



# The Potential Influence of 16 Days *Ad libitum* Consumption of Camel's Colostrum and Milk in Fresh and Cold-stored Status on Blood Glucose Values and hematological Profiles in Mice

A.A. Mohammed<sup>1</sup>, S. Al-Suwaiegh<sup>1</sup>, I. AlGherair<sup>1</sup>, H. Almarri<sup>1</sup>, A. Almuyidi<sup>1</sup>

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## ABSTRACT

**Background:** Camel's milk has been shown to improve body health upon consumption.

**Methods:** Thirty male albino mice (Body weight  $27.60 \text{ g} \pm 0.50$ ) were distributed over three groups (10 per group). The animals of control, colostrum and milk groups were fed basal diet. In addition, the three groups were given *ad libitum* water, camel's colostrum and milk in fresh (day 0) and cold-stored states (day 1-16) days to evaluate changes in blood glucose values and blood profiles. Chemical composition of camel's colostrum and milk was determined. Body weights (BW), rectal temperature, pulse rate and peripheral oxygen saturation ( $\text{SPO}_2$ ) were recorded. Blood samples were collected for recording blood glucose and blood profile values.

**Result:** The results showed colostrum contained higher solid not fat, protein and lactose values but lower fat and mineral values if compared to milk values. The final body weight and body temperature were higher in colostrum and milk groups compared to control group. Blood glucose values were lower in colostrum and milk groups compared to control one. In addition, blood glucose values were gradually increased due to extended time of cold storage of camel colostrum and milk. Furthermore, camel colostrum and milk group showed higher RBCs, WBCs, total protein and lower total cholesterol if compared to control groups.

**Key words:** Camel, Cold-stored, Colostrum, Fresh, Glucose, Lipid, Milk.

## INTRODUCTION

People residing in harsh environments often encounter significant difficulties, including inadequate nutrition and the resulting metabolic imbalances (Vilar-Compte *et al.*, 2021). Malnutrition challenges in harsh environments include limited access to nutrient-rich foods, droughts and unpredictable weather patterns affecting food production and difficulties in storing and preserving perishable foods (Gamage *et al.*, 2025). Additionally, the metabolic disorders include diabetes due to dietary limitations and stress, mineral deficiencies and dehydration (García-García *et al.*, 2020). Camels are considered the most important animal species to produce milk in the harsh environmental conditions (Djenane and Aider 2024; Mohammed *et al.*, 2025a). It has been reported 5.25 million of she-camels were approximately produced 2.12 million tons (El-Hanafy *et al.*, 2023). Both camel milk and colostrum provide nutritional profiles and health benefits to both offspring and human as well (Almasri *et al.*, 2024).

Research has investigated the possible health advantages of camel milk, examining its ability to treat specific conditions in laboratory animals and people (Kocyigit *et al.*, 2024; Mohammed and Alshaibani 2025). It has been reported that camel colostrum and milk are rich in a variety of bioactive components, including lactoferrin, immunoglobulins, minerals and vitamins suggesting a wide range of therapeutic applications (Mahala *et al.*, 2023). Researchers are beginning to unravel the mechanisms underlying these purported benefits of camel' colostrum,

<sup>1</sup>Department of Animal and Fish Production, College of Agriculture and Food Sciences, King Faisal University, P.O. Box 402, Al-Ahsa 31982, KSA, Saudi Arabia.

**Corresponding Author:** A.A. Mohammed, Department of Animal and Fish Production, College of Agriculture and Food Sciences, King Faisal University, P.O. Box 402, Al-Ahsa 31982, KSA, Saudi Arabia. Email: aamohammed@kfu.edu.sa

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milk and milk products (Kanha, 2010; Almasri *et al.*, 2024). Several studies indicated that camel's milk is effective in treating many diseases such as diabetes, cancer, viral hepatitis and other infections (Alhassani, 2024).

Cold storage is a crucial method for preserving milk quality and extending its shelf life (D'Incecco *et al.*, 2021). The main target of refrigerating dairy products is to inhibit bacterial growth and extending their shelf life (Gogliettino *et al.*, 2020; Li *et al.*, 2023). Due to the hypothesis of lowering blood glucose levels upon consuming camel's milk, the aims of the current study were to explore the changes of blood glucose levels, physiological parameters, blood profiles of adult mice consuming camel's milk and colostrum in fresh and cold-stored states.

## MATERIALS AND METHODS

The experimental procedures were approved by the ethical committee of King Faisal University [KFU-REC-2025-FEB-EA252]. The samples of camel's colostrum and milk were collected from farm far from KFU ~30.0 km. The experiments were conducted in the laboratory facilities of the Agriculture and Food Sciences College at KFU.

### Colostrum and milk samples' collection and analyses

Five Majaheem she-camels were selected for colostrum and milk collection. The she-camels were 6.0-12.0 years old. The colostrum and milk collections took place between the months of February and March. Colostrum samples were collected within 6.0-12.0 hours of parturition. The udder was cleaned prior to hand milking. The colostrum and milk samples then underwent chemical analyses (total solids, protein, fat, lactose and minerals) in addition to Brix value for immunoglobulin via refractometer in colostrum (High brix Refractometer ORZ 117) (Pérez-Marín *et al.*, 2023). Milk samples were collected two weeks after parturition. The she-camel udders, prior to milking, were cleaned with a 70% alcohol and the milker's hands were washed and sanitized with 70% alcohol. The first three milk streams were discarded and the remaining milk was then milked into a plastic sterilized container by fully emptying the udder.

### Animal management and site of study

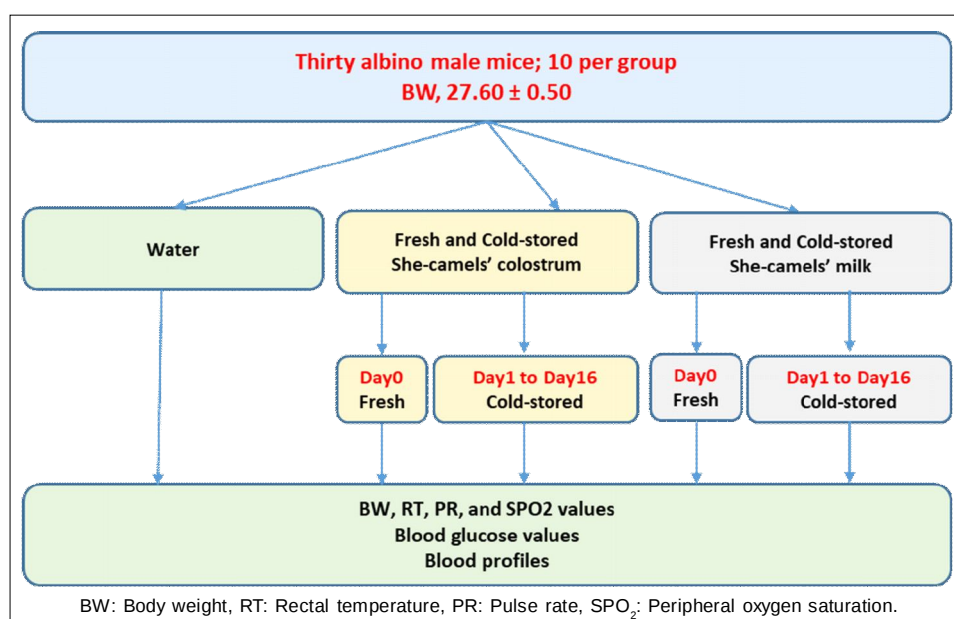
Thirty albino male mice (BW  $27.60 \pm 0.50$ g) were kept in cages ( $40.0 \times 24.0 \times 18.0$  cm) for control and the camels' colostrum and milk groups (Fig 1).

The colostrum and milk groups were offered *ad libitum* camel's fresh colostrum and milk at day one followed by

cold-stored colostrum and milk from day 2 to day 16 whereas the control group was offered *ad libitum* water. The mice's diet was pellets containing 18.0% protein, 3.20% fiber and 2.90% fat, supplemented with 1.0% minerals and vitamins, providing a total energy content of 3300 kilocalories per kilogram (ARASCO). The control group was offered *ad libitum* water whereas colostrum and milk groups were offered *ad libitum* camel's colostrum and milk diluted with water (1:1 volume) through bottles with automated nipple. The mice consumed daily ~8.0 ml of diluted milk and colostrum, respectively. This *ad libitum* method was chosen to allow the animals to regulate their intake according to their voluntary needs and reduce stress. Mice were kept controlled under 12:0h light and 12:0h dark cycle starting at 8:0 a.m. The temperature (°C) and relative humidity (%) values during the study were controlled to  $24.30 \pm 1.30^\circ\text{C}$  and  $40.0 \pm 4.0\%$ , respectively.

### Monitoring body weight, rectal temperature, heart rate, peripheral oxygen saturation and blood glucose values

Body weights (g) of control, colostrum and milk groups were recorded using digital balance (Sartorius balance, Azulmart-KSA). The mice of all groups were sedated using 26.6 mg/kg BW xylazine for immediate recording of rectal temperature, pulse rate and  $\text{SPO}_2$ . Rectal temperatures were recorded using clinical thermometer (Citizen) (Mohammed *et al.*, 2025b). Peripheral oxygen saturation ( $\text{SPO}_2$ ) and pulse rates were recorded using pulse oximeter apparatus (CMS60D-VET). Blood glucose values were recorded using blood glucose meter (iCare, Taiwan) without sedation. The tail vein of mice was punctured and 10  $\mu\text{l}$  tiny blood sample put on iCare glucose strips (TD-4279 GDH-FAD) for recording blood glucose values.



**Fig 1:** Effects of *ad libitum* consumption of fresh and cold-stored she-camels' colostrum and milk on physiological parameters, blood glucose values and blood profiles in mice.

### Blood sample collection and analyses

Blood samples were collected from the orbital sinus of control mice group, fresh and cold-stored camel colostrum and milk mice groups at the end of experiment (Hoff 2000). The obtained blood samples were analyzed using automatic hematology analyzer (Mythic 5Vet PRO Hematology Analyzer) and biochemistry analyzer (Skyla VB1). The resulting blood profiles include red and red blood cells. The resulting biochemistry profiles include total protein and urea values. In addition, total cholesterol values were recorded using digital analyzer (ZEALSON).

### Statistical analysis

Body weight, blood glucose, rectal temperature, SPO<sub>2</sub> and pulse rate, blood and plasma profile values of control and fresh and cold-stored camels' colostrum and milk groups were statistically analyzed using General Linear Model procedure of one way ANOVA (SAS 2008) according to the following model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where,

$\mu$  = Mean.

$T_i$  = Effects of fresh and cold-stored camel colostrum and milk consumption.

$e_{ij}$  = Standard error.

Duncan's multiple range test (Duncan, 1955) was used to compare between means of control and fresh and frozen-thawed camel colostrum and milk groups.

## RESULTS AND DISCUSSION

Body weight, blood glucose, rectal temperature, SPO<sub>2</sub> and pulse rate, blood and plasma profile values of control and fresh and cold-stored camel's colostrum and milk groups are shown in Fig 2 (Table 1-3).

### Chemical composition of camel's colostrum and milk

Camels' colostrum and milk were collected from farm located in Al-Ahsaa region of Majaheem camel breed. The

results showed colostrum contained higher ( $P < 0.0001$ ) solid not fat, protein and lactose values but lower fat and mineral values if compared to milk values. The recorded brix value (%) of immunoglobulin in colostrum was 27% (Fig 2).

### Body weight, rectal temperature, SPO<sub>2</sub> and pulse rate

Changes of final body weight (g), rectal temperature, pulse rate and SPO<sub>2</sub> are presented in Table 1. Value of final body weight and rectal temperature were significantly increased in colostrum and milk groups compared to those of control group and no differences was found between colostrum and milk groups. Pulse rates and SPO<sub>2</sub> values were not differed among control, colostrum and milk groups.

### Monitoring blood glucose levels

Blood glucose values per two days of mice consuming fresh and cold-stored camels' colostrum and milk for sixteen days are presented in Table 2. There were no significant differences in blood glucose levels between any of the groups at the start of the experiment. All groups had similar starting glucose levels around 131.1-133.2 mg/dl. The control group's glucose levels remained relatively stable over the sixteen days of experiment. Over the sixteen days, the fresh and cold-stored colostrum group showed the lowest blood glucose levels ( $P < 0.001$ ) compared to control or milk groups. Simultaneously, the fresh and cold-stored milk group showed a decrease ( $P < 0.05$ ) in glucose levels till day 6 of cold-storage, thereafter the values were comparable with control group till day 14 of cold-storage. On day16 of cold-storage, the milk group had the highest glucose value compared to other group.

### Blood and plasma profiles

The changes of RBC, WBCs, total protein, urea and total cholesterol values over camels' colostrum and milk *ad libitum* consumption in fresh and cold-stored for sixteen days are presented in Table 3. The control group had significantly lower RBCs, WBCs, total protein values compared to colostrum and milk groups. Urea values were

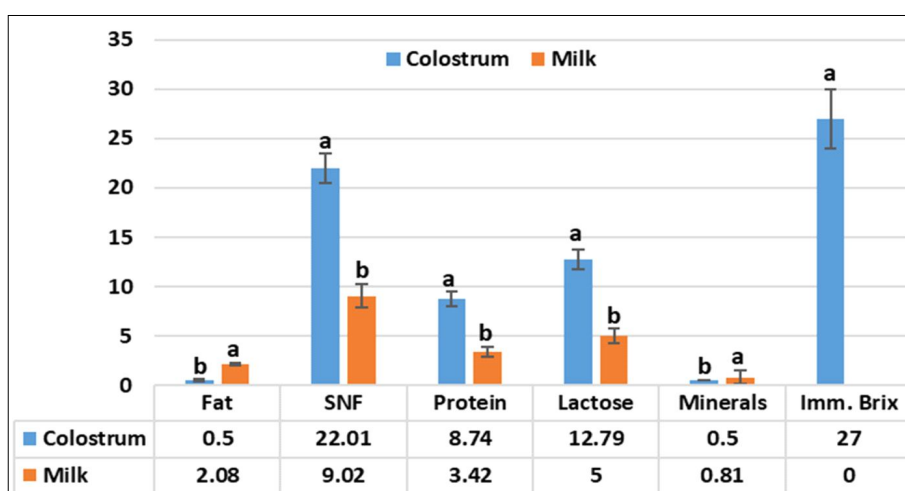


Fig 2: Chemical composition of fresh camel colostrum and camel milk. SNF, solid none fat.

lower in colostrum group compared to milk and control group. Additionally, the total cholesterol were non significantly lower in colostrum and milk groups if compared to control group.

Results of the presents experiment are shown in Fig 2 and Table 1-3 indicating the effects of camels' colostrum and milk in fresh or cold-stored on body weight gain, blood glucose profiles, blood profiles in mice. Collectively, the obtained results indicated potential effects of fresh camel colostrum and milk in decreasing blood glucose levels and cold storage gradually changes the effects. In addition, body weight gain and blood profiles (RBCs, WBCs, total protein, urea and total cholesterol) were improved in colostrum and milk groups compared to control one. These effects could be attributed to the ingredients in camel's colostrum and milk (Fig 2). Both camels' colostrum and milk contain various biological compounds, some of which can be potentially effect on blood glucose levels and body functions (Aljumaah *et al.*, 2025; Alhassani, 2024). Cold

storage, a common method for preserving food and biological samples can have significant effects on protein structures of camels' colostrum and milk.

#### Body weight, rectal temperature, SPO<sub>2</sub> and pulse rate

Changes of final body weight (g), rectal temperature, pulse rate and SPO<sub>2</sub> are presented in Table 1. Values of final body weight and rectal temperature were significantly increased in colostrum and milk groups compared to those of control group and no differences was found between colostrum and milk groups. Pulse rates and SPO<sub>2</sub> values were not differed among control, colostrum and milk groups. Camels' colostrum and milk have been confirmed to provide a variety of potential health benefits (Aljumaah *et al.*, 2025; Alhassani, 2024). A notable difference was observed in SPO<sub>2</sub> levels. The control group exhibited a considerably lower SPO<sub>2</sub> (84.90%) compared to colostrum and milk supplemented groups (87.50% and 88.30%). This

**Table 1:** Body weight (g), rectal temperature (°C), pulse rate and peripheral oxygen saturation (%) values in mice receiving *ad libitum* fresh and cold-stored camel colostrum and milk.

| Parameters                      | Control            | Colostrum          | Milk               | SEM  | P value |
|---------------------------------|--------------------|--------------------|--------------------|------|---------|
| Initial body weight, g          | 27.80              | 27.40              | 27.60              | 0.96 | 0.94    |
| Final body weight, g            | 31.60 <sup>b</sup> | 33.30 <sup>a</sup> | 33.50 <sup>a</sup> | 1.12 | 0.60    |
| Rectal temperature, °C          | 35.60 <sup>b</sup> | 35.88 <sup>a</sup> | 35.90 <sup>a</sup> | 0.07 | 0.05    |
| Pulse rate/min.                 | 165.50             | 166.60             | 165.40             | 6.24 | 0.96    |
| Peripheral oxygen saturation, % | 84.90              | 87.50              | 88.30              | 2.43 | 0.70    |

<sup>a,b</sup> Values between groups in the same row with different superscripts significantly differ at P<0.05.

SEM standard error of means.

**Table 2:** Changes of blood glucose (mg/dl) values in mice receiving *ad libitum* fresh and cold-stored camel colostrum and milk.

| Parameters          | Control            | Colostrum          | Milk               | SEM  | P value |
|---------------------|--------------------|--------------------|--------------------|------|---------|
| Control             | 132.0              | 133.0              | 134.0              | 2.04 | 0.97    |
| Fresh, day 0        | 131.2 <sup>a</sup> | 106.7 <sup>c</sup> | 118.0 <sup>b</sup> | 1.96 | 0.03    |
| Cold-stored, day 2  | 132.0 <sup>a</sup> | 108.9 <sup>c</sup> | 119.3 <sup>b</sup> | 2.24 | 0.04    |
| Cold-stored, day 4  | 132.2 <sup>a</sup> | 110.8 <sup>b</sup> | 119.8 <sup>b</sup> | 1.86 | 0.05    |
| Cold-stored, day 6  | 132.3 <sup>a</sup> | 111.0 <sup>b</sup> | 120.8 <sup>b</sup> | 1.74 | 0.05    |
| Cold-stored, day 8  | 133.4 <sup>a</sup> | 113.8 <sup>b</sup> | 125.5 <sup>a</sup> | 2.75 | 0.03    |
| Cold-stored, day 10 | 132.6 <sup>a</sup> | 114.5 <sup>b</sup> | 132.2 <sup>a</sup> | 2.56 | 0.02    |
| Cold-stored, day 12 | 133.2 <sup>a</sup> | 114.6 <sup>b</sup> | 138.6 <sup>a</sup> | 1.88 | 0.02    |
| Cold-stored, day 14 | 132.8 <sup>a</sup> | 117.3 <sup>b</sup> | 139.8 <sup>a</sup> | 2.34 | 0.01    |
| Cold-stored, day 16 | 133.5 <sup>a</sup> | 120.3 <sup>b</sup> | 141.0 <sup>a</sup> | 2.04 | 0.02    |

<sup>a,b,c</sup> Values between groups in the same row with different superscripts significantly differ at P<0.05.

**Table 3:** Changes of blood profiles of mice consuming fresh and cold-stored camel milk and colostrum.

| Parameters                | Control           | Colostrum          | Milk              | SEM  | P value |
|---------------------------|-------------------|--------------------|-------------------|------|---------|
| RBCs, 10 <sup>6</sup> /μl | 7.50 <sup>b</sup> | 8.50 <sup>a</sup>  | 8.45 <sup>a</sup> | 0.35 | <0.0001 |
| WBCs, 10 <sup>3</sup> /ml | 5.70 <sup>b</sup> | 6.80 <sup>a</sup>  | 6.60 <sup>a</sup> | 0.55 | 0.001   |
| Total protein, g/dl       | 4.10 <sup>b</sup> | 4.50 <sup>a</sup>  | 4.60 <sup>a</sup> | 0.15 | 0.01    |
| Urea, mg/dl               | 30.0 <sup>a</sup> | 26.50 <sup>b</sup> | 31.3 <sup>a</sup> | 1.05 | 0.05    |
| TC, mg/dl                 | 106.0             | 98.0               | 101.0             | 3.34 | 0.60    |

<sup>a,b</sup> Values between groups with different superscripts in the same row significantly differ at P<0.05.

SEM standard error of means; RBCs, Red blood cells; WBCs, White blood cells, TC, Total choleterol.

suggests that camel colostrum and milk consumption may have a positive impact on oxygen saturation. The higher  $\text{SPO}_2$  in the camel colostrum and milk groups could indicate improved respiratory function or oxygen utilization due to higher RBCs and Hb values (Table 3) (Khan *et al.*, 2025).

### Blood glucose levels

Blood glucose values per two days of mice consuming fresh and cold-stored camels' colostrum and milk for sixteen days are presented in Table 2. The control group exhibits a relatively stable blood glucose level throughout the experimental period, with a slight increase towards the end. The fresh camel colostrum supplementation indicates the strongest hypoglycemic effect followed by fresh camel milk if compared to control group at day zero. The hypoglycemic effect of camel milk has been confirmed in several studies (Zhang *et al.*, 2023; Mohammed and Alshaibani, 2025) whereas the hypoglycemic effect of camel colostrum has been not explored to the best of our knowledge earlier. Camel milk is suggested to be a suitable hypoglycemic factor in experimental animals and diabetic people (Zhang *et al.*, 2023). It has been assumed that camel milk contains insulin-like proteins that enhance health of diabetic patients (Ayoub *et al.*, 2024). The camel colostrum contains higher immunoglobulin content (Brix% 27.0 Fig 2) as mentioned in other studies (Mohammadabadi and Kumar, 2024). The hypoglycemic effects of colostrum and milk decreased with extended time of cold storage. Camel milk resulted in hyperglycemic effect at day 12, day 14 and day 16 of cold storage if compared to control and colostrum group. With cold-stored procedure, such insulin-like proteins in camel colostrum and milk might be denatured and aggregated. Prolonged exposure to cold temperatures can also disrupt the delicate balance of non-covalent interactions that maintain a protein's three-dimensional structure. This disruption can cause the protein to unfold or lose its native conformation (Masson and Lushchekina, 2022).

### Blood and plasma profiles

The changes of RBC, WBCs, total protein, urea and total cholesterol values over camels' colostrum and milk *ad libitum* consumption in fresh and cold-stored state for sixteen days are presented in Table 3. Camel colostrum and milk appear to have positive effects on RBC, WBCs, total protein, urea and total cholesterol values. Camels' colostrum and milk supplementation seem to enhance the production or levels of red blood cells, white blood cells, suggesting a potential immune-modulatory effects. Furthermore, cold storage of camel colostrum and milk did not seem to significantly alter its effects on these hematological parameters. The higher concentration of bioactive compounds such as lactoferrin and various immunoglobulins (IgM, IgA, IgG and IgD) are found in camel colostrum and milk, which has turned camel colostrum and milk into substances with extraordinary medicinal properties (Alhassani, 2024). The presence of high levels of these compounds along with various vitamins (C, B1,

B2, E, A) (Khalik *et al.*, 2024), lysozymes, insulin-like molecules and lactoperoxidase cause the therapeutic potential of camel milk (El-Kattawy *et al.*, 2021).

The camels' colostrum and milk increased total protein levels (4.5 and 4.6 g/dl) if compared to control group (4.1 g/dl) due to camel colostrum and milk proteins contents (Fig 2). The colostrum group had significantly lower urea levels (26.5 mg/dl) compared to the control and milk groups (30.0 and 31.3 mg/dl), which is generally indicative of better kidney function. The total cholesterol were non significantly lower in colostrum and milk groups if compared to control group (Table 3) as indicated in other studies (Khalid *et al.*, 2023). The digestion of camel colostrum and milk proteins can release bioactive peptides. Some of these peptides have shown potential to interfere with cholesterol absorption in the gut and promote cholesterol excretion (Sboui *et al.*, 2022). In addition, camels' colostrum and milk are notably rich in Vitamin C, which is involved in the synthesis of bile acids from cholesterol. Increased bile acid production can lead to the utilization of more cholesterol, potentially lowering blood cholesterol levels.

## CONCLUSION

Significant effects of fresh and cold-stored camel colostrum and milk were recorded on body function and blood profiles. The most prominent findings of this study indicated that fresh camel colostrum and milk supplementation gave the strongest hypoglycemic effect and the effects were decreased gradually with extended cold storage time. Further studies are still required to explore the effects of fresh camel colostrum and milk on diabetic experimental model animals with different body weights.

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### Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the official stance of their affiliated institution.

### Informed consent

Ethical Approval of Scientific Research Deanship Committee of King Faisal University (ETHICS3145).

### Conflict of interest

The authors have no conflicts of interest to disclose.

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