# The Potential of Camel Milk and Extracts of Major Plants Browsed by the Animal for Diabetes Treatment

**Negussie Bussa[1]*, Anteneh Belayneh[2], and Merga Deressa[3]**

[1]Department of Food Science and Post Harvest Technology, Institute of Technology, Haramaya University, P. O. Box 138 Dire Dawa, Ethiopia
[2]Department of Biology, College of Natural and Computational Sciences, Haramaya University, P. O. Box 282 Dire Dawa, Ethiopia
[3]School of Nursing, College of Health and Medical Sciences, Haramaya University, P. O. Box 138 Dire Dawa, Ethiopia

**Abstract:** Diabetes is one of the world's greatest healthcare challenges affecting millions of people, and recognized as one of an emerging, and challenging public health problems in Ethiopia. This study was done to evaluate the potential of camel milk and extracts of major plants browsed by the animal for the treatment of diabetes. Fresh samples of both camel milk and major plant species frequently browsed by camels were collected from Babile (Oromia Region) and Shinille (Somali region). Taxonomic identification of the plant species browsed by the animal was made, the leaves were dried under shade, and pulverized for nutrient analysis and extraction. Crud extracts were kept under a low temperature ($4^0$ C) until fed to experimental rats. Eighty adult Winstar rats were divided into sixteen groups and group one through twelve were injected Streptozotocin (STZ) for diabetic whereas groups thirteen through sixteen kept non-diabetic. Group one through six were fed on the plant extracts. Groups seven through sixteen were diabetic and non-diabetic male and female treated with camel milk, Glibenclamide (500 µg/kg, p.o.), and aqueous solutions. Blood glucose levels of the rats were measured before STZ, 72 hours after STZ, and every week until the end of the experiment. Camel milk feeding showed glucose level reduction by 20.5% in male rate and 21.1% in female rate. There is no significant difference in glucose level reduction between male and female ($p>0.05$). Extracts from *Acacia brevispica* and *Dichrostachys cinerea* showed 28.1% and 21% of glucose level reductions, respectively in diabetic rats. *Balanites aegyptiaca* showed 55.4% of glucose level reduction, significant change ($p>0.05$). This preliminary finding indicated that using camel milk in the diet could be alleviate diabetes, which is encouraging for further research work with more parameters and better laboratory facilities.

**Keywords**: Babile; Blood Glucose; Glibenclamide; Shinille; Streptozotocin; Winstar rats

## 1. Introduction

Diabetes mellitus is one of the most severe and incurable metabolic disorders characterized by increased blood glucose level as a result of an absolute or relative lack of insulin and failure of insulin to act on its targets tissue (Valiathan, 1998). It is one of the world's greatest healthcare challenges currently affecting more than 371 million people globally, and 4.8 million people died due to diabetes in 2012 (IDF, 2012). Diabetes is expected to affect 552 million people by 2030 of which more than 90% of diabetic patients will have Type 2 diabetes (IDF, 2011a). Moreover, 183 million people (50%) with diabetes are undiagnosed and 80% of people with diabetes live in low and middle-income countries (IDF, 2011b). In Africa, about 12.1 million people were estimated to be living with diabetes in 2010, and this is projected to increase to 23.9 million by 2030 (Motala and Ramaiva, 2010). In Ethiopia, national data on the prevalence and incidence of diabetes mellitus (DM) are not well organized so far. However, patient attendance rates and medical admissions in hospitals were rising (Tamiru and Alemseged, 2010). Ethiopia was ranked third among the ten top countries in Africa with 1.4 million DM cases and estimated prevalence of 3.32% by year 2012 (IDFA, 2012). Other studies indicated its prevalence among adults aged 35 years and above was 5.1% [95% CI: 3.8, 6.4] for urban and 2.1% [95% CI: 1.2, 2.9] for rural dwellers (Solomon *et al*., 2014). As a whole, prevalence of the disease in Africa was estimated as 4.9% (IDF, 2013). Diabetes mellitus was recognized as one of the emerging public health problems in Ethiopia (Solomon *et al*., 2014).

Camel milk contains insulin-like and protective protein used for the treatment of many ailments like diabetes, autism, and diarrhea and possesses anti-tumors properties (Gul *et al*., 2015). Moreover, it is endowed with very strong immune system (Gader and Alhaider, 2016). Camel milk so called white gold of the desert is more similar to human milk than any other milk and differs from other ruminant milk because it contains low cholesterol, low sugar, high minerals (sodium, potassium, iron, copper, zinc and magnesium), high vitamin C, protective proteins like as lactoferrin, lactoperoxidase, immunoglobulins, lysozyme (Yadav *et al*., 2015).

Developing oral administration of insulin is a challenge due to the acidic medium in the stomach that destroys insulin (Ikebukuro *et al*., 2002). Experiments done

*Corresponding Author. E-mail: negussiebussa@yahoo.com


ISSN 1993-8195 (Online), ISSN 1992-0407 (Print)

around the world showed that camel milk was successfully tested on laboratory animals and clinical studies on diabetic patients resulted in a drastic fall in their blood sugar levels (Rastellini *et al*., 1997). Several reports indicated that daily drinking of camel milk may supplement as much as 60% of the insulin in diabetic patients (Yagil and Van Creveld, 2000; Amal, 2015). Insulin in camel milk is safe and efficacious in improving long-term glycemic control in diabetic patient (Kula, 2016). Camel milk has traditionally been used to treat diabetes because it does seem to contain high levels of insulin or an insulin-like protein, which appears to be able to pass through the stomach without being destroyed (Agrawal *et al*., 2002). Camel milk is not neutralized by the acidic juices in the stomach, unlike other forms of orally administered insulin sources obtained through foods (Amal, 2015).

The annual camel milk production in Ethiopia is estimated as 75,000 tones that ranks second in camel milk production in the world next to Somalia (Felleke, 2003). Camel's milk constitutes an important part of the diet in pastoral societies (Sallam *et al*., 2008). Despite the important contribution of camel milk to pastoralists living in the lowlands of the Ethiopia, little emphasis is put on finding out the potential of camel milk in healing some of the ailment like diabetes (Agrawal *et al*., 2002; Asresie and Yusuf, 2014; Amal, 2015).

The research reports showed wide ranges of variation on quality and composition of camel milk (Khalid *et al*., 2007; Konuspayeva *et al*., 2009; Omar and Hamad, 2010), which are associated with the diversity of forage species browsed by camels (Khaskheli *et al*., 2005; Omar *and* Hamad, 2010). For example, the milk normally has a sweet and sharp taste, but sometimes can have salty taste due to the type of plants browsed by camels (Khaskheli *et al*., 2005). Due to such diverse quality and composition, camel milk was reported to have different therapeutic properties, such as anti-carcinogenic (Magjeed, 2005), anti-diabetic (Agrawal *et al*., 2007), and anti-hypertensive (Quan *et al*., 2008).

Therefore, given the increasing numbers of people affected by diabetes, production of large quantities of camel milk, and lack of awareness on its healing power in Ethiopia, this study was designated to elucidate the potential of camel milk and associated plant species browsed by the animal for the treatment of diabetes. The study was aimed at finding easily available alternative options for treating the disease, add more value to camel milk, and improve the livelihood of camel rearing pastoralist communities in the country.

## 2. Materials and Methods

### 2.1. Camel Milk

Fresh camel milk was purchased from local markets of Babile Woreda, stored in milk coolers during transport and kept in a refrigerator ($4^0$ C) for daily consumptions by experimental white Winstar rats.

### 2.2. Experimental Animal

Adult white Winstar rats were purchased from Ethiopian Public Health Institute and bred on the campus of Haramaya University in a cage. The first generation at the ages of 75 to 90 days was used, which were housed in the laboratory animal house with fresh water in feeding bottles and standard rat chow available *ad libitum*. They were maintained in 12-hour light and dark cycles at 22–$25^0$C room temperature. The use of the animals for laboratory purposes was approved by the ethical committee of Haramaya University, following the established ethical procedures on the use of animals for experimental purposes in Ethiopia.

### 2.3. Sampling Plant Species Browsed by Camels

The major plants frequently browsed by camels were collected from the study areas namely Erer valley in Babile Woreda of Oromia region and Shinile Woreda of Somali region given attention for plant parts browsed by the animal and inflorescence and fruits for identification. We targeted the Woredas because of the comparatively high number of camels reared in the areas. Informants did identification and ranking of top browsed plant species. A total of 75 informants (64 males and 11 females) were identified using a random sampling (camel herders) and a systematic random sampling methods for key informants (elderly camel herders). Taxonomic identification of the plant species was done at Haramaya University Herbarium. The collected plant materials were dried under shade to protect the loss of any compound due to sun radiation, and ground by means of IKA Universal Mixer M20. Nutrient analysis was done in animal nutrition laboratory of Haramaya University. The rest of the powders were stored for further analysis of plant extracts for eliciting information concerning their effect on diabetic rats.

### 2.4. Extraction from Browses of the Plant Species

20.0 g of the dried plant powder was weighed in a 100 ml Erlenmeyer flask with 70 ml of hexane of 99% purity grade (the plant sample had to be submerged in a solvent) for pre-extraction. The Erlenmeyer was placed in a sonicator-bath (Branson 8210 or some other type) and sonicated at $40^0$ C for 30 minutes. The mixture was filtered using filter paper, followed by washing the Erlenmeyer with 20 ml of hexane and then with 50 ml of hexane. The filtrate was poured in a round-bottomed flask and the solvent was concentrated in vacuum (at about 11 mm Hg) up to 5-10 ml by means of Rota vapor, utilizing a water bath at $40^0$ C. This residue was brought in a 30ml vessel to let the solvent evaporate. The open vessel was left overnight in a well ventilated hood in order to evaporate the last traces of the solvent in the hexane pre-extract. The solids, collected on the filter, were broken up and dried in the air overnight in the hood. The dried material was extracted in the same way with methanol-water (90:10). The dried material from

the filters was placed in an Erlenmeyer of 100 ml to which 70 ml of 90% methanol was added. The mixture was sonicated as above at $40^0$C for 30 minutes, after which it was filtered, followed by washing the Erlenmeyer with 20 ml of 90% methanol. The filtrate was poured in a round-bottomed flask and the solvent was evaporated in vacuum completely. The dry 90% methanol extract was dissolved in 100% methanol by using the sonicator-bath and poured in a 30 ml vessel to let it evaporate overnight in the hood.

**2.5. Chemicals**

Streptozotocin (STZ) which was obtained from Sigma-Aldrich, Mumbai, India was used in this study to induce diabetes to white Winstar rats under experiment. Each vial of sterilized STZ powder contained 1 gram of STZ active ingredient with the chemical name, 2-Deoxy-2-[[ (methylnitrosoamino)-carbonyl] amino]-D glucopyranose and 200 mg citric acid. It was prepared in 1-gram vials and kept in a cold store (Refrigerator temperature at 2-8° C) away from light as recommended by Weiss (1982). STZ possibly damages pancreatic β cells and reduces insulin production (Aminu *et al.*, 2016). After 72 hours of injecting STZ into the rats, blood glucose rose and the rats became diabetic. When β cells are damaged and blood glucose level is increased, this situation creates hypoinsulinemia (Lenzen, 2008). After the injection of STZ to rats, the blood glucose levels were raised in all rats. This means that blood glucose levels were beyond normal levels and all rats became hyperglycemic except the control rats fed on normal food (rat chow) only.

**2.6. Chemical Composition of Browses**

Proximate composition of the plant parts and rat chow for moisture content, total ash, crude protein, crude fiber, and crude fat were determined using AOAC official methods of 925.05, 923.03, 979.09, 962.09 and 4.5.01; respectively (AOAC, 2000). Utilizable carbohydrate and total energy contents in the plant part and rat chow were calculated following the official methods of AACC (AACC, 2000).

**2.7. Experimental Design**

The experimental rats were divided into three main groups, i.e. plant extractions taste group, camel milk taste male group and camel milk taste female group. Plant extract taste groups were diabetic rats treated with extracts of six plant species. Camel milk taste male group and camel milk taste female group were diabetic and non-diabetic rats treated with camel milk, Glibenclamide (500 µg/kg, p.o.), and aqueous solution (Table 1). Glibenclamide is a standard antidiabetic drug.

Table 1. Experimental Group and their Treatments.

| No | Group | Site/Sex | Condition of the Rats | Treatment |
|---|---|---|---|---|
| 1 | BE1 | Babile | Diabetic | Extract of *Acacia brevispica* |
| 2 | BE2 | Babile | Diabetic | Extract of *Dichrostachys cinerea* |
| 3 | BE3 | Babile | Diabetic | Extract of *Acacia nilotica* |
| 4 | SE1 | Shinille | Diabetic | Extract of *Acacia tortilis* |
| 5 | SE2 | Shinille | Diabetic | Extract of *Salvadora persica* |
| 6 | SE3 | Shinille | Diabetic | Extract of *Balanites aegyptiaca* |
| 7 | MDC | Male | Diabetic | Camel Milk |
| | FDC | Female | Diabetic | Camel Milk |
| 8 | MDG | Male | Diabetic | Glibenclamide |
| | FDG | Female | Diabetic | Glibenclamide |
| 9 | MDW | Male | Diabetic | Water |
| | FDW | Female | Diabetic | Water |
| 10 | MNC | Male | Non Diabetic | Camel Milk |
| | FNC | Female | Non Diabetic | Camel Milk |
| 11 | MNW | Male | Non Diabetic | Water |
| | FNW | Female | Non Diabetic | Water |

*Note: Each group n = 5 (BE=Babile plant extract, SE = Shinille plant extract, MDC= diabetic male rats treated with camel milk, FDC= diabetic female rats treated with camel milk, MDG= diabetic male rats treated with Glibenclamide, FDG= diabetic female rats treated with Glibenclamide, MDW= diabetic male rats treated with water, FDW= diabetic female rats treated with water, MNC= non-diabetic male rats treated with camel milk, FNC= non-diabetic female rats treated with camel milk, MNW= non-diabetic male rats treated with water, FNW = non-diabetic female rats treated with water)*

Eighty adult rats from both sexes weighting 200-250 grams (75-90 days old) were segregated according to sex. Then, they were divided into sixteen groups and an experiment was conducted for three weeks. The first six diabetic groups were fed, orally by oral gavage (18 gauge), with plant extracts of 5 – 10 ml once every day (three plant species from Babile and three from Shinille). Group seven were divided in two male and female

diabetic rats and fed with 5 – 10 ml of camel milk morning, midday, and evening every day until the end of the experiment. Group 8 and 9 were divided in two male and female diabetic rats and treated with glibenclamide and water, respectively. Groups 10 and 11 were control consisting of non-diabetic groups of male and female rats treated with camel milk and water, respectively. All groups were fed on rat chow and water *ad libitum*. The diabetic rats were induced to diabetes using STZ at the dose of 60 mg/kg body weight. Streptozotocin induces diabetes within 3 days by destroying the beta cells (Karunanayake *et al*., 1975; Aminu *et al*., 2016). Body weight and blood glucose level of each rat was measured at the beginning of the experiment. Then, blood glucose level was measured after 72 hours, after first, second, and third weeks of the experimental period so that the chemical diabetes could be verified in rats injected with Streptozotocin as stated by Bhuyan *et al.* (1974). One ml of blood was taken from the rats to measure blood glucose level (Levi *et al*., 1977). Blood samples were taken for the measurement of glucose for three consecutive weeks after the initial baseline data were taken for each group and subgroups. This phase of the work was carried out once every week for the following three weeks in diabetic and control rats as suggested by Thulesen *et al.* (1997).

**2.8 Data Analyses**

The data of all groups (both diabetic and non diabetic rats groups) were organized on the excel data sheet. Then the data were checked for normal distribution and statistical analysis was run using R software version x64 3.3.1. (R Foundation for statistical computing, 2016). Means of groups were compared using the LSD test to identify the significant differences among the groups treated with extracts from different plant species.

## 3. Results and Discussion

### 3.1. Major Plant Species browsed by the Camel

A total of 29 plant species, which are browsed by camels, were documented from AW-Sherif Kebele and 59 plant species from Erer Ebada of Babile Wereda. The highest number of plant species record in Erer Ebada Kebele could be attributed to the high diversity and good vegetation stand of the area. The overall plant diversity (Shannon Diversity index) and evenness for Erer Ebada of Babile Wereda was 3.55 and 0.72, respectively (Anteneh and Sebsebe, 2011). The high diversity of the plant species could also explain the high number of camels reared in the area. Similarly, a total of 21 plant species, which are browsed by the camel, were documented from Shinile Woreda. In both Woredas, plant species browsed by camels were identified with the help of members of the local community using priority-ranking exercise. Then ten major browsed plant species that belong to six families were identified from Babile sites (Table 2) and twelve major plant species that belongs to six families were identified from Shinille sites (Table 3).

Table 2. Plant species browsed by camels in Babile Woreda.

| Code No. | Local name | Scientific name | Family | Habit |
|---|---|---|---|---|
| B1 | Hamareessa (O) | *Acacia brevispica* Harms | Fabaceae | Shrub |
| B2 | Serkema (O) | *Acacia nilotica* (L.) Willd. ex Del. | Fabaceae | Tree |
| B3 | Sophensa (O) | *Acacia senegal* (L.) Willd. | Fabaceae | Shrub |
| B4 | Dhirii (O) | *Acalypha fruticosa* Forssk. | Euphorbiaceae | Shrub |
| B5 | Jirme (O) | *Dichrostachys cinerea* (L.) Wight & Arn. | Fabaceae | Shrub |
| B6 | Haroresa (O) | *Grewia bicolor* Juss. | Tiliaceae | Shrub |
| B7 | Alibal (O) | *Ochna inermis* (Forssk.) Schweinf. ex Penz. | Ochnaceae | Shrub |
| B8 | Dergu (O) | *Pavonia burchellii* (DC.) Dyer | Malvaceae | Shrub |
| B9 | Likimee (O) | *Rhus natalensis* Krauss | Anacardiaceae | Shrub |
| B10 | Hudu Qable (O) | Not identified | Fabaceae | Shrub |

*Note: O = Afan Oromo; B = Babile.*

Most of the major plant species browsed by camel in Babile Woreda are shrubs except *Acacia nilotica,* which is sparsely available in the localities. This indicates that the area is dominated by bushy vegetation. The vegetation analysis in Erer valley showed dominance of shrubs and climbers (Anteneh *et al*., 2011). Among these ten major plant species, three top priority plants species browsed by camel were selected. These are *Acacia brevispica, Dichrostachys cinerea* and *Acacia nilotica*, which were further processed for the experimental purpose using their crude extracts to see their effect on blood glucose levels of diabetic rats.

Similarly, among 12 major plant species from Shinille, three top priority plants species browsed by camel viz., *Acacia tortilis, Salvadora persica,* and *Balanites aegyptiaca*, were selected and processed for the experimental purpose to see their effect on blood glucose levels of diabetic rats.

Table 3. List of plant species browsed by camel in Shinille Woreda.

| Code No. | Local name | Scientific name | Family | Habit |
|---|---|---|---|---|
| SH1 | Gelol (S) | *Acacia nilotica* (L.) Willd. ex Del. | Fabaceae | Tree |
| SH2 | Adad (S) | *Acacia senegal* (L.) Willd. | Fabaceae | Shrub |
| SH3 | Qudaha (S) | *Acacia tortilis* (Forssk.) Hayne | Fabaceae | Tree |
| SH4 | Qud (S) | *Balanites aegyptiaca* (L.) Del. | Balanitaceae | Tree |
| SH5 | Qadew (S) | *Cadaba glandulosa* Forssk. | Caparidaceae | Shrub |
| SH6 | Qalan (S) | *Cadaba rotundifolia* Forssk. | Caparidaceae | Tree |
| SH7 | Geres (S) | *Dobera glabra* (Forssk.) Juss. ex Poir. | Salvadoraceae | Tree |
| SH8 | Lebi (S) | *Delonix elata* (L.) Gamble | Fabaceae | Tree |
| SH9 | Asha'ado (S) | *Grewia schweinfurthii* Burret | Tiliaceae | Shrub |
| SH10 | Adey (S) | *Salvadora persica* L. | Salvadoraceae | Shrub |
| SH11 | Hangey (S) | *Sarcostemma viminale* subsp. *stipitaceum* | Ascelepiadaceae | Climber |
| SH12 | Sala'asays (S) | *Triumfetta heterocarpa* Sprague and Hutch. | Tiliaceae | Shrub |

*Note:* SH = Shinille; S= Somali language

Table 4. Chemical/nutrient composition of major plant species browsed by camel in Babile Woreda.

| Plant Species | DM | Ash | OM | EE | CF | CP | TN |
|---|---|---|---|---|---|---|---|
| *Acacia brevispica* | 92.44 | 7.50 | 92.49 | 3.07 | 16.92 | 21.88 | 3.5 |
| *Acacia nilotica* | 91.97 | 5.31 | 94.69 | 4.22 | 12.25 | 12.44 | 1.99 |
| *Acacia senegal* | 90.02 | 11.41 | 88.59 | 3.13 | 23.76 | 17.01 | 2.72 |
| *Acalypha fruticosa* | 91.48 | 14.81 | 85.19 | 3.22 | 20.83 | 20.13 | 3.22 |
| *Dichrostachys cinerea* | 92.21 | 6.51 | 93.49 | 1.92 | 19.26 | 15.17 | 2.43 |
| *Grewia bicolor* | 92.03 | 10.08 | 89.92 | 3.27 | 24.57 | 15.36 | 2.46 |
| *Ochna inermis* | 92.87 | 6.35 | 93.65 | 3.42 | 15.58 | 13.22 | 2.11 |
| *Pavonia burchellii* | 91.53 | 7.70 | 75.97 | 3.92 | 12.18 | 23.43 | 3.75 |
| *Rhus natalensis* | 92.89 | 18.23 | 81.77 | 3.17 | 21.34 | 25.18 | 4.03 |
| Not identified | 91.90 | 12.23 | 87.77 | 2.44 | 21.55 | 18.18 | 2.91 |

*Note: O = Afan Oromo; DM = dry matter; OM = organic matter; EE = ether extract; CF = crude fiber; CP = crude protein; TN = total nitrogen. Three species i.e. Rhus natalensis, Pavonia burchellii and Acacia brevispica were ranked from 1st to 3rd with their crud protein, respectively.*

Table 5. Chemical/nutrient composition of major plant species browsed by camel in Shinille Woreda.

| Plant Species | DM | Ash | OM | EE | CF | CP | TN |
|---|---|---|---|---|---|---|---|
| *Acacia nilotica* | 91.17 | 10.75 | 89.25 | 3.81 | 17.88 | 10.98 | 1.76 |
| *Acacia senegal* | 91.59 | 9.38 | 90.62 | 3.02 | 19.32 | 13.22 | 2.12 |
| *Acacia tortilis* | 91.88 | 14.15 | 85.85 | 4.04 | 21.32 | 11.47 | 1.84 |
| *Balanitesaegyptiaca* | 92.61 | 18.28 | 81.72 | 2.29 | 18.44 | 15.07 | 2.41 |
| *Cadaba glandulosa* | 92.65 | 23.50 | 76.49 | 2.19 | 19.44 | 9.63 | 1.54 |
| *Cadaba rotundifolia* | 92.235 | 15.52 | 84.48 | 1.77 | 8.06 | 15.55 | 2.49 |
| *Dobera glabra* | 90.25 | 23.19 | 76.81 | 0.72 | 20.72 | 10.5 | 1.68 |
| *Delonix elata* | 90.55 | 17.14 | 82.86 | 6.33 | 11.09 | 12.06 | 1.93 |
| *Grewia schweinfurthii* | 92.61 | 17.37 | 82.63 | 3.89 | 18.16 | 16.92 | 2.71 |
| *Salvadora persica* | 90.52 | 32.97 | 67.03 | 2.52 | 12.76 | 10.59 | 1.69 |
| *Sarcostemma viminale* subsp. *Stipitaceum* | 93.49 | 10.46 | 89.54 | 7.69 | 11.43 | 4.77 | 0.76 |
| *Triumfetta heterocarpa* | 92.10 | 9.84 | 90.15 | 7.66 | 20.98 | 11.67 | 1.87 |

*Note: S = Somali; DM = dry matter; OM = organic matter; EE = ether extract; CF = crude fiber; CP = crude protein; TN = total nitrogen; Grewia schweinfurthii, Cadaba rotundifolia and Balanitesaegyptiaca are ranked 1st to 3rd with their crud protein content, respectively.*

### 3.2 Nutrient Analysis of Major Plant Species Browsed by Camel

For nutrient analysis, a total of 22 major plant species were collected from Babile and Shinile Woredas (districts). Samples from both areas were analyzed for moisture, crud fiber, protein, fat, and ash contents (Tables 4 and 5). The largest number of plant species belongs to the family Fabaceae that accounts for about 40% of the total major plants species browsed by camel in these two Woredas.

### 3.3. Effect of Camel Milk on the Glucose Level of Diabetic Rats

The initial blood glucose levels in diabetic male rats treated with camel milk (MDC), diabetic male rats treated with Glibenclamide (MDG), diabetic male rats treated with aqueous solution (MDW), non-diabetic male rats treated with aqueous solution (MNW) and non-diabetic male rats treated with camel milk (MNC) were 97, 96, 97, 104 and 95 mg/dl, respectively. The induction values for the above five male rat groups were 204, 205, 202, 196 and 94 mg/dl, respectively. After a three week treatment, the blood glucose was found to be 182, 104, 206, 98 and 91 mg/dl, respectively. The treatment with camel milk conducted for three weeks in male rats reduced blood glucose by 20 mg/dl. Similarly, preliminary trials reflected a low prevalence of diabetes in Raica community traditionally consuming camel milk (Sahani *et al.,* 2007). Treatment of the diabetic and non-diabetic male rats with Glibenclamide and camel milk reduced blood glucose level by 100 and 4 mg/dl, respectively (Table 6).

Table 6. Changes in the mean blood glucose levels of White Winstar rats induced to diabetes with Streptozotocin (STZ) and treated with camel milk and control groups (n = 5 for each group).

| Treatment | Initial BG (mg/dl) | After 72 hrs BG (mg/dl) | 1st week BG (mg/dl) | 2nd week BG (mg/dl) | 3rd week BG (mg/dl) |
|---|---|---|---|---|---|
| Diabetic (M)+ Camel milk | 97±3.22 | 204 ±7.81 | 202 ±7.60 | 194 ±6.62 | 182±6.11 |
| Diabetic (F)+ Camel milk | 92±3.02 | 196 ±6.80 | 195 ±6.82 | 174 ±6.11* | 181±6.22 |
| Diabetic (M)+ Glibenclamide | 96 ± 2.18 | 205 ± 6.25 | 176 ± 4.15 | 142 ± 2.28 | 104 ± 1.13 |
| Diabetic (F) + Glibenclamide | 92 ± 3.14 | 198 ± 3.62 | 171 ± 3.17 | 136 ± 2.20 | 98 ± 2.16 |
| Diabetic (M) + Water | 97 ± 3.10 | 202 ± 7.71 | 204 ± 7.93 | 210 ± 7.89 | 206 ± 7.65 |
| Diabetic (F)+ Water | 89±2.92 | 196±6.82 | 200±6.96 | 198±6.84 | 202±6.78 |
| Non-Diabetic (M) + Water | 104±3.65 | 94±3.21 | 94±3.24 | 98±3.44 | 98±3.40 |
| Non-diabetic (F)+ Water | 88±3.11 | 86±2.94 | 92±3.28 | 90±3.21 | 94±3.33 |
| Non-diabetic (M)+ camel milk | 95±3.34 | 95±3.30 | 94±3.27 | 90±3.18 | 91±3.16 |
| Non-diabetic (F)+ camel milk | 92±2.76 | 94±3.26 | 98±3.61 | 92±2.82 | 88±2.74 |

*Note: * The lowest glucose level reduction from all experimental groups; M = Male; F = Female; BG = Blood Glucose.*

The initial blood glucose levels in diabetic female rats treated with camel milk (FDC), diabetic female rats treated with Glibenclamide (FDG), diabetic female rats treated with aqueous solution (FDW), non-diabetic female rats treated with aqueous solution (FNW) and non-diabetic female rats treated with camel milk (FNC) were 92, 92, 89, 88 and 92 mg/dl, respectively. The induction values for the above five female rat groups were 196, 198, 196, 86 and 94 mg/dl, respectively. After a three-week treatment, the blood glucose was found to be 181, 98, 202, 94 and 88 mg/dl, respectively. Camel milk feeding resulted in a 20.5% reduction in glucose level in male rats and 21.1% in female rats. Treatment of diabetic and non-diabetic female rats by Glibenclamide and camel milk reduced blood glucose levels by 100 and 6 mg/dl, respectively. Camel milk treatment showed better performance in male rats than female ones. There were 5 mg/dl blood glucose reductions in male rats than female rats. However, there was no significant ($p>0.05$) difference in glucose level reductions between male and female rats.

### 3.4. Effect of Plant Extracts on the Glucose Level of Diabetic Rats

Three plants from Babile (*Acacia brevispica, Dichrostachys cinerea*, and *Acacia nilotica*) and three from Shinille (*Acacia tortilis, Salvadora persica*, and *Balanites aegyptiaca*) were prioritized for testing the effect of browsed plant species by camel on the glucose level of diabetic rats. The initial blood glucose levels of rats before STZ induction ranged between 91 and 116 mg/dl. However, the blood glucose level rose by minimum of 165 and a maximum of 212 mg/dl after 72 hours of inducing the rats to diabetes with STZ. On the third week of treating the diabetic rats with extracts of six top prioritized plant species browsed by camel, the blood glucose level was in the range of 124 mg/dl and 202 mg/dl. Comparing the values of initial blood glucose levels to final (third week) records indicated that extracts of some major plant species browsed by camel reduced hyperglycemia (Table 7).

Table 7. Changes in the mean blood glucose levels of White Winstar rats induced to diabetes with streptozotocin (STZ) and treated with plant extracts from Babile and Shinille areas (n = 5 for each group).

| Plant Extract | Initial BG (mg/dl) | After 72 hrs BG (mg/dl) | 1st week BG (mg/dl) | 2nd week BG (mg/dl) | 3rd week BG (mg/dl) |
|---|---|---|---|---|---|
| *Acacia brevispica* (BE) | 96±3.12 | 185±6.58 | 171±6.10 | 180 ±6.22 | 160±5.24 |
| *Dichrostachys cinerea* (BE) | 97 ±3.18 | 178±6.31 | 175 ±6.12 | 172 ±6.08 | 161±5.25 |
| *Acacia nilotica* (BE) | 102 ±3.36 | 202±7.86 | 212±7.94 | 208±7.86 | 202±7.84 |
| *Acacia tortilis* (SE) | 116±4.56 | 212±8.12 | 218±8.06 | 210±7.88 | 198±6.86 |
| *Salvadora persica* (SE) | 100±3.40 | 184±6.18 | 186±6.28 | 194±6.72 | 170±5.53 |
| *Balanites aegyptiaca* (SE) | 91±2.76 | 165±5.11 | 135±4.56 | 132±4.80 | 124±4.10 |

*Note: BE = Plant extract from Babile; SE = Plant extract from Shinille; BG = Blood Glucose.*

Extracts from *Acacia brevispica* and *Dichrostachys cinerea* resulted in 28.1% and 21% reductions in glucose levels of diabetic rats, respectively. Extracts from *Balanites aegyptiaca* resulted in a 55.4% reduction in glucose level, which is a significant decline ($p>0.05$). According to the World Health Organization (WHO), almost 70% of diabetic patients use plants as a primary source of anti-diabetic agents in order to satisfy their principal health needs (Bailey and Day, 1989). In comparison to known anti-diabetic prescription medicines (synthetic agents), herbal drugs and preparations are of considerable interest for the ethno-botanical community and are considered to be less toxic and free from adverse effects (Pari and Umamaheswari, 2000; Atmakuri and Dathi, 2010; Tarafdar *et al*., 2015). Similarly, such promising plant species of *Balanites aegyptiaca* could be given attention for further studies for their effect as anti-diabetic agents and toxicity effects. Consistent with the results of this study, fruit extracts and leaf extracts from *B. aegyptiaca* was reported to significantly reduce mean plasma glucose levels of diabetic rats (Khalil et al., 2016). Similarly, fruit extracts of *B. aegyptiaca* induced significant reductions in serum glucose, glucagon, total lipids, total cholesterol, triglycerides level and transaminases activities (Zaahkouk *et al*., 2003).

In general, treatment with some plant extracts such as *Balanites aegyptiaca, Acacia brevispica,* and *Dichrostachys cinerea* and camel milk slightly reduced blood glucose levels compared with the control groups (rats) fed on rat chow. Thus, improvements were observed in the glucose level of rats induced with STZ. However, none of the treatments of either plant extracts or camel milk brought the blood glucose to the normal level.

## 4. Conclusion

In this study, we found that extracts of some plant species and camel milk reduced blood glucose levels by more than 20%. Extracts from *Acacia brevispica* and *Dichrostachys cinerea* resulted in 28.1% and 21% reductions in blood glucose levels of diabetic rats, respectively. What is more, extracts of *Balanites aegyptiaca* resulted in a 55.4% reduction in blood glucose level of diabetic rats. However, there were no marked differences between blood glucose levels of diabetic male and diabetic female rats treated with camel milk. The results of the study imply that the reductions in blood glucose levels by as much as 20% due to consumption of camel milk provides diabetic patients a signal to make camel milk part of their diet. The substantial reduction in blood glucose level as a result of treating the diabetic rats with extracts of the *Balanites aegyptiaca* indicates that this plant species holds a key for finding a safe cure for the disease. Therefore, we recommended further in-depth research into the potential of extracts of browse of *Balanites aegyptiaca* and camel milk for treating diabetes.

## 5. Acknowledgements

We would thank Haramaya University, Office of the Vice-President for Research Affairs for fully supporting this study. Our special thanks go to the staff of the Central Laboratory particularly, Andarege Zelalem, Tsegu Kiros, Doyo Ngaressa, Genet Fetene and staff of College of Veterinary Medicine for their continued support in handling the laboratory animals used in this study. Similarly, we also thank Shawangizaw Teketel and Gemechu Tafa for their assistance in analyzing the nutrient composition of plant parts browsed by camel and rat chows. Finally, we thank Wynitu Getachew, Helen Bekele and Yenenish Tadesse for assisting us in this study.

## 5. References

AACC (American Association for Clinical Chemistry). 2000. Approved methods of the AACC (10th ed.). St. Paul, MN: American Association of Cereal Chemists (Methods 08-01, 30-25, 44-15A, 46-10, 54-10, 54-21).

Agrawal, R. P. Swami, S. C. Beniwal, R., Kochar, D. K. Sahani, M.S. Tuteja, F. C. and Gouri, S. K. 2002. Role of camel milk in type I diabetes. National Research on camel, Bikaner, India.

Agrawal, R. P. Budania, S. Sharma, P. Gupta, R. and Kochar, D. K. 2007. Zero prevalence of diabetes in camel milk consuming Raica community of north-west Rajasthan, India. Diabetes Research and Clinical Practice, 76: 290-296.

Amal, B. S. 2015. Camel milk as a potential therapy for controlling diabetes and its complications: A review

of in vivo studies. Journal of food and drug analysis, 23: 609-618.

Aminu Mohammed, Koorbanally, N. A., and Shahidul Islam. 2016. Anti-diabetic effect of *Xylopia aethiopica* (Dunal) A. Rich. (Annonaceae) fruit acetone fraction in a type 2 diabetes model of rats. *Journal of Ethnopharmacology*, 180: 131-139.

Anteneh, B. and Sebsibe, D. 2011. Diversity and Population Structure of Woody Species Browsed by Elephants in Babile Elephant Sanctuary, eastern Ethiopia: an implication for conservation. *Ee-JRIF – Agriculture and Forestry issue*, 3(1): 20-32.

Anteneh, B. Tamrat, B. and Sebsebe, D. 2011. The natural vegetation of Babile Elephant Sanctuary, eastern Ethiopia: implications for biodiversity conservation. Ethiop. *J. Biol. Sci.*, 10(2): 137-152.

AOAC (Association of Official Analytical Chemists). 2000. Journal of AOAC International. An international Journal of Analytical Science, AOAC International. 83: 1-6.

Asresie, A. and Yusuf, M. 2014. Traditional Consumption, Therapeutic Value and Its Derived Dairy Products of Dromedary Camel (Camelus Dromedaries) Milk in Somali Regional State, Eastern Ethiopia: A Review. *Global Journal of Animal Scientific Research*, 3(1): 240-246.

Atmakuri, L. R. and Dathi, S. 2010. Current Trends in Herbal Medicines. *Journal of Pharmacy Research*, 3(1): 109 – 113.

Bailey, C. J. and Day, C. 1989. Traditional plant medicines as treatments for diabetes. *Diabetes Care* 12: 553-564.

Bhuyan, B. K,. Kuentzel, S. L., Gray, L. G., Wallach, D. and Neil, G. L. 1974. Tissue distribution of streptozotocin (NSC 85998). *Cancer Chemotherapy Report*, 58: 157-65.

FAO (Food and Agriculture Organization). 2001. Estimated camel population of Africa and the World. FAO STAT Database. (http://www.fao.org/ag/againfo/projects/en/pfl/documents.html)

Felleke, G. 2003. A Review of the Small Scale Dairy Sector - Ethiopia. FAO Prevention of Food Losses Programme: Milk and Dairy Products, Post-harvest Losses and Food Safety in Sub-Saharan Africa and the Near East.

Gader, A. G. M. A. and Alhaider, A. A. 2016. The unique medicinal properties of camel products: A review of the scientific evidence. *Journal of Taibah University Medical Sciences*, 11(2): 98-103.

Gul, W., Farooq, N., Anees, D., Khan, U. and Rehan, F. 2015. Camel Milk: A Boon to Mankind. *IJRSB*, 3(11): 23-29.

Khaskheli, M. Arain, M. A. Chaudhry, S. Soomro, A. H. and Qureshi, T. A. 2005. Physico-chemical quality of camel milk. *Journal of Agriculture and Social Sciences*, 2:164-166.

IDF (International Diabetes Federation Diabetes). 2013. IDF diabetes atlas (6th Edn.). Belgium, Brussels.

IDF (International Diabetes Federation). 2012. Clinical Guidelines Task Force. Global Guideline for Type 2 Diabetes. International Diabetes Federation, 166 Chaussee de La Hulpe, B-1170, Brussels, Belgium.

IDF (International Diabetes Federation). 2011a. Global diabetes plan 2011-2021. Retrieved from http://www.idf.org/experts-launch-first-ever-global-diabetes-plan-new-york

IDF (International Diabetes Federation). 2011b. IDF diabetes atlas (5th ed). Brussels, Belgium: International Diabetes Federation.

IDFA (International Diabetes Federation Atlas). 2012. Diabetes at glance, Africa. Estimate of diabetes prevalence based on extrapolation from similar countries. Sixth edition.

Ikebukuro, K. Adachi, Y. Yamada, Y. Fujimoto, S. Seino, Y. and Oyaizu, H. 2002. Treatment of Streptozotocin-induced diabetes mellitus by transplantation of islet cells plus bone Marrow cells via portal vein in rats. *Transplantation*, 73 (4):512-8.

Karunanayake, E. H. Hearse, D. J. and Mellows, G. 1975. The metabolic fate and elimination of streptozocin. Biochemical Society Transactions. 3: 410-14.

Khalid, A. A. Alia, A. A. and Abdella M. A. 2007. Milk Composition of Dromedary Camels (*Camelus dromedaries*): Nutritional Effects and Correlation to Corresponding blood Parameters. *Pakistan Journal of Biological Sciences*, 10: 2724-2727.

Konuspayeva, G. Faye, B. and Loiseau, G. 2009. The composition of camel milk: a meta-analysis of the literature data. Journal of Food Composition and Analysis, 22, 95-101.

Kula Jilo 2016. Camel Milk and its Therapeutic Effects: A Review. *Global Veterinaria* 16 (4): 378-388.

Lenzen, S. 2008. The mechanisms of alloxan-and streptozotocin-induced Diabetes. Diabetologia, 51: 216–226.

Levi, J. A. Wiernik, P. H. and Diggs, C. H. 1977. Combination chemotherapy of advanced Previously Treated Hodgkin's disease with streptozocin, CCNU, Adriamycin and bleomycin. *Medical and pediatric oncology*, 3: 33-40.

Magjeed, N. A. 2005. Corrective effect of milk camel on some cancer biomarkers in blood of rats intoxicated with aflatoxin B1. *Journal of the Saudi Chemical Society*, 9: 253-263.

Motala, A. and Ramaiya, K. 2010. Diabetes: The Hidden Pandemic and its Impact on Sub-Saharan Africa. The Diabetes Leadership Forum, Africa, Johannesburg, 30 September and 1 October, 2010 Novo Nordisk.

Nasser, S. A. K, Alaa S. A, Salwa A.W.A., Wasfy, El Mileegy, I. M. H., Hamed, M. Y. and Hussein M. A. 2016. Antidiabetic and Antioxidant Impacts of

Desert Date (Balanites aegyptiaca) and Parsley (Petroselinum sativum) Aqueous Extracts: Lessons from Experimental Rats. *Journal of Diabetes Research*, 2016: 1-10.

Omar, A. A. and Hamad, A. A. 2010. Compositional, technological and nutritional aspects of dromedary camel milk. International Dairy Journal, 20: 811-821.

Pari, L. and Umamaheswari, J. 2000. Antihyperglycaemic Activity of Musa sapientum Flowers: Effect on Lipid Peroxidation inAlloxan Diabetic Rats. *Phytotherapy Research*, 14(2): 136 – 138.

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

Rastellini, C., Shapiro, R., Corry, R., Fung, J., Starzl, T. E. and Rao, A. S. 1997. An attempt to reverse diabetes by delayed islet cell transplantation in Humans, *Transplantation proceedings*, 29: 2238-2239.

Sallam, A. B., Ali, M. A. and Nikhala, M. A. 2008. Camels (Camelus dromedarius) under pastoral systems in North Kordofan, Sudan: Seasonal and parity effects on milk composition. *Journal of Camelid Sciences*, 1: 32-36.

Samir A. M. Z., Somaia Z. A. R., and Mattar, A. F. 2003. Anti-diabetic properties of water and ethanolic extracts of *Balanites aegyptiaca* fruits flesh in senile diabetic rats. *The Egyptian Journal of Hospital Medicine*, 10: 90 – 108.

SAS (Statistical Analysis System). 1999 – 2016. The SAS System of software for data management, analysis, and presentation. John Wiley and Sons, Inc.

Solomon Mekonnen Abebe, Yemane Berhane, Alemayehu Worku and Abebayehu Asse 2014. Diabetes mellitus in North West Ethiopia: a community based study. BMC Public Health, 14: Page 97.

Tamiru, S, and Alemseged, F. 2010. Risk Factors for Cardiovascular Diseases among Diabetic Patients in Southwest Ethiopia. *Ethiop J Health Sci*., 20: 121- 128.

Tarafdar, R. G. Nath, S. Talukdar, A. D. and Choudhury, M. D. 2015. Antidiabetic plants used among the ethnic communities of Unakoti district of Tripura, India. *Journal ofEthnopharmacology*,160: 219–226.

Thulesen, J. Qrskov, C. Holst, J. J. and Poulsen, S. S. 1997. Short Term Insulin Treatment prevents the diabetogenic action of streptozotocin in rats. *Endocrinology*, 138 (1): 62-68.

Valiathan, M. S. 1998. Healing Plants. *Current Science,* 75 (11): 1122 – 1127.

Weiss, R. B. 1982. Streptozocin: A review of its pharmacology, efficacy and toxicity. *Cancer Treatment Report*, 66 (3): 427-38

Yagil, R. and Van Creveld, C. 2000. Medicinal use of camel milk. Fact or fancy? In: Proceedings of the 2nd International Camelid Conference on Agroeconomics of Camelids. Kazakhstan: Almaty, September P80.

Yadav, A. K., Kumar, R., Priyadarshini, L. and Singh, J. 2015. Composition and medicinal properties of camel milk: A Review. *Asian Journal of Dairy and Food Research*, 34(2): 83-91.