



Nutritional Quality of Ardi Goat'S Colostrum and Milk: Potential Influence on Blood Glucose Values and Lipid Profiles in Fresh and Cold-stored Status in Mice

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ABSTRACT

Background: Goat's milk and milk products has been shown to offer some benefits for blood glucose regulation, liver health and kidney function.

Methods: Sixty male albino mice were classified into three groups; control, goat's colostrum (fresh and cold-stored) and goat's milk (fresh and cold-stored). Chemical composition and immunoglobulins values of Ardi goat's milk and colostrum were determined through milkoscan system and Brix refractometer, respectively. Body weights (BW), rectal temperature (RT), pulse rate (PR) and peripheral oxygen saturation (SPO₂), blood glucose and total protein values and lipid profiles were recorded.

Result: The results showed that goat's colostrum had higher ($P<0.0001$) solid not fat (SNF), protein and lactose but lower fat values compared to goat's milk. Ardi goat's colostrum had 21.0% brix of immunoglobulins. Goat milk group had higher body temperature compared to goat colostrum and control groups. Pulse rate and peripheral oxygen saturation values were not differed among groups. Total protein values were higher in colostrum and milk groups compared to control one. Fresh colostrum followed by fresh milk resulted in significant decrease in blood glucose if compared to control group. Cold storage of goat colostrum and milk resulted in progressive increase in blood glucose values compared to fresh states. High-density lipoprotein (HDL) values were increased in colostrum group compared to milk and control groups. Furthermore, triglycerides (TG) and low-density lipoprotein (LDL) values were decreased in colostrum and milk groups compared to control group.

Key words: Blood, Cold storage, Colostrum, Fresh, Glucose, Goat, Lipids, Milk.

INTRODUCTION

The majority of milk produced comes globally from cows (Claeys *et al.*, 2014), with goat's milk accounting for 1.5% (dos Santos *et al.*, 2023). Goat breeds have been reared as sources of meat and milk for human due to their low feed requirements and low production costs (Tajonar *et al.*, 2022; Mohamed *et al.*, 2023; Gawat *et al.*, 2023; Abdullah *et al.*, 2024). Their relatively low feed requirements and production costs make them an attractive option for farmers, especially those with limited feed resources.

Goat's milk has gained popularity and the production of goat's milk has increased in recent years (Miller and Lu 2019; Massaglia *et al.*, 2019; Zulkifli *et al.*, 2023). The number of dairy goats specifically raised for milk production is increasing due to greater demand (Navarrete-Molina *et al.*, 2024). While Asia accounts for the majority of global dairy goat production and consumption, examining the worldwide dairy goat industry offers valuable insights for establishing successful modern operations (Meza-Herrera *et al.*, 2024). The goat species plays a fundamental socioeconomic and environmental role in many regions of Europe and France boasts the most developed market for goat milk production (Miller and Lu, 2019). In fact, the production of goat milk has increased in recent years and 70% of the total production is used for cheese making.

Goat milk is widely known for its significant positive effects on human nutrition and health due to its unique

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composition and nutritional advantages including proteins, lipids and others (Turkmen 2017; Cohen-Zinder *et al.*, 2025). Proteins of goat milk were associated with beneficial health characters as regulation of immune system regulation, anti-inflammatory properties, antioxidant and antimicrobial activities (Tsakali *et al.*, 2020; ALKaisy *et al.*, 2023). The unique compositional and nutritional advantages of goat milk lipids including the fat content and fatty acid composition (Gallier *et al.*, 2020; Liao *et al.*, 2024) make them valuable material for extensive research. The milk fat globule membrane is owing to its emerging role in anti-inflammatory, antimicrobial and cholesterol-lowering effects (Singh, 2018; Argov-Argaman *et al.*, 2021).

Goat's colostrum is a highly specialized secretion providing essential immunoglobulins, concentrated nutrients and bioactive factors that support its immediate survival and development to newborn kids (Betancor-Sánchez *et al.*, 2025; González-Cabrera *et al.*, 2025). The composition of goat colostrum changes rapidly after kidding, transitioning to mature milk within the first 24-48 hours (Marounek *et al.*, 2012). The concentration of goat colostrum immunoglobulins and other bioactive factors decreases significantly during this period, while lactose content increases. The quality of colostrum, particularly its immunoglobulin concentration, is crucial for the kid's health. Genetic and environmental factors such as species, dry-off strategies, health, nutrition and vaccination status can influence colostrum quality (Wicki *et al.*, 2025). The question arose, does the goat's colostrum and milk able to promote health properties in fresh and cold storage states. Therefore, the aims of the present experiment were to determine the nutritional quality of goat's colostrum and milk and their effects on blood glucose and lipid profiles upon *ad libitum* consumption in fresh and cold-stored states in mice.

MATERIALS AND METHODS

The procedures of the experiment were approved by the ethical committee of King Faisal University [KFU-REC-2025-APR-EA3261]. Ardi goat's colostrum and milk were obtained from a farm located in Al-Ahsaa region. Experiments were carried out in the experimental animal laboratories of Agriculture and Food Sciences College at King Faisal University in KSA.

Colostrum and milk samples' collection and analyses

Five purebred Ardi goats were selected for colostrum and milk collection. The goats were 1.5-2.0 years old. The colostrum and milk samples' collections took place during February. Colostrum samples were obtained within 6-12 hours of parturition by hand milking. The udder and milker's hands were cleaned prior to hand milking and the samples were placed in sterilized plastic bottles. The colostrum samples then underwent chemical analysis to determine their composition (fat, protein, lactose, total solids and minerals) in addition to Brix percentage *via* refractometry (High brix Refractometer ORZ 117) (Pérez-Marín *et al.*, 2023; Mohammed *et al.*, 2025a,b). Thereafter, the milk samples were collected within 10 days after birth. To ensure an adequate milk volume, kids were separated from their mothers for three hours prior to each collection. The first three milk streams were discarded and the remaining milk was then collected into sterilized container by fully emptying the udder.

Mice and experimental groups

Sixty albino male mice (28.90 ± 0.45) were kept in cages ($40.0 \times 24.0 \times 18.0$ cm) for control, colostrum and milk groups (Fig 1). The goats' colostrum and milk groups were offered *ad libitum* fresh colostrum and milk at day 1 followed by cold-stored colostrum and milk at day 2, day 3 and day 4 whereas the control group was offered *ad libitum* water. Goat's colostrum and milk were diluted with water (1:1 volume) and offered to mice through bottles with automated nipple. The mice consumed daily 8.0-10.0 ml of diluted milk and colostrum, respectively. This *ad libitum* method was chosen to allow the animals to regulate their intake

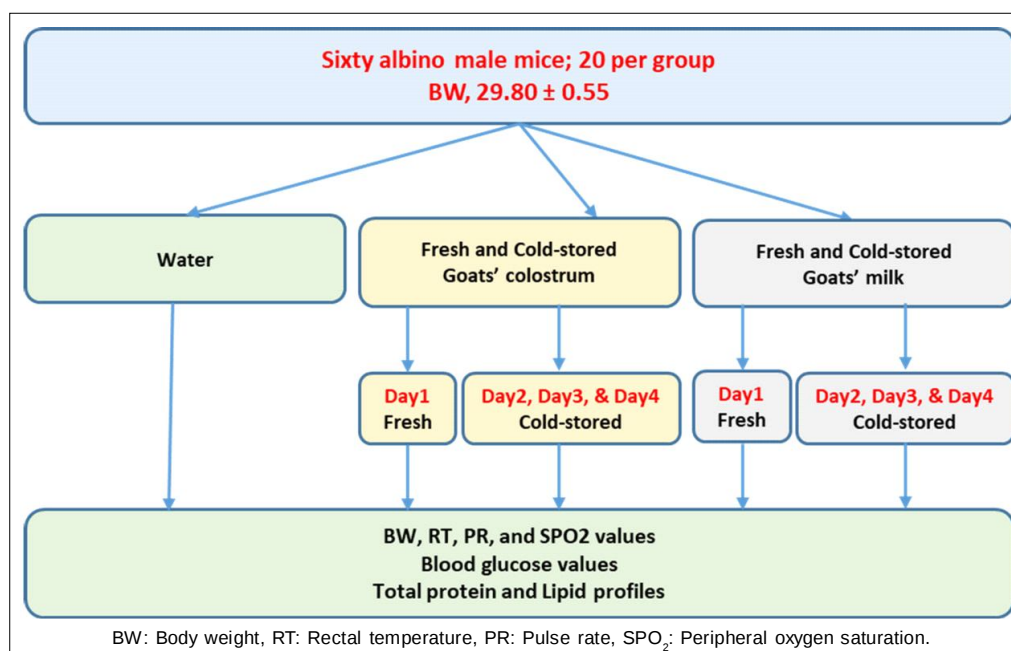


Fig 1: Effects of *ad libitum* consumption of fresh and cold-stored goats' colostrum and milk on physiological parameters, blood glucose values and lipid profiles in mice.

according to their voluntary requirements and reduces stress. Animals had free access to commercial diet and live in controlled light and dark cycle (12h: 12h). The temperature (°C) and relative humidity (%) values during the study were controlled to $23.50 \pm 1.5^\circ\text{C}$ and $38.0 \pm 4.0\%$, respectively.

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

Body weights (g) of control, goats' colostrum and milk groups were recorded using digital balance (Sartorius balance, Azulmart-KSA). Rectal temperature (Citizen), heart rate, peripheral oxygen saturation (Pulse oximeter CMS60D-VET), blood glucose values (Contour care, Japan) and lipid profiles (total cholesterol TC, triglycerides TG, high density lipoprotein HDL, low density lipoprotein LDL, TC/HDL) (Hnxyisite) were recorded (Mohammed *et al.*, 2025c).

Statistical analysis

Chemical composition of goats' colostrum and milk were statistically analyzed using T-test procedure. Body weight, rectal temperature, SPO_2 and pulse rate and blood glucose values of control group, 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,

μ = Mean.

T_i = Effects of fresh and cold-stored goats' colostrum and milk consumption.

e_{ij} = Standard error.

Duncan's multiple range test (Duncan, 1955) was used to compare between means of control, goats, colostrum and milk groups.

RESULTS AND DISCUSSION

Chemical composition of ardi goat colostrum and milk

Chemical composition of Ardi goat colostrum and milk is presented in Table 1. The results indicated that Ardi goat

colostrum had higher ($P < 0.0001$) SNF (13.40 vs. 8.55), protein (7.88 vs. 2.62), lactose (11.56 vs. 2.82) and density (1.0316 vs. 1.0247) but lower fat contents (0.46 vs. 3.02) and minerals (0.20 vs. 0.40) compared to Ardi goat milk, respectively. Moreover, the Brix value (%) of immunoglobulin content in goat's colostrum is 21.0%.

Body weight, rectal temperature, pulse rate and peripheral oxygen saturation

Changes of rectal temperature, pulse rate and SPO_2 among Ardi goat's colostrum, milk and control groups are presented in Table 2. The rectal temperature value (°C) was significantly higher in milk group compared to colostrum and control groups whereas pulse rates and SPO_2 values were not differed among groups.

Monitoring blood glucose levels

Blood glucose values per day of mice consuming fresh and cold-stored Ardi goat's colostrum and milk are shown in Fig 2. There were no significant differences in blood glucose values between any of the groups at the start of the study (day 0). The control group's glucose levels remained relatively stable over the four days of experiment. All groups had similar starting glucose levels around 133.0-136.0 mg/dl (day 0). At day 1, the fresh Ardi goat's colostrum group showed the lowest blood glucose value ($P < 0.0001$) followed by Ardi goat's milk and control groups, respectively. At day 2, the same trend of blood glucose values was observed among groups as day 1. At day 3, no significant differences was found among groups. At day 4, Ardi goat's milk showed the highest blood glucose value followed by control and colostrum groups, respectively.

Total protein and lipid profiles

Changes of total protein and lipid profiles of Ardi goat's colostrum, milk and control groups are presented in Table 3. The results showed that total cholesterol values were significantly decreased in colostrum and milk groups compared to control group. The high-density lipoprotein (HDL) values were increased in colostrum group compared to milk and control groups. Furthermore, triglycerides (TG), low-density lipoprotein (LDL) and TC/HDL values were decreased in colostrum and milk groups compared to control group.

Table 1: Chemical composition of Ardi goat's colostrum and milk.

Parameters %	Colostrum	Milk	SEM	P value
Fat	3.21 ^b	3.83 ^a	0.4	<0.0001
Solid not fat	13.40 ^a	8.55 ^b	1.38	<0.0001
Protein	5.92 ^a	3.18 ^b	1.23	<0.0001
Lactose	6.73 ^a	4.65 ^b	0.45	<0.0001
Mineral	0.20 ^b	0.40 ^a	0.01	<0.0001
Density	1.0316 ^a	1.0247 ^b	0.02	<0.0001
Freezing point	-0.402	-0.408	0.03	<0.0001
Brix immunoglobulin, %	21.0	-	-	-

^{a,b} Values between groups in the same row with different superscripts significantly differ at $P < 0.05$. SEM standard error of means.

The results of the present study are showed in Fig 2 and Table 1-3 indicating the chemical composition of Ardi goat's colostrum and milk and their effects in fresh or cold-stored state on physiological parameters, blood glucose, total protein and lipid profiles. The obtained results showed the potential effects of Ardi goat's colostrum in modifying total protein, lipid profiles and blood glucose values followed by Ardi goat milk and control groups, respectively. There is an increasing number of goats being raised specifically for milk production and accompanied by rising consumer demand for goat milk (Pulina *et al.*, 2018; Miller and Lu, 2019; Liao *et al.*, 2024). It has been shown that goat's milk is considered a highly desirable alternative to human milk (Ke *et al.*, 2017). The growing interest for goat milk might be due to nutritional benefits, easier digestion and reduced allergenicity, health and wellness trends (Stergiadis *et al.*, 2019).

Chemical composition of Ardi goat colostrum and milk

Chemical composition of Ardi goat colostrum and milk is presented in Table 1. The results indicated that Ardi goat colostrum had higher ($P<0.0001$) SNF (13.40 vs. 8.55), protein (7.88 vs. 2.62), lactose (11.56 vs. 2.82) and density (1.0316 vs. 1.0247) but lower fat contents (0.46 vs. 3.02) and minerals (0.20 vs. 0.40) compared to Ardi goat milk, respectively. Moreover, the refractometer Brix value (%) of immunoglobulin content in goat's colostrum is 21.0%. This result is consistent with other studies (Sánchez-Macías *et al.*, 2014; dos Santos *et al.*, 2023). Goat's colostrum, the initial secretion following parturition, differs significantly from mature milk. The varying components of colostrum highlight its crucial function in supplying newborn kids with essential immune defenses and a dense source of nutrients, thereby supporting their adaptation to life outside

Table 2: Changes in rectal temperature (°C), pulse rate and peripheral oxygen saturation (%) of mice receiving *ad libitum* fresh and cold-stored goat's colostrum and milk.

Parameters, %	Control	Colostrum	Milk	SEM	P value
Body weight, g	28.70	29.10	28.90	0.45	0.97
Rectal temperature, °C	35.70 ^b	35.64 ^b	35.87 ^a	0.08	0.05
Pulse rate/min.	165.7	164.8	166.4	4.70	0.93
Peripheral oxygen saturation, %	86.40	88.30	87.90	2.60	0.50

^{a,b} Values between groups in the same row with different superscripts significantly differ at $P<0.05$.

Table 3: Total protein (g/dl), total cholesterol, high-density lipoproteins, triglycerides, low-density lipoproteins of mice receiving *ad libitum* fresh and cold-stored Ardi goat's colostrum and milk.

Parameters, %	Control	Colostrum	Milk	SEM	P value
Total protein, g/dl	6.66 ^b	7.00 ^a	6.90 ^a	0.40	<0.0001
TC, mg/dl	121.6 ^a	108.0 ^b	105.0 ^b	3.40	<0.001
HDL, mg/dl	66.11 ^b	77.0 ^a	65.70 ^b	2.45	0.95
TG, mg/dl	76.22 ^a	52.0 ^b	65.50 ^b	1.43	<0.0001
LDL, mg/dl	39.00 ^a	19.0 ^b	20.00 ^b	0.79	<0.0001
TC/HDL, mg/dl	1.65 ^a	1.40 ^b	1.31 ^b	0.07	<0.0001

^{a,b,c} Values between groups in the same row with different superscripts significantly differ at $P<0.05$. TC Total cholesterol, HDL High-density lipoproteins, TG Triglycerides, LDL Low-density lipoproteins SEM Standard error of means.

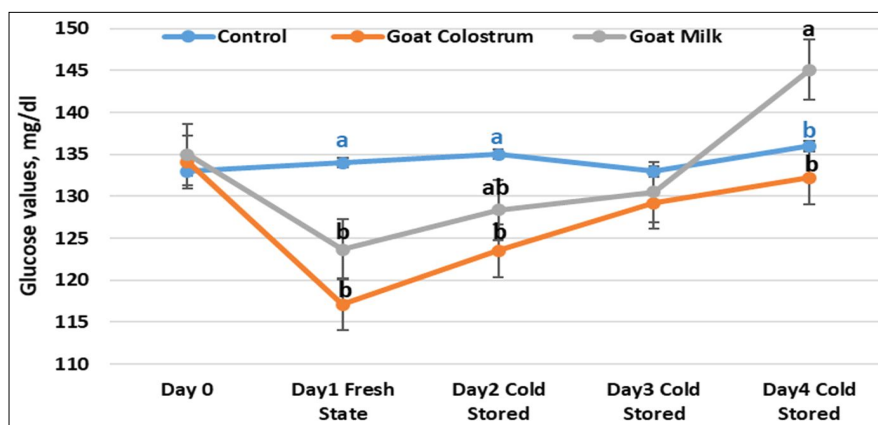


Fig 2: Effects of goat colostrum and milk cold-stored on blood glucose values.

the uterus. Goat's colostrum has a dry matter much higher than milk (14.0% vs. 29.0%), especially the high protein content which composed of 80.0% immunoglobulins (Sánchez-Macías *et al.*, 2014; Liu *et al.*, 2021). Goat's colostrum has higher fat content than mature milk fat (Zhang *et al.*, 2024). In addition, bioactive peptide precursors are present in goat colostrum in considerable quantities as such as α -lactalbumin and β -lactoglobulins (Soloshenko *et al.*, 2020). Liu *et al.* (2021) found that goat colostrum had higher values of protein, fat, minerals, EGF, IGF-I, LTF and IgG, but lower values of lactose and cAMP. There are different factors effect on goat's colostrum and mature milk composition including species, parities, lactation stage, nutrition, environmental and health factors (Fan *et al.*, 2023; Pérez-Marín *et al.*, 2023; Wicki *et al.*, 2025). Strategies of dry-off can influence colostrogenesis and colostrum composition. In addition, starch prepartum supplementation can impact concentration of colostrum IgG. Furthermore, inflammation may enhance immunoglobulin contents in goat colostrum (IgG, IgM) (Wicki *et al.*, 2025). The bioactive factors of goats' colostrum remains unknown (Pérez-Marín *et al.*, 2023; Mondeshka *et al.*, 2022; Wicki *et al.*, 2025).

Rectal temperature, peripheral oxygen saturation and pulse rate

Changes of rectal temperature, pulse rate and SPO₂ among control, goat's colostrum and milk groups are shown in Table 2. The pulse rates and SPO₂ values were not differed among groups whereas rectal temperature (°C) was higher ($P < 0.05$) in milk group compared to values in colostrum and control groups. This could be owing to the period of experiment, colostrum and milk substances don't directly provide significant amounts of substances that would immediately alter respiratory function or oxygen-carrying capacity of the blood in healthy mice. Hence, consumption of goat's colostrum and milk is unlikely to trigger a rapid and significant change in pulse rate in healthy individuals. The higher value of rectal temperature in milk group compared to those of colostrum and control groups might be owing to significant increased of energy metabolism as showed by Liu *et al.* (2021).

Blood glucose levels

Blood glucose values per day over consuming *ad libitum* fresh and cold-stored goat's colostrum and milk are shown in Fig 2. There was no significant differences in blood glucose levels between any of the groups at the start of the experiment (day 0). The control group's glucose levels remained relatively stable over the four days of experiment. All groups had similar starting glucose levels around 133.0-135.0 mg/dl (day 0). At day 1, the fresh goat's colostrum group showed the lowest blood glucose value ($P < 0.0001$) followed by goat's milk and control groups, respectively. At day 2, day 3 and day 4, goat colostrum and goat milk were given to mice over cold-stored condition. At day 2 and day 3, the blood glucose values were the lowest in colostrum group followed by milk and control groups, respectively. At

day 4, the blood glucose values were the lowest in milk group followed by colostrum and control groups, respectively. These effects could be attributed to the ingredients in goat's colostrum and milk (Table 1). Both goat's colostrum and milk contain various biological compounds, some of which can be potentially effect on blood glucose levels and body functions. Liu *et al.* (2021) found that goat's colostrum had higher values of protein and IGF-I compared to goat's milk, which might be owing to its higher hypoglycemic effects. In addition, goat's milk used in type 2 diabetic mice improve glucose metabolism (Chen *et al.*, 2024). Cold storage is a common method for preserving food and biological samples, which can have a significant effect on goat's colostrum and milk. The changes in goat milk during storage after milking and heating was reported (Yanmış and Coşkun, 2018).

Lipid profiles

Changes of total protein and lipid profiles of colostrum, milk and control groups are presented in Table 2. The higher total protein values in colostrum and milk group could be attributed to higher amino acid metabolism, replication and repair, nucleotide metabolism of those groups compared to control one (Liu *et al.*, 2021). Total cholesterol values were decreased in colostrum and milk groups if compared to control group. This could be owing to cholesterol homeostasis regulation, colostrum and milk components, gut microbiota modulation, antioxidant effects of colostrum and milk (Adar *et al.*, 2012). HDL values were increased in colostrum group if compared to milk and control groups. This could be attributed to higher fat contents and fatty acid profiles in colostrum if compared to milk and control groups (Table 1) as mentioned in other studies (Liu *et al.*, 2021). Furthermore, triglycerides (TG), low-density lipoprotein LDL and TC/HDL values were decreased in colostrum and milk groups if compared to control group. Certain proteins, peptides and other bioactive compounds in colostrum and milk might interfere with LDL production or enhance its clearance from the circulation. The combined effects of the various components in colostrum and milk influencing triglyceride metabolism, LDL production and HDL levels might likely work synergistically to produce this beneficial shift in the lipid profiles (Contarini *et al.*, 2014; El-Zahar *et al.*, 2021; Silva *et al.*, 2024).

CONCLUSION

Ardi goat's colostrum and milk offered *ad libitum* in fresh condition showed the highest hypoglycemic effect whereas the extended time of cold storage of colostrum and milk resulted in gradual increase in blood glucose values. Furthermore, lipid profiles were improved due to goat's colostrum and milk consumption.

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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.

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Informed consent

Ethical Approval of Scientific Research Deanship Committee of King Faisal University.

Conflict of interest

The authors have no conflicts of interest to disclose.

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