 females in each). The patients are close in gender, ages and ethnicity.

The 30 patients followed strict diet, exercise and insulin treatment for 2 months with attempts to obtain euglycemia. After this period, the patients were randomly divided into the previously mentioned 2 groups. The control group received usual medical care i.e. heath advices, diet, exercise and insulin and group 2 study group received the same medical care as for the control group in addition to 0.5 L/day of raw dromedary's camel milk for each member of the group for 12-month period. The milk was consumed by 250 ml/twice a day in the morning and evening. Patients with any acute metabolic complications like hypoglycemia, ketoacidosis, cardiovascular diseases, renal, heart or acute infections were not included in the study.

Our previous published study has revealed that camel milk caused significant reduction in the insulin dosages necessary to obtain euglycemia in the study group. These were in contrast to the results of the subjects who did not receive camel milk as their insulin doses necessary to maintain euglycemia increased significantly compared to the original doses [1].

Significant improvements were occurred in the lipid metabolism of the study group members (subjects who did receive camel milk) with significant decrease in the bad lipids (cholesterol and LDL) and significant increase in the good lipids (HDL). Our findings showed a reduction in the total cholesterol values by 35% for the individuals of the study group since the 4th month of the camel milk consumption. This was in contrast to the results of the total cholesterol results for the control group where no improvement in the total cholesterol values were observed, a rather there was an increase in the total cholesterol levels of the control group (by 18%).

As mentioned previously, high levels of cholesterol are closely associated to diabetes. Cholesterol is essential for life. However excess cholesterol or hypercholesterolemia is associated with cardiovascular diseases [17]. Hypercholesterolemia is associated with several cardiovascular diseases such as hypertension, myocardial infarction, arteriosclerosis, angina pectoris, heart attack or stroke [18]. In this respect dromedary's camel milk has a protective effect against cardiovascular diseases.

Dromedary's camel milk significantly increased HDL (good lipids) of the study group. Our findings showed significant increase in the mean value of the HDL for the study group by 236.5% after 3-4 months of the camel milk uses. This was in contrast to the results of measurements of the HDL of the subjects who did not receive the camel milk where no improvement was observed in their HDL values. HDL "good" cholesterol" removes excess cholesterol in the arteries and transports it back to the liver for excretion or re-utilization, and thus preventing the arteries from clogging [19-22]. Improving of HDL values of the study group as a result of the camel milk consumption facilitates regulation of blood cholesterol and contribute in the prevention of CHD.

Camel milk has shown significant reduction in the LDL (bad lipids) levels in the individuals of the study group. Our findings showed significant reduction in the LDL values for the individuals of the study group by 78% after 3 month of camel milk consumption. This was in contrast to the results of the LDL values for the control group where their LDL values did not improve.

Also, camel milk significantly reduced the VLDL values in the individuals of the study group. Our findings showed significant reduction in the VLDL values for the study group by 33% after 3 months of the camel milk uses. This is in contrast to the results of VLDL of the control group where their VLDL did not improve. LDLs and VLDLs are known as the "bad" cholesterols [23]. VLDLs are carriers of cholesterol and TAGs [24,23]. Elevated plasma TAGs and VLDLs are directly associated with the risk of atherosclerotic heart diseases [20]. During circulation, VLDL is converted in the

bloodstream into LDL. Hypercholesterolemia is associated with a high level of LDL and low level of HDL [20,21]. The strong effects of dromedary's camel milk to decrease the LDLs and VLDLs values form additional protection against lipid abnormalities and CHD.

Also, camel milk significantly reduced the TAGs values in the individuals of the study group. Our findings showed reduction in the TAGs values for the study group by 33% after 4 months of the camel milk uses. This was in contrast to the TAGs values of the control group where their results showed no improvement in the TGs values compared to the initial values. TAGs are the storage lipids (fatty acids) in animal and plant cells [24]. Increase in TAG-rich lipoproteins is one of the symptoms clustered in metabolic syndrome and is associated with increased plasma free fatty acid level derived from central obesity and insulin resistance. Increase in TAG-rich lipoproteins is also related to several coronary risk factors such as remnant hyperlipidemia, decreased HDL-cholesterol, elevated small dense LDL, postprandial hyperlipidemia, and hypercoagulability [20]. High doses of parenteral insulin therapy improved carbohydrate metabolism in the subjects who did not receive camel milk but it did not improve lipid metabolism [1], this dictates the necessity to prescribe lipid-lowering drugs like Lipitor for the diabetic patients who suffer hypercholesterolemia.

Significant improvement in lipid metabolism of the study group after consumption of the dromedary's camel milk may be postulated to the fact that Camelus dromedary's milk contains high levels of insulin as mentioned previously [1]. Also,it contains little fat about 2% and this fat consists mainly of polyunsaturated fatty acids that are completely homogenized and gives the milk its smooth white appearance [2]. This contributes to the control of blood cholesterol. On the other hand, camel milk has high concentrations of volatile acids especially the essential fatty acid, the linoleic acid and other polyunsaturated fatty acids, which are essential for human nutrition [25]. Fats in camel milk dispersed as small micelles instead of a layer that are non-reactive to acid. This might explain the relatively good solubility, readily absorption and metabolism of camel milk compare to the milk of other mammals.

Camel milk is very nutritious, tonic and has a high satiety value. It possesses hypoallergenic, antibacterial, antiviral, hypoglycemic and other medicinal properties and fully compatible with human milk [2]. Camel milk is the most beneficial for human nutrition. Nutrition plays a vital role in health maintenance and in the prevention of diseases.

Camelus dromedary's milk contains high levels of ascorbic acid (vitamin C) of 5.7-9.8%, which is 3 times greater than of other mammalian milks. Camel milk is also rich in other vitamins such as B12, E, B1, B2 and A. Camel milk has high concentrations of minerals such as calcium, iron, magnesium, cupper, manganese, sodium, phosphorus, zinc and potassium [4]. It is known that vitamins A, C and E possess anti-oxidant properties and remove free radicals. Removal of free radicals by camel milk prevents tissues damage including the β-cells of the pancreas [26]. Free radicals play a role in the enhancement of oxidation of LDLs and the exhaustion of HDLs. The two opposing processes are atherogenic. The high concentrations of antioxidants in camel milk and the effects of camel milk in lowering body fats in healthy individuals and in patients with IDDM might strengthen the insulin receptors to become more responsive to available insulin in camel milk [4].

In conclusion, camel milk has been proven very effective in improving lipid metabolism in the subjects who received it. This was in contrast to the lipid parameters of the subjects who did not receive camel milk as their lipid parameters did not improve. It seems that dromedary's camel milk works well with the body's own restorative and regenerative mechanisms to overcome any metabolic aberrations in lipid metabolism that might resulted from diabetes mellitus and from other factors. Camel milk is very well tolerated and it is absolutely safe for human uses. Thus, dromedary's camel milk can safely be used as an alternative medicine to treat lipid abnormalities and hypercholesterolemia associated with diabetes or resulted from other factors. The mechanism by which dromedary's camel milk effectively improves lipid metabolism in type 1 diabetic patients needs further studies.

Acknowledgements

This work was supported partially by a research grant from Sudan Ministry of Higher Education & Scientific Research. The authors are thankful to Gadarif Health Insurance Fund for the permission to use their premises to do some of the lipid analyses free of charge and also they are thankful to Mrs. Amal Awad Aljeed for her assistance in following up with the patients' analyses and for delivering the camel milk to the patients. Also, the authors are thankful to Dr. Faiz Hamadelneel (King Khalid University, Saudi Arabia), Dr. Yassir Fadol and Mr. Manhal Gaafar (University of Gadarif, Sudan) for their assistance to perform the statistical analysis.

Conflict of Interests

The authors declare that, they do not have any conflict of interest regarding this study.

Author Contribution

Abdalla KO conceived and designed the study and wrote the final manuscript. Ahmed A Fadlalla and Mohammed A Abdellah Ahmed conducted the clinical follow up of the patients in the clinic that include adjusting and prescribing the insulin doses for the patients and contributed in the study design and in writing the final manuscript; all authors have implemented the overall supervision and the implementation of the project including its data collection and analysis. All authors have read and approved the final version submitted.

References

1. Abdalla KO, Fadlalla AA. Effects of Sudanese Dromedary's Camel Raw Milk on Insulin Doses and Carbohydrate Metabolism in Type 1 Diabetic Patients. J Biomol Res Ther. 2018;7:159.
2. Abdalla KO. Camel milk is an alternative and a complementary treatment to the current parenteral insulin therapy of insulin-dependent diabetes mellitus. Gezira journal of health sciences. 2016 Dec;12(2):65-87.
3. Abdalla KO. Camel milk is an alternative and a complementary treatment to the current parenteral insulin therapy of type 1 diabetes mellitus. The 6th Annual Conference-the Medical & Health Sciences Studies, University of Khartoum. 2015;229.
4. Abdalla KO. An overview of the therapeutic effects of camel milk in the treatment of type 1 diabetes mellitus. J Bio-molecular Research Therapeutics.2014 Mar;3(3):118.
5. Toth PP, Potter D, Ming EE. Prevalence of lipid abnormalities in the United States: the National Health and Nutrition Examination Survey 2003-2006. J Clin Lipidol. 2012 Jul-Aug;6(4):325-30.
6. LIPITOR. https://www.rxlist.com/lipitor-drug.htm#P.
7. Mohamed Mohamed Khair. Treatment experiences, Alsahafa news paper. 2013 Feb.
8. Lipitor (atorvastatin). https://www.iodine.com/drug/atorvastatin
9. Sboui A, Djegham M, Khorchani T, Hammadi M, Barhoumi K,et al. Effect of camel milk on blood glucose, cholesterol and total proteins variations in alloxan-induced diabetic dogs. Int'l J. of diabetes and metabolism. 2010;8:5-11.
10. Abdalla KO (2016, 2012). Scientific monograph: Treatment of incurable ailments with camel's milk and urine by scientific research (book in Arabic). ISBN: 5-15-64-99942-978. Published by Sudan Ministry of Higher Education & Scientific Research and International University of Africa in Sudan.
11. Chaillous L, Carel JC, Thivolet C. Lack of effect of one year oral insulin therapy in recent-onset type 1 diabetes: Results of a multicentric randomized controlled trial. Diabetologia; 1999;42:A62- A62.
12. Stryer Lubert. Biochemistry, 4th Edi., New York: WH Freeman and Company. 2005:773-774.
13. Sircar S. Medical Physiology. Stuttgart: Thieme Publishing Group. 2007;537-538.

14. Voet D, Voet JG, W Pratt C. Fundamentals of Biochemistry .2nd Edi., John Wiley and Sons, Inc. 547, 556.
15. Rhoades RA, Bell DR. Medical physiology: principles for clinical medicine. 3rd edi., Philadelphia: Lippincott Williams & Wilkins. 2009;644-647.
16. Najjar S."Insulin Action: Molecular Basis of Diabetes". Encyclopedia of Life Sciences. John Wiley & Sons.2003 Jan.
17. Lecerf JM, de Lorgeril M."Dietary cholesterol: from physiology to cardiovascular risk". British J of Nutrition. 2011;106(1):6-14.
18. Ulmer H, Kelleher C, Diem G, Concin H. "Why Eve is not Adam: prospective follow-up in 149650 women and men of cholesterol and other risk factors related to cardiovascular and all-cause mortality". J Women's Health (Larchmt). 2004 Jan;13(1):41-53.
19. Lewis GF, Rader DJ."New insights into the regulation of HDL metabolism and reverse cholesterol transport" Circ. Res. 2005;96(12):1221-1232.
20. Olson RE. "Discovery of the lipoproteins, their role in fat transport and their significance as risk factors". J Nutrition. 1998 Feb;128(2):439S-443S.
21. Brown MS, Goldstein JS. How LDL receptors influence cholesterol andatherosclerosis.SciAm. 1984 Nov;251(5):57-66.
22. Gordon T, Castelli WP, Hjortland MC, Kannel WB, Dawber TR. High density lipoprotein as a protective factor against coronary heart disease. Am J Med. 1977 May;62(5):707-714.
23. Rhodes CM, Stryer L, Tasker R. Biochemistry 4th Edi., San Francisco: W.H. Freeman. 280, 703.
24. Tymoczko JL, Berg T, Stryer L, Berg JM. Biochemistry. San Francisco: W.H. Freeman. 2002; 726-727.
25. Agrawal RP, Beniwal R, Sharma S, Kochar DK, Tuteja FC, et al. Effect of raw camel milk in type 1 diabetic patients: 1 year randomized study. Journal of Camel Practice and Research. 2005;12(1):27-35.
26. El-Agamy EI, Ruppanner R, Ismail A, Champagne CP, Assaf R. Antibacterial and antiviral activity of camel milk protective proteins. J Diary Res. 1992 May;59(2):169-75.