Effect of probiotic fermented camel milk containing Oat milk on hyperglycemia in streptozotocin-induced diabetic rats

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Abstract

The present study was conducted to evaluate physicochemical, rheological, microbiological, antioxidant and sensory properties of probiotic fermented camel milk made from camel milk mixed with Oat milk. Fermented camel milk was made from camel milk served as a control, and the other treatments were made from camel milk after mixing with 25 and 50 % Oat milk. Results revealed that mixing of camel's milk with Oat milk were more effective in increasing the total solids, protein, ash, fiber, acidity, viscosity, phenolic content and antioxidant activity and these increments were proportional to the mixing ratio. Fermented camel milk containing 50 % Oat milk had the highest scores for sensory properties compared to other fermented camel milk treatments. This blend (fermented camel milk containing 50 % Oat milk) was evaluated as hypoglycaemic agent streptozotocin-induced diabetic rats. In this respect, twenty four male adult albino rats of Sprague Dawely strain weighing 150- 185 g were divided into 4 groups as follows: Group (1) non-treated non-diabetic rats (negative control). Group (2) diabetic rats (received Streptozotocin (STZ), 60 mg/Kg BW) (positive control). Group (3) diabetic rats fed on basal diet with fermented camel milk (10g/day) by epi gastric tube. Group (4) diabetic rats fed on basal diet with fermented camel milk containing 50 % Oat milk (10g/day) by epi gastric tube. The treatment of diabetic rats with fermented camel milk containing 50 % Oat milk showed a significant decreases (p<0.001) in levels of blood glucose, malondialdehyde (MDA), low density lipoprotein (LDL), cholesterol (CL), triglyceride (TG), AST, ALT, ALP, creatinin and urea and increased (p<0.001) high density lipoprotein (HDL) and total protein and albumin in comparison to diabetic rats. Consumption of fermented camel milk containing 50 % Oat milk in diabetic rat groups caused significant improvement in all
these factors, compared to the positive control group (untreated diabetic rats). Also in this study, for the first time, we demonstrated that administration of fermented camel milk containing 50% Oat milk in diabetic rats resulted in enhanced blood complications compared to the untreated diabetic group, indicating that fermented camel milk containing 50% Oat milk can play a preventive role in such patients.

**Key words:** probiotic, Oat milk, camel milk yoghurt, physicochemical, blood glucose, cholesterol, urea.

**Introduction**

Diabetes is one of the most common chronic diseases, and it has shown an increasing rate of occurrence over the past decade (Bullard et al., 2018). Diabetes mellitus (DM) is a metabolic disorder that is characterized by an abnormal long-term increase in plasma glucose levels. Diabetes is mainly classified into four types, i.e., type I diabetes (T1DM), type II diabetes (T2DM), gestational diabetes, and specific types of diabetes due to other causes (American Diabetes Association, 2019).

Many factors, such as protein, and fat metabolisms, insulin deficiency or resistance as well as altered carbohydrate are usually the reasons for high blood glucose levels leading to diabetes mellitus. Chronic hyperglycemia related to diabetes is often associated with many other complications, such as neurological, renal, retinal, cardiovascular, dermatological and nerve diseases (Atwaa et al, 2021).

In type II diabetes mellitus, progressive decline in insulin action referred as insulin resistance and pancreatic β-cell dysfunction leads to increased levels of blood glucose (Srinivasan et al., 2005). A major risk factor for insulin resistance is obesity, which is generally caused by a western style high fatty diet and physical inactivity (Zheng et al., 2012).

The current treatment for type II diabetes includes insulin and oral hypoglycemic drugs such as sulfonylurea derivatives, thiazolidinediones, biguanides, and α-glucosidase inhibitors. These medications have side effects, e.g. osteoporosis and sodium retention, thiazolidinediones induce obesity and sulfonylurea derivatives can lead to incidences of severe hypoglycemia, whereas biguanides like metformin put patients at risk of developing lactic acidosis (Hamza et al., 2010 and Bandawane et al., 2020).
Thus, there is an increasing need to search for effective antidiabetic agents exhibiting fewer side effects. As an alternative, large number of population is trying to rely on plant-based remedies for management of this metabolic disorder. (Bandawane et al., 2020).

Antioxidants can reduce markers of oxidative stress in both experimental and clinical models of diabetes (Hoshyar et al., 2015).

Camel milk is characterized than cow's milk where it has a high nutritional and health value because it contains immune proteins such as lysozyme, which is an antioxidant and anti-inflammatory, aminoglobulins, with no beta-lactoglobulin which may cause allergic reactions to some people, and contains a large amount of iron, potassium, vitamin C, E, and A (Salem et al., 2017; Khalesi et al., 2017).

Fermented camel milk is proved to have some health benefits, proved or not, such as antioxidant activity, angiotensin I-converting enzyme (ACE) inhibitory activity, hypocholesterolaemic effect, antimicrobial activity, activity against diarrhea, anticancer activity (Solanki and Hati, 2018).

Increased attention has been given to improving fermented dairy products containing probiotic bacteria because of their health benefits (Atwaa et al., 2022). Dairy products containing probiotics have spread in many countries around the world (Tharmaraj & Shah, 2003) to obtain a dietetic therapeutic effect that reduces the symptoms associated with high cholesterol (Walsh et al., 2010).

Cereals and their components have been accepted as a functional food due to its provision of vitamins, dietary fiber, protein, antioxidants, energy, and minerals required for human health. Also, cereals can be used as fermentable substances for the growth of probiotic bacteria (Charalampopoulos et al., 2002: Atwaa et al, 2020).

Oat (Avena sativa L.) and oat products are a good sources of soluble dietary fiber, β-glucan, vitamin E, polyunsaturated fatty acids and their consumption in the human diet is beneficial to human well-being (Tiwari and Cummins 2012: Ramzan, 2020).

Therefore, the aim of this study was to produce fermented camel milk mixed with Oat milk, and the effect of fermented camel milk mixed with Oat milk on hyperglycemia in streptozotocin-induced diabetic rats.
Material and Methods

Materials:
Camel milk was obtained from Desert Research Center, Dokki, Egypt. Oat flakes purchased from local market. Food grade "-amylase from *Bacillus subtilis* was purchased from Sigma Aldrich which had an activity of 2000IU in a powder form, other chemicals and reagents were purchased form Sigma-Aldrich. ABT-5 culture containing *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium bifidum* were obtained from the Microbiological Resources Center (MIRCEN), Faculty of Agric. Aim Shams Univ., Egypt.

Methods:

Preparation of oat milk sample:
Oat milk was prepared according to enzymatic method described by Deswal *et al.*, (2014) About 1 kg of rolled oats was ground into a laboratory food processor to produce finely granulated oat flour and then mixed with 2.7 kg of water. Calcium chloride at a concentration of 0.04% (w/w) was added as a catalyst for the enzyme. Oat slurry was treated with "-amylase (77.78 mg kg\(^{-1}\) of Rolled oats) for liquefaction for 49 min at 75 \(^\circ\)C. The liquefied oat solids were then filtered through muslin cloth to get the Oat milk. At the end of the treatment, the enzyme was inactivated by heating at 100 \(^\circ\)C for 5 min.

Fermented camel milk manufacture:
Probiotic fermented camel's milk was manufactured according to the method reported by Tamime and Robinson, (1999) and modified with Atwaa *et al.*, (2020).
Treatments were carried out as follows:
Whole camel milk as a control (C)
Whole camel milk mixed with 25 % Oat milk (T1)
Whole camel milk mixed with 50 % Oat milk (T2)
Milk of all treatments homogenized at 55–60\(^\circ\)C for 2 min using a high speed mixer (22,000 rpm/min), heat-treated in a thermostatically controlled water bath at 85 \(^\circ\)C for 30 min, cooled to 42\(^\circ\)C in an ice bath, inoculated with 5 % (w/v) ABT5 culture, incubated at 42\(^\circ\)C for 6–8 h until a firm curd was obtained, the curd was refrigerated at 4\(^\circ\)C overnight, stirred using the mixer, stored at 4 \pm 1 \(^\circ\)C, then analyzed.
after 1 day from manufacture for physicochemical, rheological, microbiological, and sensory properties.

**Chemical Composition:**

The dry matter, protein, fat, ash contents and titratable acidity (expressed as lactic acid %) were determined as described in AOAC (2007). The pH values were measured by digital laboratory pH meter (HANNA Digital). Viscosity of fermented camel milk was determined according to Aryana(2003).

**Determination of total phenolic content:**

The total phenolic content (TPC) of the extract was determined by Folin-Ciocalteu assay using Gallic acid as the standard according to Kaur and Kapoor (2002). The total phenolic content was expressed as gallic acid equivalents (mg GAE/100g dry weight basis) through the calibration curve of Gallic acid.

**Radical scavenging activity (Scavenging DPPH):**

The antioxidant activity was evaluated by the DPPH (2, 2-diphenyl-1-picrylhydrazyl) assay according to Brand Williams et al.,(1995). The scavenging activity percentage (AOA%) was determined according to Mensor et al.,(2001) as follows:

\[ \text{AOA} \text{%} = 1 - \frac{\text{Abs}_{\text{sample}} - \text{Abs}_{\text{blank}}}{\text{Abs}_{\text{control}}} \times 100 \]  

(1)

**Sensory evaluation:**

The sensory properties of yoghurt samples were assessed by 10 panel members of the Dairy Sci., Dep., Fac. Agric., Zagazig, Univ. for flavour (60) body and texture (30) and appearance (10) as reported according to Nelson and Trout (1981).

**Experimental design of biological study**

Thirty-two male adult Wistar rats weighing 200-250 g will be collected from Agricultural Reached Center, Giza, Egypt. All animals kept under controlled conditions of light (12 h of light and 12 h of darkness) with the ambient temperature of 22±2°C and relative humidity of 40 - 60% and free access to water and food in the Animals’ Room. All animals will be allowed free access to standard diet. The normal diet composition will be as follows: Casein (20%), sucrose (50%), Corn Starch (15%), powdered cellulose (5%), corn oil (5%), mineral mix (3.5%), vitamin mix (1%), DL- Methionine (0.3%), Choline bitartrate (0.2%) according to AIN-93 guidelines (Reeves et al., 1993). After acclimation on a basal diet for seven days Albino rats were classified
into two main sections, where the first one (n= 8) received only the standard diet and served as the normal control group while the second one (hyperglycemia rats, n= 24) will be subjected to 60 mg/Kg BW Streptozotocin (STZ) intraperitoneally injection. After 24-48h, rats that showing fasting blood glucose more than 200 mg dl-1 will be considered diabetic rats. Diabetic rats will be divided into three groups (n = 8 each) .The first did not receive any treatment and served as the hyperglycemia positive control. The second and third ones received 10g/day probiotic camel milk yoghurt and 10g/day probiotic camel milk yoghurt containing 50 % Oat milk respectively. The body weight of rats will be measured at the beginning of experimental period and after 7 days intervals. At the end of the experiment and after an overnight fasting (10 hr), rats will be killed, blood samples will be collected and centrifuged at 3000 rpm to obtain the blood serum which will store at (−20ºC) for biochemical analysis.

**Biochemical analysis:**

Insulin was determined in human blood samples according to the method of (Thomas, et al., 2014). Blood glucose level was determined according to the method of Clinical Methods (Trinder, 1969).The method of Caraway (1955) was used to determine serum uric acid, while serum creatinine level was measured by the method of Bohmer (1971) and serum urea was determined according to Marsch et al., (1965). Total antioxidant capacity (TAC) and malondialdehyde (MDA) were determined in serum according to Koracevic et al. (2001) and Satoh (1979). Alanine amino transferase (ALT), aspartate amino transferase (AST) enzymes were measured according to the methods described by Bergmeyer and Harder, (1986) . Total cholesterol, will be determined according to the method of Enzymatic Colorimeter, Deweerdt and Later (2009). Total lipids and triglycerides will be determined according to the method of Devi and Sharma, (2004). The LDL will be calculated using Friedewald formula (Friedewald et al., 1972) as following:

\[
\text{LDL-cholesterol} = \frac{(\text{Total cholesterol}) - (\text{HDL-cholesterol}) - (\text{Triglycerides}/5)}{2}
\]
Statistical analysis:
The obtained results were evaluated statistically using analysis of variance as reported by McClave & Benson (1991). In addition the other reported values were expressed as mean ±SD and ±SE, two – tailed Student’s t test was used to compare between different groups. P value less than 0.05 was considered statistically significant. SPSS (Chicago, IL, USA) software window Version 16 was used.

Results and discussion
Chemical composition of fresh camel milk and Oat milk:
The chemical composition of fresh camel milk, Oat milk and dried whey protein concentrate are illustrated in Table (1). Total solids, protein, fat, ash carbohydrate and fiber contents of camel milk were (12.58, 3.18, 4.12, 0.82, 4, 46 and 0.0 g/100g) respectively. These results are in agreement with the data obtained by Rahli et al.,(2013) and Omar et al., (2019).Total solids, protein, fat, ash carbohydrate and fiber contents of Oat milk were (21.70, 2.30, 1.74, 0.354, 17, 30 and 2.04 g/100g) respectively. These results are in agreement with the data obtained by Atwaa et al., (2020). While, total solids, protein, fat, ash carbohydrate and fiber contents of dried whey protein concentrate were (95.40, 87.36, 0.10, 2.62, 5, 32 and 0.0 g/100g) respectively. These results are in agreement with the data obtained by El-Batawy et al., (2019).

Table 1. Chemical composition of fresh camel milk and Oat milk

<table>
<thead>
<tr>
<th>Components ( %)</th>
<th>Camel milk</th>
<th>Oat milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids</td>
<td>12.22±0.20</td>
<td>20.85±1.60</td>
</tr>
<tr>
<td>Protein</td>
<td>3.12±0.06</td>
<td>2.44±0.14</td>
</tr>
<tr>
<td>Fat</td>
<td>4.02±0.08</td>
<td>1.70±0.09</td>
</tr>
<tr>
<td>Ash</td>
<td>0.85±0.04</td>
<td>0.40±0.02</td>
</tr>
<tr>
<td>Fiber</td>
<td>----</td>
<td>2.12±0.10</td>
</tr>
</tbody>
</table>

Chemical composition of fermented camel milk made from camel milk mixed with Oat milk:
Table (2) shows the chemical composition of fermented camel milk made from camel milk mixed with Oat milk, it can be seen that control fermented camel milk had the lowest total solids (TS), protein, ash and fiber contents it was significantly (P ≤ 0.05) compared with
Fermented camel milk containing Oat milk treatments. The TS, protein, ash and contents of fermented camel milk containing Oat milk increased gradually by increasing the mixing ratio, this may be due to a high TS, protein, ash and fiber contents of Oat milk (El-Batawy et al., 2019). Concerning fat content, mixing of camel milk with Oat milk did not affect on fat content of resultant fermented camel milk. These results are in agreement with those reported by Atwaa et al., (2020), who found that partial replacement of camel milk with Oat milk increased the TS, protein, ash and carbohydrate contents of resultant yoghurt compared with camel milk yoghurt.

**Table 2:** Chemical composition probiotic fermented camel milk made from camel milk mixed with Oat milk

<table>
<thead>
<tr>
<th>Components (%)</th>
<th>Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
</tr>
<tr>
<td>Total Solids %</td>
<td>12.24±0.46&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein %</td>
<td>3.18±0.16&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat %</td>
<td>4.08±0.18&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ash</td>
<td>0.88±0.07&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fiber %</td>
<td>---</td>
</tr>
</tbody>
</table>

* Values (means ±SD) with different superscript letters are statistically significantly different (P ≤ 0.05).  
C: fermented camel milk made from camel milk as a control (C).  
T<sub>1</sub>: fermented camel milk made from camel milk mixed with 25 % Oat milk  
T<sub>2</sub>: fermented camel milk made from camel milk mixed with 50 % Oat milk

Titratable acidity, pH values viscosity, total phenolic content and radical scavenging activity of fermented camel milk made from camel milk mixed with Oat milk:

Data illustrated in Table, (3) indicated that titratable acidity (TA) of the control fermented camel milk had the lowest value, this may be due to a high antimicrobial components such as lactoferrin, lysozyme and immunoglobulin's in camel milk which decreased viability of starter culture (Galeboe et al., 2018). The acidity of y fermented camel milk made from camel milk mixed with Oat milk increased gradually by increasing the mixing ratio; this may be due to contains Oat milk.
fermentable substance which improved viability of starter culture (El-Batawy et al., 2019). pH values of all treatments behaved reverse trend to TA. Similar results were obtained by Atwaa et al., (2020) who found that partial replacement of camel milk with Oat milk increased the TA and decreased pH values of resultant camel milk yoghurt.

Viscosity of the control fermented camel milk (C), was the lowest value, while mixing of camel milk with Oat milk greatly increased of viscosity. Similar results were reported by Omar et al., (2019) they observed that increasing the total solid in milk caused an increase in the viscosity of the yoghurt gel.

Total phenolic content fermented camel milk made from camel milk mixed with Oat milk were increased by increasing the mixing ratio compared to control fermented camel milk, this may be due to a higher total phenolic content of Oat milk (Ibrahim et al., 2020) than camel milk (Soliman and Shehata, 2019). These results are in agreement with those reported by Ibrahim et al., (2020) who found that total phenolic content and radical scavenging activity of fermented camel’s milk increased when fortified camel milk with different ratios of kiwi and avocado. Also, Atwaa et al., (2020) found that addition of Oat milk to camel milk increased the total phenolic content and radical scavenging activity of fermented camel milk.

**Table 3:** Titratable acidity, pH values, viscosity, total phenolic content and radical scavenging activity of fermented camel milk made from camel milk mixed with Oat milk

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatments</th>
<th>C</th>
<th>T1</th>
<th>T2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acidity%</td>
<td></td>
<td>0.78±0.03</td>
<td>0.85±0.06</td>
<td>0.94±0.08</td>
</tr>
<tr>
<td>pH values</td>
<td></td>
<td>4.80 ±0.08</td>
<td>4.74±0.14</td>
<td>4.66 ±0.06</td>
</tr>
<tr>
<td>Viscosity (C.P.S.)</td>
<td></td>
<td>2120±88</td>
<td>2310±94</td>
<td>2430±98</td>
</tr>
<tr>
<td>Total phenolic content (mg/g)</td>
<td></td>
<td>1.42 ±0.04</td>
<td>2.48±0.25</td>
<td>3.18±0.22</td>
</tr>
<tr>
<td>Radical scavenging activity RSA %</td>
<td></td>
<td>8.35±0.54</td>
<td>11.14±1.05</td>
<td>14.06±162</td>
</tr>
</tbody>
</table>

* Values (means ±SD) with different superscript letters are statistically significantly different (P ≤ 0.05).
Sensory properties of fermented camel milk made from camel milk mixed with Oat milk:

Data presented in Table (4) showed that the mixing of camel milk with Oat milk increased greatly the sensory attributes of the resultant fermented camel milk, especially its flavor and body & texture as compared with the control fermented camel milk and this improvement was proportional to mixing ratio. Control fermented camel milk had the lowest score for sensory properties this may be due to a very weak body & texture and inferior flavor of curd produced from camel milk (Soliman and Shehata, 2019; Atwaa et al, 2020). On the other hand, the use of Oat milk improved all sensory attributes of the resultant fermented camel milk. This finding is consistent with the observation of Atwaa et al, (2020) who reported that fortification of camel milk with Oat milk increased the sensory attributes scores of the resultant fermented camel milk.

Table 4: Sensory properties of fermented camel milk made from camel milk mixed with Oat milk

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Treatments</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C</td>
<td>T₁</td>
<td>T₂</td>
</tr>
<tr>
<td>Flavor (60)</td>
<td>39.6±2.50</td>
<td>43.2±2.20</td>
<td>45.8±3.24</td>
</tr>
<tr>
<td>Body &amp; Texture (30)</td>
<td>21.4±1.14</td>
<td>24.3±1.84</td>
<td>27.5±1.44</td>
</tr>
<tr>
<td>Appearance (10)</td>
<td>7.6±0.55</td>
<td>8.2±0.86</td>
<td>9.3±0.52</td>
</tr>
<tr>
<td>Total Scores (100)</td>
<td>69.5±3.12</td>
<td>76.8±3.64</td>
<td>85.2±3.36</td>
</tr>
</tbody>
</table>

* Values (means ±SD) with different superscript letters are statistically significantly different (P ≤ 0.05).

Effect of fermented camel milk containing Oat milk on Final weight and body weight gain of diabetic rats:

Data presented in Table (5) showed that FW and BWG were significantly (P<0.05) affected by the treatments. The use of 10 g/day fermented camel milk containing 50% Oat milk in diabetic rats gave the best values of FW (296.4 g) and BWG (18.98 %), respectively compared to positive control group which showed FW (282.6 g) and BWG (13.22 %), respectively. This improvement may be ascribed to the Oat milk high vitamins, minerals, and antioxidants contents, which may prevent/avoid the body’s cells damage by free radicals (Ramzan, 2020). Accordingly, Gohari et al (2019) found that unfermented and
fermented Oat milk addition in rat diets promoted a significant increment \((P < 0.01)\) of the body weight gain and enhanced nutritional status in comparison to group 2 (negative control group).

**Table 5:** Final weight and body weight gain of diabetic rats treated with lemon grass leaves extract

<table>
<thead>
<tr>
<th>Group</th>
<th>Initial weight (g)</th>
<th>Final weight (g)</th>
<th>B W G %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (1)</td>
<td>248.2±4.6(^a)</td>
<td>302.3±5.2(^a)</td>
<td>21.79±1.2(^a)</td>
</tr>
<tr>
<td>Group (2)</td>
<td>249.6±2.8(^a)</td>
<td>282.6±3.7(^d)</td>
<td>13.22±1.8(^d)</td>
</tr>
<tr>
<td>Group (3)</td>
<td>248.3±4.5(^a)</td>
<td>290.5±5.2(^c)</td>
<td>16.99±1.3(^c)</td>
</tr>
<tr>
<td>Group (4):</td>
<td>249.1±4.5(^a)</td>
<td>296.4±4.8(^b)</td>
<td>18.98±1.6(^b)</td>
</tr>
</tbody>
</table>

Mean values of six rat's ± SD. A, b, c….of the small letters in the same column are significantly different at \((p \leq 0.05)\).

Group (1) non-treated non-diabetic rats (negative control).
Group (2) non-treated diabetic rats (positive control).
Group (3) diabetic rats treated with fermented camel milk.
Group (4) diabetic rats treated with fermented camel milk containing 50 % Oat milk.

**Effect of fermented camel milk containing Oat milk on blood glucose and insulin of diabetic rats:**

Data presented in Table 6, shows that administration fermented camel milk containing Oat milk in diabetic treated groups lead to significant decrease \((p \leq 0.05)\) in serum glucose level and increase in insulin levels as compared with untreated STZ-induced diabetic rats. The way of oat lowering the blood glucose level is multiway mechanism by converting glucose into glycogen and increase the glucose uptake by body for its breakdown as energy source (Varma et al., 2016). Another way to lowering the blood glucose in the body is resultant short chain fatty acids formed by the fermentation of beta-glucan, which increased insulin responsive glucose transporter type 4 that affects the glucose-insulin homeostasis (Khoury et al., 2012).

Also, some factors may contribute to the observed hypoglycemic effect of camel milk such as, camel milk contains a high concentration of insulin(52 units/liter), camel milk does not form coagulum in the stomach or the acidic media, thereby it prevents degradation of insulin in
the stomach, amino acid sequences of some camel milk proteins are rich in half-cystine, which has superficial similarity with insulin family of peptides (Beg et al., 1986, Wangoh, 1993; Singh, 2001 and Mailam et al., 2017). In line with our results, Varma et al., (2016) and Ashraf et al., (2020) who found that diabetic rats treated with Oat or camel milk showed increasing in the blood insulin levels and decreasing in the blood sugar levels compared to the untreated diabetic rats group. 

**Table 6:** Effect of fermented camel milk containing 50% Oat milk on blood glucose and insulin of rate groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Parameters</th>
<th>Insulin (µU/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Blood glucose concentration (mg/dL)</td>
<td></td>
</tr>
<tr>
<td>Group (1)</td>
<td>98.40±3.60&lt;sup&gt;c&lt;/sup&gt;</td>
<td>19.14±0.62&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Group (2)</td>
<td>245.60±5.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.46±0.48&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Group (3)</td>
<td>122.50±4.90&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12.20±0.55&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Group (4)</td>
<td>102.40±3.70&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.26±0.60&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Mean values of six rat's ± SD. A, b, c... of the small letters in the same column are significantly different at (p ≤0.05).

Group (1) non-treated non-diabetic rats (negative control).
Group (2) non-treated diabetic rats (positive control).
Group (3) diabetic rats treated with fermented camel milk.
Group (4) diabetic rats treated with fermented camel milk containing 50% Oat milk.

**Effect of fermented camel milk containing Oat milk on the serum lipid profile of diabetic rats.**

From the results presented in Table 7, it can be noticed that, among diabetic rats groups, group 4 treated with fermented camel milk containing Oat milk had the lowest total cholesterol (72.8 mg/dl) compared to positive control which had the highest total cholesterol (91.2 mg/dl).

Concerning triacylglyceride and LDL positive control group had the highest content of triacylglyceride and LDL (101.2 and 43.56 mg/dl, respectively) compared with rat's treated with fermented camel milk.
containing Oat milk which recorded significant decrease in triacylglyceride and LDL contents with (77.6 and 22.08 mg/dl, respectively).

As for HDL content, (+ve) control group had the lowest HDL content (27.40 mg/dl) compared to others group, while rat’s administration of diet supplemented with fermented camel milk containing Oat milk recorded significant increase in HDL level (35.20 mg/dl).

There was significant increase (P<0.05) in the levels of serum cholesterol, triacylglyceride and LDL-c and a decrease in level of HDL-c in the positive control when compared to normal fed and fermented camel milk containing Oat milk treated rats. Treatment fermented camel milk containing Oat milk significantly decreased the levels of total cholesterol, triglycerides and LDL-c as compare to the positive control.

The mechanism behind bringing down the serum cholesterol by oat β-glucan is that it helps in the lowering of bile acid reabsorption that ultimately ends in the increment of Bile acid excretion in feces. That promotes more bile acid production by the liver utilizing cholesterol in the serum (Yao et al., 2006 and Khoury et al., 2012).

Also, a high insulin concentration of camel milk can cause the activation of lipoprotein lipase enzyme (Hull, 2004 and Agrawal et al., 2007). Farah, (1993) reported that a high mineral content of camel milk (sodium, potassium, zinc, copper and magnesium) as well as a high vitamin C intake may act as antioxidant thereby removing free radicals. Similar results were obtained by Varma et al., (2016) and Mailam et al, (2017) who found that Oat or camel milk had Hypocholesterolaemic effect.

**Table 7:** Effect of fermented camel milk containing 50 % Oat milk on lipid profile of oxidative stress rats

<table>
<thead>
<tr>
<th>Groups</th>
<th>Total cholesterol (TC) (mg/dl)</th>
<th>Triglycerides (TG) (mg/dl)</th>
<th>HDL (mg/dl)</th>
<th>LDL (mg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (1)</td>
<td>69.4±2.2d</td>
<td>79.5±2.3c</td>
<td>38.2±2.1a</td>
<td>15.3±1.2d</td>
</tr>
<tr>
<td>Group (2)</td>
<td>91.2±3.6a</td>
<td>101.2±5.4a</td>
<td>27.4±1.8d</td>
<td>43.56±1.5a</td>
</tr>
<tr>
<td>Group (3)</td>
<td>84.6±2.4b</td>
<td>84.5±4.6b</td>
<td>30.2±1.4c</td>
<td>37.5±1.4b</td>
</tr>
</tbody>
</table>
Mean values of six rat's ± SD. A, b, c….of the small letters in the same column are significantly different at (p ≤0.05).

**Effect of fermented camel milk containing Oat milk on liver function parameters in diabetic rats:**

Data illustrated in Table (8) showed that the untreated group (positive control) showed significant increase in AST, ALT and ALP and decrease in total protein and albumin at (p ≤0.05) in comparing with normal control group. On the other hand the group treated with fermented camel milk containing Oat milk showed significant increase in total protein and albumin and decrease in AST, ALT and ALP comparing with positive control group. This decrease in the values of aminotransferase enzymes and the restoration of some vital functions by the hepatocytes can be attributed to the high content of Oat from phenolic and bioactive components such as avenanthramides, phenolic acids and flavonoids as phenolic compounds which work to preserve the plasma membrane in hepatocytes and protect it from rupture and the exit of the cytosol loaded with these enzymes. (Xu et al., 2009: Ramzan, 2020). Also, a high vitamin C and mineral content of camel milk may act as antioxidant, which decrease in the values of aminotransferase enzymes (Mailam et al, 2017). These results were collaborated by Yang et al., (2019) and Dikhanbayeva et al, (2021) who found that Oat or fermented camel milk significant reduction in the levels of ALT, AST, and ALP; increase in TP and albumin levels in serum.

**Table 8:** Effect of fermented camel milk containing 50 % Oat milk on liver function parameters in oxidative stress rats

<table>
<thead>
<tr>
<th>Group</th>
<th>Aspartate aminotransferase (AST U/L )</th>
<th>Alanine aminotransferase (ALT U/L )</th>
<th>Total protein (g/dl)</th>
<th>Total albumin (g/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (1)</td>
<td>35.6±1.2 d</td>
<td>43.8±2.1 d</td>
<td>6.34±0.3 a</td>
<td>3.82±0.2 a</td>
</tr>
<tr>
<td>Group (2)</td>
<td>81.6±2.5 a</td>
<td>88.2±3.5 a</td>
<td>5.61±0.2 c</td>
<td>2.94±0.7 b</td>
</tr>
<tr>
<td>Group (3)</td>
<td>42.2±1.4 b</td>
<td>54.6±2.4 b</td>
<td>5.94±0.5 b</td>
<td>3.08±0.3 b</td>
</tr>
<tr>
<td>Group (4)</td>
<td>38.2±1.6 c</td>
<td>47.6±3.1 c</td>
<td>6.08±0.3 ab</td>
<td>3.78±0.3 a</td>
</tr>
</tbody>
</table>
Mean values of six rat's ± SD. A, b, c….of the small letters in the same column are significantly different at (p ≤0.05).

**Effect of fermented camel milk containing Oat milk on kidney function parameters in diabetic rats:**

Data presented in Table (9) showed that the positive control showed significant increase in creatinin and urea at (p < 0.05) in comparing with normal control group. While group treated with fermented camel milk containing Oat milk showed significant decrease in creatinin and urea comparing with positive control group. Creatinin and urea of different rat groups were reduced respectively as follows negative control, rat group treated with fermented camel milk containing Oat milk, rat group treated with fermented camel milk in comparison to positive control.

Concerning MDA, it can noticed that positive control was 69.20 μmol/L which considered the highest mean value of MDA compared to negative control which recorded the lowest value (44.30μmol/L ). There is a significant decrease in rat treated with rat group treated with fermented camel milk containing Oat milk with 47.68 μmol/L .Malondialdehyde has a very devastating process altering the structure and function of cell membranes (Nair and Nair, 2015). The formation and increase of MDA level can lead to oxidative mechanisms, high cytotoxicity and inhibitory actions. MDA acts as a tumor promoter and co-carcinogenic agent (Koc 2003).These results were collaborated by Aly et al,(2021) and El-Zahar et al,(2021) who found that Oat or fermented camel milk supplementation effectiveness in decrease in creatinin urea and malondialdehyde comparing with positive control group.

**Table 9:** Effect of fermented camel milk containing 50 % Oat milk on kidney function parameters in oxidative stress rats

<table>
<thead>
<tr>
<th>Group</th>
<th>Creatinin (mg/dl)</th>
<th>Urea (mg/dl)</th>
<th>Malondialdehyde (MDA) (μmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (1)</td>
<td>0.43±0.02d</td>
<td>15.6±0.2d</td>
<td>44.30±1.3d</td>
</tr>
<tr>
<td>Group (2)</td>
<td>0.86±0.05a</td>
<td>25.2±0.5a</td>
<td>69.20±2.5a</td>
</tr>
<tr>
<td>Group (3)</td>
<td>0.65±0.04b</td>
<td>20.4±0.4b</td>
<td>52.46±1.4b</td>
</tr>
<tr>
<td>Group (3)</td>
<td>0.48±0.03c</td>
<td>17.5±0.5c</td>
<td>47.68±1.8c</td>
</tr>
</tbody>
</table>
Mean values of six rat's ± SD. A, b, c….of the small letters in the same column are significantly different at (p ≤0.05).

**Conclusion**

The mixing of camel milk with Oat milk improved the chemical, antioxidant, rheological and sensory properties of stirred probiotic camel milk yoghurt, and these improvements were proportional to mixing up to 50 % which added nutritive and healthy benefits to resultant probiotic camel milk yoghurt. Consumption of probiotic camel milk yoghurt containing 50 % Oat milk in diabetic rat groups caused significant decreased in levels of blood glucose, malondialdehyde (MDA), low density lipoprotein (LDL), cholesterol (CL), triglyceride (TG), AST, ALT, ALP, creatinin and urea and increased high density lipoprotein (HDL) and total protein and albumin in comparison to diabetic rats.

**References**


properties of camel milk through profiling of its bioactive peptides on dipeptidyl peptidase IV (DPP-IV) and insulin receptor activity. *Journal of dairy science, 104*(1), 61-77.


Gohari ; S.T., O. I. El-Batawyand Samar M. Mahdy.(2019). Biological Attributes of Unfermented and Fermented Oat Milk Compared to


تأثر لبن الإبل المتخمر الحيوي المحتوي على لبن الشوفان على ارتفاع السكر في الدم في الفئران المصابة بداء السكري المستحث بفعل الاستربتوزوتوسين

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أجرت الدراسة الحالية لتقييم الخصائص الفيزيوكيميائية والمضادات للأكسدة والحسية لبن الإبل المتخمر الحيوي المصنع من لبن الإبل الممزوج ببن الشوفان. تم صنع لبن الإبل المتخمر من لبن الإبل واستخدم كلين من أجل تأهيل المقارنة، بينما كانت المعاملات الأخرى مصنوعة من لبن الإبل بعد مزجها مع لبن الشوفان بنسبة 55٪. أظهرت النتائج أن خلط لبن الإبل مع لبن الشوفان كان أكثر فاعلية في زيادة المواد الصلبة الكلية والبروتين والمادة والألياف والحموضة واللوزومة والمحتجز الفيتوني ونشاط مضادات الأكسدة وكانت هذه الزيادات متباينة مع نسبة الخليط. كما أظهر لبن الإبل المتخمر المحتوي على 50٪ من لبن الشوفان أعلى الدرجات في الخصائص الحسية مقارنة بغيره من معاملات لبن الإبل.
المتخمر. تم تقييم هذا المزيج (لبن الإبل المخمر المحتوي على 50% من لبن الشوفان) كعامل خافض لسكر الدم الناجم عن الاستربتوزوتسين في الفئران المصابة بداء السكري. في هذا الصدد، تم تقسيم أربعة وعشرين من ذكور الفئران البالغة من سلالة Sprague Dawely بين 200 إلى 250 جرامًا إلى 4 مجموعات على النحو التالي: المجموعة (1) الفئران غير المعاملة وغير المصابة بداء السكري (التحكم السيبي). المجموعة (2) الجرذان المصابة بداء السكري (تناولت استربتوزوتسين (STZ)، 100 مجم / كجم من وزن الجسم (التحكم الإيجابي) المجموعة (3) فئران مصابة بداء السكري تتغذى على النظام الغذائي الأساسي مع لبن الإبل المخمر (10 جم / يوم). المجموعة الرابعة: فئران مصابة بداء السكري تم تغذيتها على النظام الغذائي الأساسي مع لبن الإبل المخمر المحتوي على 50% لبن الشوفان (10 جم / يوم). أظهرت معاملة الفئران المصابة بداء السكري ينخفض السكر في الدم ، الماليوديايل كسيد (MDA) ، البروتينات الدهنية منخفضة الكثافة (LDL) ، الكوليسترول (CL) ، الدهون الثلاثية (TG) ، ALT، AST، ALP، الكرياتينين والبيرونيكازا زيادة (p≤0.05). أظهرت معاملة الفئران المصابة بداء السكري ينخفض السكر في الدم والبروتين الدهني عالي الكثافة (HDL) والبروتينات الكلي والألبومين مقارنة بالفئران المصاببة بداء السكري. أدى استهلاك لبن الإبل المتخمر المحتوي على 50% من لبن الشوفان في مجموعات الفئران المصابة بداء السكري إلى تحسن معيّن في كل هذه العوامل. مقارنة بالمجموعة الضابطة الإيجابية (الفئران المصابة بداء السكري). في هذه الدراسة أيضاً، وأول مرة، أظهرنا أن إعطاء لبن الإبل المتخمر المحتوي على 50% من لبن الشوفان في الجرذان المصابة بداء السكري أدى إلى زيادة المؤشرات الحيوية للدم مقارنة بمجموعة مرضى السكر غير المعاملة، مما يشير إلى أن لبن الإبل المتخمر المحتوي على 50% من لبن الشوفان يمكن يلعب دورًا وقائيًا لمرضى السكري.