Blood metabolites of one-humped camel (*Camelus dromedarius*) versus sheep during summer heat stress

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Abstract:

BACKGROUND: Camel and sheep have high disperse and tolerance in tropical regions. But different results of harsh condition tolerance ability of them have been reported. **OBJECTIVES:** The objective of this study was to determine the heat stress tolerance in camel and sheep by evaluating changes in blood serum metabolites and to report and compare the serum biochemical profile of sheep and camel during long heat stress of warm summer. **METHODS:** In this experiment, blood metabolites of camel and sheep were taken and compared with each other in four consecutive months during warm months (high summer). **RESULTS:** There was a significant difference between the values of urea, glucose, total protein, albumin, phosphors, calcium, ALT, ALP, uric acid, cholesterol, triglyceride, total bilirubin, and LDH of sheep and camels. Overall urea, glucose, total protein, albumin, phosphors, and calcium values were significantly higher in camels compared to sheep ($p<0.01$). Oppositely, sheep had significant higher values for uric acid, cholesterol, triglyceride, total bilirubin, and LDH ($p<0.01$). However AST and creatinine were not significantly different between sheep and camels. **CONCLUSIONS:** Sheep sensitivity to heat stress was appeared in increasing in uric acid, cholesterol, triglyceride, total bilirubin, and LDH values compared to camel; so as it might be told sheep had more lipolysis-pattern during heat stress; their high blood LDH and total bilirubin were signs of red blood cell rupture or liver damage; and significant higher blood uric acid value in sheep makes them susceptive to a kidney problem such as gout.

Introduction

Livestock production is negatively affected by detrimental effects of extreme climates. High ambient temperatures and forage scarcity are the two factors that significantly impact the productivity and well-being of ewes during summer. Heat stress occurs when any combination of air temperature, relative humidity, air movement, and solar radiation cause the effective temperature of environment to be more than the animal's comfort zone. High ambient temperature augments effort of the ruminant to dissipate body heat and as a result rate of respiration, body temperature, heartbeat, and water consumption increase while feed intake decreases. Sheep rectal temperature increases when the ambient temperature is above 32 ◦C. Hyperthermia develops when heat production exceeds heat loss (Sejian et al., 2010).

During exposure to high environmental temperatures, domestic animals trigger a series of physiological compensatory mechanisms that allow the body to adapt itself to extreme environmental conditions and to facilitate the maintenance of vital functions by drastic changes in the animals' biological functioning.

Camels are hardy animal species. They have currently been breeding in several provinces of Iran and there is an increasing interest in breeding them. Camels are seasonal breeders with a long gestation period whose reaching to puberty takes very long time. Sheep are the most adapted and dispersed livestock breed, particularly in tropics.

Camels and sheep are well adapted to low nutritive forages and they can live in harsh environment. These animals showed well survivability with low quality forage and water including high salt content. Camels had only weight loss but sheep also showed high liver enzymes (AST, ALT) and blood glucose decreasing during heat stress (Assad and El-Sherif, 2002). These animals are different in fore-stomach compartments but their energy production sources and microbial fermentation are similar. Glucose therapy in sheep and camel after 16-20 hours starvation have shown different results. Camels have had significantly higher blood glucose concentration, 360 minutes after intravenous glucose infusion (Elmahdi et al., 1997).

Studying the effects of saline drinking water and dietary protein shortage in camels and sheep demonstrated that camels are more tolerant than sheep, both in drinking saline water and dietary protein shortage (Assad et al., 1997).

Blood metabolite changes related to age, disease, nutrition, physiological status, and weather changes have been reported in both camel and sheep (Assad et al., 1997; Chaudhary and Iqbal, 2000; Assad and El-Sherif, 2002; Ramin et al., 2005; Sejian et al., 2010; Kiran et al., 2012). Indicators of dietary energy level such as glucose, triglyceride, cholesterol, total protein, urea, and creatinine were affected by season and nutrition level in camels. Therefore, the objective of this study was to determine the heat stress tolerance in camel and sheep by evaluating changes in blood serum metabolites.

Materials and Methods

18 one-humped female camels aged 2-14 and 21 ewes aged 1.5 to 5 years old were randomly selected. Geographical location of sheep was research station of University of Jiroft (Iran) (28˚.4 North latitude and 57˚.4 Longitude with 712 m altitude) and camels were reared in a private farm (28˚.39 North latitude and 59˚Longitude with 640 m altitude) in Bam. Based on weather information and Temperature-Humidity Index (THI) of these districts, heat stress is severe and sharp. Monthly, THI was 29.4, 31.6, 29.6, and 28 respectively in June, July, August, and September. During experiment period (summer), animals had been grazing in desert and range. The animals were housed in well-natural-ventilated sheds made of asbestos roofing at the height of 3.4 m which were open from the sides, and were maintained under proper hygienic conditions.

The animals had ad labium access to good-quality drinking water and had been received routine vaccines (enterotoxaemia) and antihelmintic just one month before experiment started. Taking blood sample started in the middle of June and continued until mid-August 2014. Animals were held in corral during the morning before going to graze. Blood samples were taken in 4 sessions, every month. Animals were bled via jugular using 7-ml-capacity evacuated blood collecting tubes (Medical polymer Co, Ltd. China). Samples for serum analyses were placed in an ice bath and immediately transported to the laboratory. Biochemical parameters (urea, creteanine, glucose, total protein, Albumin, phosphors, calcium, AST, ALT, ALP, uric acid, cholesterol, triglyceride, total bilirubin, and LDH) were measured with diagnostic kits (Pars Azmoun Company-Iran local laboratory) (AUTOLAB PM4000 AMS-Rome-Italy CE). Data in progress was subject to repeated measures of ANOVA using Proc Mixed of the SAS (SAS, 1996) monthly. LSMEANS and PDIFF were used for the means comparison ($p<0.05$).

Results

The LSMEANS values of biochemical parameters of sheep and camel are presented in Table1. The results of this study demonstrated some classical changes in blood metabolites during heat stress. Significant differences between the values of urea, glucose, total protein, albumin, phosphors, calcium, ALT, ALP, uric acid, cholesterol, triglyceride, total bilirubin, and LDH of sheep and camels were recorded. However, AST and creatinine were not statistically significant between sheep and camels. Overall urea, glucose, total protein, albumin, phosphors, and calcium values were significantly higher in camels compared to sheep ($p<0.01$). Oppositely, sheep had significant higher values for uric acid, cholesterol, triglyceride, total bilirubin, and LDH ($p<0.01$).

Discussion

Heat stress is one of the environmental stress-related factors that dramatically affects livestock production; but heat stress tolerance is different from animal to animal. In this experiment, it has been shown that camel is more tolerant in high- temperature environments.

Camels had significantly high blood serum glucose concentration compared to sheep. That is same to other results (Elmahdi et al., 1997). Sheep are more sensitive to stress conditions such as thermoneutralones (Gao et al., 2007), and Tygesen et al. (2008) observed lower serum glucose concentration during the pre-partum period when ewes were fed low feeding level during the last third of gestation. Similar results were found in heat-stressed non-pregnant adult ewes just because of sub-optimal feeding (Sejian et al., 2010). These higher serum glucose levels have been attributed to a reduction in blood insulin or a decrease in systemic insulin sensitivity in camels.

One of the main cues during harsh environment situation such as heat stress is the ability to regulate glucose concentration and camel could do the best. Decrease in blood glucose under hot climate is mainly attributed to high respiration rate, causing high utilization of glucose by the respiratory muscles. The significant decrease in feed intake also contributes to the heat-induced decrease in glucose and protein (MacÃas-Cruz et al., 2013). The sheep has high respiration rate in high weather temperature (Srikandakumar et al., 2003). It is well established that under stress conditions, glucose uptake of the cells is suppressed and the level of serum glucose is increased in order to provide adequate amounts of glucose to the sensitive organs such as heart and brain. Indeed, during severe dehydration, camels have to decrease their basal metabolism to a minimal level with hyperinsulinemia leading to decreased glucose utilization, whereas gluconeogenesis allows glucose production to be maintained(Delavaud et al., 2013).

In hot environment, non-lactating cattle had lower insulin and glucose level, whereas NEFA level and heart and respiration rate had been higher in them. Despite insulin, glucose, arginine therapy in these cattle, blood glucose and insulin value were low (Itoh et al., 1998). It might be said that there is an inverse relationship between NFEA and insulin concentration; and blood glucose concentration is the result of the balance between the rate of utilization and production that severely was influenced by heat stress in ruminants. In our experiment, sheep had higher blood lipid metabolites such as triglyceride, cholesterol, and lower glucose concentration compared to camels. Accordingly, ruminant failed to balance between glucose

Table 1. LSMEANS ±SEM of serum bichemical parameters in sheep and one-humped camel. ns= non significant.

	Sheep	Camel	p-Value
Glucose (mg/dl)	43.25 ± 1.36	60.11± 1.36	<0.0001
total protein (g/dl)	7.14± 0.12	7.52± 0.12	0.03
Albumin (g/dl)	4.90 ± 0.08	5.15± 0.08	0.042
Urea (mg/dl)	26.81 ± 1.17	34.26±1.17	<0.0001
creatinine (mg/dl)	1.55± 0.08	1.38± 0.08	ns
uric acid (mg/dl)	3.17 ±0.19	2.16± 0.19	0.0005
total bilirubin (mg/dl)	3.04± 0.32	1.30± 0.32	0.0005
Cholesterol (mg/dl)	56.64± 1.68	42.17± 1.68	<0.0001
Triglicerid (mg/dl)	66.36± 4.74	39.97± 4.74	0.0003
Calcium (mg/dl)	10.26± 0.25	11.16± 0.25	0.015
Phosphors (mg/dl)	7.52± 0.27	9.81± 0.27	<0.0001
ALP (IU/l)	179.05± 18.16	57.70± 18.16	<0.0001
GOT/AST (IU/l)	92.31±4.22	101.36± 4.22	ns
GPT/ALT (IU/l)	27.07± 1.49	20.89 ± 1.49	0.005
LDH (IU/l)	1097.20± 38.89	710.81± 38.89	<0.0001

production and utilization particularly during heat stress.

In buffalo calves, the heat stress conditions induced significant decreases in total protein concentration levels and significant increases in heat shock protein concentrations (Marai and Haeeb, 2010). Saline water intake in sheep decreased serum protein concentration compared to camel (Assad et al., 1997). In our experiment, other nitrogenous metabolite such as urea, albumin, uric acid, and creatinine showed significant difference. Camel had significantly higher urea and albumin and lower uric acid compared to sheep.

Urea is a product of deamination of protein in liver and creatinine is produced in muscles during creatinine-phosphate usage. Uric acid is produced during Pyrimidine-base metabolism. Both have very high permeability to nephron membrane and their exchange is a simple diffusion in particular to urea. Change in kidney function is an ability of camels. It has shown that they reduce forestomach dilution rate and feed intake with continuous flow of saliva isotonic fluid and buffering capacity after 11 days water deprivation (Von Engelhardt et al., 2006). Perhaps high blood urea concentration in camels is related to their powerful kidney filtration.

Jaber et al. (2004) implied that water restriction has a direct effect on blood urea concentration. They implied that water deficiency leads to increased water re-absorption in the distal tubule and particularly the collecting ducts of the nephron, consequently urea re-absorption is expected to increase as it is a highly permeable molecule. In addition, hypovolemia- due to water insufficiency- is expected to cause a decrease in renal blood flow and thus leads to a decreased filtration rate and high blood urea concentration. Alamer (2009) observed lower glomerular filtration rate in goat during hot summer. This cue was increased along with water deprivation for three consecutive days. But after 6 hours of rehydration, goat had urea and creatinine concentration similar to hydration time. In our results, camel had higher urea concentration than sheep. Therefore, the rise in serum urea concentration could be related to the maintenance of renal function at a lower level, which consequently reduces the clearance rate of serum urea.

In clinical diagnosis, the uric acid concentration in gouty arthritis patients has been evaluated on (a) decreased destruction of uric acid, (b) overproduction of uric acid, and (c) an abnormality in the kidney excretion of uric acid. Uric acid is the hepatic product of urine metabolism. After primary filtration by the kidney, the metabolic uric acid is reabsorbed into the blood circulation system or secreted into the urine. Therefore, high blood uric acid concentration in sheep might be abnormal metabolism of kidney excretion of uric acid. Also in sheep, cattle, and buffalo, high blood uric acid values were related to higher microbial metabolism and high ruminal dilution rate.

LDH, ALT, and ALP were higher in sheep. These showed that heat stress severely affects these enzymes. But AST was not significantly different between sheep and camels. In the present study, the mean values of serum AST and ALT of sheep were 92.31 and 27.07, respectively. These serum enzymes in camels were 74.09 and 15.19, respectively, during peak and low breeding seasons and did not have any significant difference (Ali et al., 2008). LDH and ALT are released into the circulation following changes in the permeability of the sarcolemma in response to various pathologies and exposure to environmental stressors; heat stress increased GPT and GOT activities in the blood plasma of birds (Melesse et al., 2011). Srikandakumar et al. (2003) observed lower AST concentration during summer in Ommani and Merino sheep. They implied there was no liver damage, but rather a slowdown of the function of the liver, when animals were subjected to heat stress.

Enzymatic parameters such as ALT, AST, LDH, and ALP are of interest only in the case of liver or muscle disorders. Overall, these values in camels were lower than in sheep. Higher values of them have been reported during conditions of low blood protein, copper, and disease in camels (Faye et al., 1995). In our experiment, blood metabolite values had similar confident interval references for camels (Nazifi and Maleki, 1998) and sheep (Tanaka et al., 2008). Low and high feeding groups of pregnant sheep in temperature conditions had shown non- significant difference in hepatic enzymes such as AST and LDH concentrations (Tanaka et al., 2008).Whereas in our experiment, sheep showed high level of mentioned blood enzymes during heat stress.

Perhaps in hot summers, sheep's liver cannot be adapted to elevated weather temperature in order to maintain blood enzymes concentrations. But in camels, AST and ALT enzymes were not affected by season and age (Ali et al., 2008). It is said that camel showed main changes in AST and ALT concentration after having been chronically affected by parasite diseases and significant changes in the related organs such as liver. Clinical serum enzymatic activity was measured to assist us in the overall evaluation of the health status of the animal. The increases in these enzymes suggest that there is liver damage when the animals were subjected to heat stress.

Total bilirubin of 0.13 mg/l in camels and 0.3 mg/l in sheep were observed in our experiment. These parameters in healthy and parasitic camels were 0.22 and 0.32 mg/dl, respectively (Heidarpour et al., 2012). This metabolite is produced from heme pigment process of old red blood cells and many factors affect its concentration in blood serum such as liver dysfunction, sever hemolysis and icterus. Total bilirubin was significantly higher in sheep compared to camels in this research. Heidarpour et al. (2012) reported no significant difference between blood bilirubin concentration of healthy and parasitic camels, but they indicated a positive correlation between bilirubin, AST, MDA, and GGT enzymes. Therefore, higher serum bilirubin concentration in sheep- as well as higher blood AST, LDH, and ALT enzymes concentration- may be related to erythrocyte rupture due to heat stress. Also, camel red blood cells have nucleus and they can tolerate viscosity changes in blood.

Triglyceride and cholesterol were significantly higher in sheep compared to camels. It is shown that everything which induces malnutrition or food restriction in sheep, significantly causes an increase in cholesterol and triglyceride mass from body fat accumulation. Due to this massive lipolysis, NEFA is released in the bloodstream, acting as an alternative energy source for other tissues in order to preserve glucose production. Feed intake restriction, caused by water deprivation for 4 days, enhanced blood cholesterol and triglyceride values significantly (Jaber et al., 2004). But in pregnant ewes treated alike in low and high feeding groups, there was no significant difference in triglyceride and cholesterol concentrations and low-feeding ewes were maintained almost the same level observed as in the high-feeding ewes (Tanaka et al., 2008). In high summer, NEFA and low glucose concentrations in dairy cattle have been reported that may partially be responsible for the low fertility of heat stressed high yielding dairy cattle. Lower total cholesterol concentration in dairy cattle exposed to summer heat stress during postpartum has been attributed to high milk production and negative energy balance (Shehab-El-Deen et al., 2010).

Serum Ca and P concentrations were not affected by heat stress in our experiment, but these metabolite concentrations were significantly higher in camel. A Ca:P ratio of 1:1 to 2:1 is usually recommended that is obtained in this experiment in camels and sheep. Blood calcium value has not been affected by heat stress in Awassi sheep (Denek et al, 2006). On the contrary, Srikandakumar et al. (2003) indicated that plasma Ca concentration would be decreased with hypoproteinemia as a consequence of the possible reduced feed intake associated with heat stress. It is said that there is a direct relation between blood protein and Ca values. Camel has higher Ca, P, and total protein values compared to sheep.

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مقایسه متابولیت‌های خون شتر تک کوهانه در برابر گوسفند در طول استرس گرمایی تابستان

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چکیده

زمینه مطالعه: شتر و گوسفند از مقاومت و گستردگی زیادی در مناطق خشک برخوردارند. اما نتایج متفاوتی از توانایی آنها در تحمل این شرایط گزارش شده است. **هدف:** هدف این آزمایش، بررسی تحمل استرس گرمایی در شتر و گوسفند به وسیله ارزیابی تغییرات متابولیت‌های سرم خون، گزارش و مقایسه پروفیل بیوشیمیایی سرم خون گوسفند و شتر در طول استرس گرمایی طولانی تابستان است. **روش کار:** در این آزمایش نمونه‌های خون گوسفند و شتر در چهار ماه متوالی اخذ و مورد مقایسه قرار گرفت. **نتایج:** تفاوت معنی‌داری بین مقادیر اوره، گلوکز، کل پروتئین، آلبومین، فسفر، کلسیم،آنزیم‌های آمینوترانسفراز، اسید اوریک، کلسترول، تری گلیسرید، کل بیلی روبین و لاکتات دهیدروژناز گوسفند و شتر مشاهده شد. بطورکلی اوره، گلوکز، کل پروتئین، آلبومین، فسفر، کلســیم به طور معنی‌داری در شتر بالاتر از گوســفند بود ($p<0/01$). برعکس گوسفندان به طور معنی‌داری مقادیر بالاتری از اسید اوریک، کلسترول، تری گلیسرید، کل بیلی روبین و لاکتات دهیدروژناز نشان دادند ($p<0/01$). با این وجود آنزیم‌های آمینوتراسفراز و کراتین دو حیوان تفاوتی با یکدیگر نشان نداد. **نتیجه گیری نهایی:** این نتایج نشان داد گوسفند به استرس گرمایی حساسیت بیشتری دارد که با افزایش اســید اوریک، کلســترول، تری گلیسرید، کل بیلی روب ین و لاکتات دهیدروژناز نمایان می‌شود. بطوریکه شاید بتوان گفت گوسفندان در طول استرس گرمایی الگوی متابولیسمی لیپولیز را دارند. بالابودن لاکتات دهیدروژناز و کل بیلی روبین نشانه تخریب گلبول قرمز یا آسیب کبدی می‌باشد. همچنین غلظت بالای اسید اوریک خون گوسفندان سبب حساسیت بیشتر آنها به آسیب‌های کلیوی مانند نقرس می‌شود.

واژه های کلیدی: متابولیت، استرس گرمایی، گوسفند، شتر

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