



Original Paper

DOI: 10.22067/veterinary.v1-2i10-11.64963

Received: 2017-Jun-07

Accepted after revision: 2017-Sep-20

Published online: 2018-Sep-26

Relationship between fructusamine, glucose, total protein, and albumin concentrations of serum in late pregnancy and early lactation of dairy Saanen goat

Roya Pourmohammad,^a Mehrdad Mohri,^{a,b} Hesam A. Seifi^{a,b}

^a Department of Clinical Sciences, Faculty of Veterinary Medicine, Ferdowsi University of Mashhad, Mashhad, Iran

^b Center of Excellence in Ruminant Abortion and Neonatal Mortality, Faculty of Veterinary Medicine, Ferdowsi University of Mashhad, Iran Iran.

Keywords

albumin, fructosamine, glucose, Saanen goat, total protein

Abstract

The changes in serum fructosamine concentration of dairy Saanen goats during late pregnancy and early lactation and its relationship to serum glucose, total protein, and albumin concentrations was investigated. Eleven Saanen goats were selected for the study. Blood samples were collected by the jugular vein in 30, 15 and 7 days before the expected time of parturition (D-30, D-15, and D-7, respectively) and also 12 hours and 3, 7, 13, and 42 days post-partum (H+12, D+3, D+7, D+13, and D+42, respectively). The serum concentrations of fructosamine, glucose, albumin, and total protein were measured. The maximum concentration of fructosamine was at 12 hours post-partum and decreased thereafter. Serum concentration of glucose significantly increased from D-15 up to 12 hours post-partum and then decreased and stayed at the

same level. The serum concentrations of albumin and total protein significantly increased during post-partum period. There were significant correlations between fructosamine and glucose concentrations at post-partum period and overall time of the study. Linear regression analysis between each sampling amount of glucose and three consecutive fructosamine concentrations revealed significant positive correlation between glucose of each sampling time with the fructosamine of first sampling time thereafter. According to the correlation between glucose and fructosamine amounts during the study, especially post-partum period in Saanen goat, fructosamine measurement could be used as a useful indicator of energy economy and probably stress in Saanen goat; but controversy between reports in ruminants needs further studies for better understanding of fructosamine as energy biomarker in ruminants.

Abbreviations

Glu: glucose
 Fruc: fructosamine
 Alb: albumin
 TP : total protein

IRANIAN JOURNAL OF VETERINARY SCIENCE AND TECHNOLOGY

Tel: +98 51 3880 3742 Fax: +98 51 3876 3852
 Web: ijvst.um.ac.ir Email: ijvst@um.ac.ir

Corresponding author:

Mehrdad Mohri
 Department of Clinical Sciences and Center of Excellence
 in Ruminant Abortion and Neonatal Mortality, Faculty
 of Veterinary Medicine, Ferdowsi University of Mashhad,
 Mashhad, Iran.

Email: mohri@um.ac.ir

Introduction

Energy economy during late pregnancy and early lactation has considerable effect on the health and productivity of ruminants. In late pregnancy and early lactation, a decrease in blood glucose (Glu) will help hypoglycemia to develop which is a risk factor for metabolic disorders. Ketosis, fatty liver and pregnancy toxemia are the most important diseases near parturition in ruminants [1]. Also, pregnancy toxemia in dairy goats occur in the condition of energy deficiency, especially when it is accompanied by stress and multiple births [2]. The most important factor in the negative energy balance in goat and sheep is the increased need to energy, especially in the last month of pregnancy [3]. As a result, because of the important role of Glu in the metabolic process, the Glu measurement is appropriate in monitoring of herds metabolic status. Since the Glu concentration is dependent on other factors such as stress, daily activity, nutrition, and drugs, it is not a reliable marker for the evaluation of energy status in long periods [4].

Fructosamine (Fruc) is a glycosylated protein that is formed by the non-enzymatic and irreversible reaction of carbonyl group of sugar and free amino-group of protein and then it will be isomerized to a stable ketoamine [5]. The amount of glycation depends on the average blood Glu concentration as well as half-life of the blood proteins [6]. Synthesis of Fruc requires at least 2-3 weeks, so does not relate to the actual Glu concentrations. According to the average half-life of the protein in different species, the Fruc concentrations reflect the serum Glu concentration over the previous 1-3 weeks [7]. Serum Fruc concentration is proved to be an indicator of persistent hyperglycemia, e.g. diabetes mellitus, in humans, dogs and cats [8]. There are numerous articles concerning the use of Fruc in small animal practice and also some studies describing the usage of Fruc as part of the metabolic profile in dairy cows, ewes, and mares [6, 9, 10, 11, 12, 13]. The relationship between Fruc and Glu amounts in dog was previously reported [14, 15]. On the other hand, no correlations were reported in transition dairy cow and late pregnant sheep [12, 13]. Similar controversy was also existed concerning the relationship between Fruc, albumin (Alb), and total protein (TP) concentrations [12, 13, 16]. There is limited information about the use of Fruc in dairy goats as energy biomarker. In addition, negative energy balance is an important subject in dairy breeds of goat. Thus, it is important to investigate the physiological changes of Fruc and its relationships with other biochemical variables (TP, Alb and Glu concentrations) for deter-

mining the value of Fruc measurement as diagnostic and/or prognostic energy biomarkers of Saanen goats during late pregnancy and early lactation period.

Results

The mean \pm SE of Fruc for all goats during the study was 314 ± 5.36 $\mu\text{mol/l}$. The changes of serum Fruc, Glu, total protein, and Alb concentrations during the time of study are shown in figures 1 and 2. There was no significant difference in the serum concentration of Fruc pre-partum, post-partum, and throughout the study. Significant differences in the amounts of Alb were seen pre-partum, post-partum, and throughout of the trial. TP concentrations were significantly changed post-partum and throughout the study, but not at pre-partum period. The maximum concentration of Fruc was at 12 hours post-partum and decreased thereafter. Serum concentration of Glu significantly increased from D-15 up to 12 hours post-partum and then decreased and approximately stayed at the same amounts. The serum concentrations of Alb and TP significantly increased during post-partum period.

There were significant correlations between Fruc

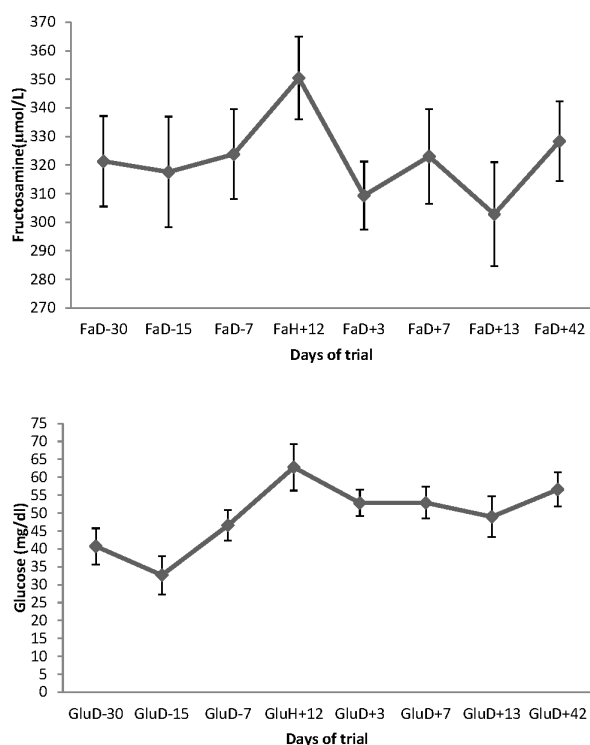


Figure 1.

The mean (\pm SE) serum Fruc and Glu concentrations in dairy Saanen goats during late pregnancy and early lactation.

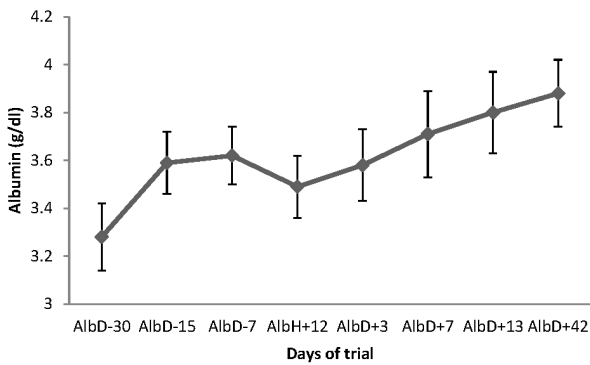
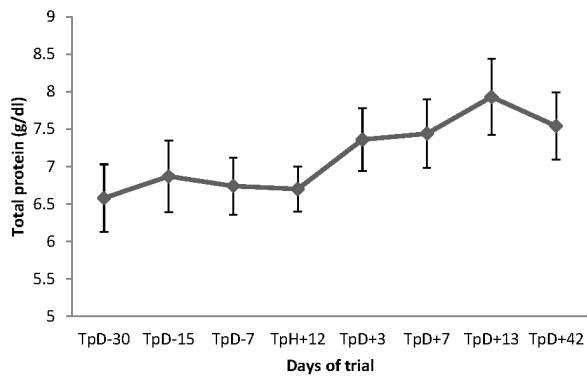


Figure 2. The mean (\pm SE) serum Alb and TP concentrations in dairy Saanen goats during late pregnancy and early lactation.

and Glu concentrations at postpartum period and overall time of the study ($r = 0.37$, $p = 0.006$ and $r = 0.26$, $p = 0.02$, respectively) but no significant correlation was seen at pre-partum period. There were not any correlations between Fruc, total protein, and Alb amounts at pre-partum, postpartum and overall time of the study. Within the same sampling time, only the Glu and Fruc amounts of D+13 has significant correlation ($r = 0.81$, $p = 0.005$). From the retrospective viewpoint, Pearson analysis revealed significant correlations between the concentrations of Glu and Fruc at D-7 with H+12 ($r = -0.72$, $p = 0.019$), D+3 with D+7 ($r = 0.669$, $p = 0.024$), and D+3 with D+42 ($r = 0.724$, $p = 0.012$). Linear regression analysis between each sampling amount of Glu and three consecutive Fruc concentrations revealed significant positive correlation only between Glu with Fruc of first sampling time thereafter (Figure 3).

Discussion

Several reports recommend the usage of Fruc as part of the metabolic profile in dairy cows, ewes and mares [10, 12, 13, 17]. In the present study the cumulative mean \pm SE of Fruc during the trial in 11 Saanen goats was 314 ± 5.36 $\mu\text{mol/l}$. Cantley et al. [18] report-

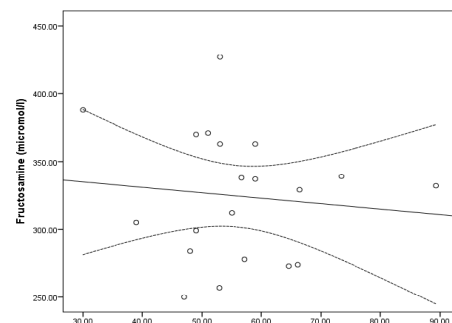
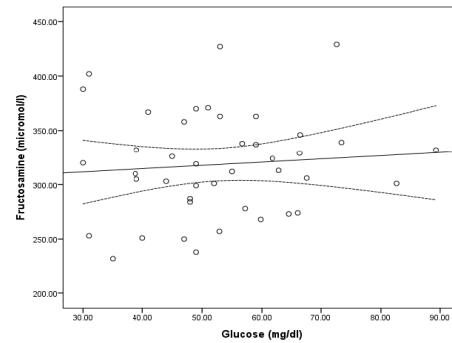
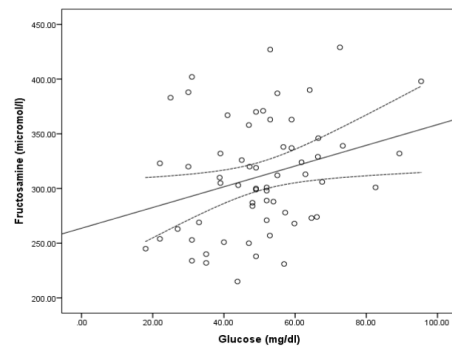


Figure 3. Linear regression analysis between the concentration of serum Glu at each sampling time and Fruc of first (top panel, $Y = 0.947X + 263.74$, $r = 0.288$, $p = 0.024$), second (middle panel, $Y = 0.299X + 302.7$, $r = 0.086$, $p = 0.59$), and third (bottom panel, $Y = -0.402X + 346.92$, $r = 0.106$, $p = 0.656$) sampling in 11 Saanen goats.

ed that the concentration of Fruc in 67 late pregnant sheep was 172 ± 2 $\mu\text{mol/l}$ (mean \pm SE). Sorondo and Cirio [13] reported that in late-pregnant Corriedale sheep during 11 weeks of study, the concentration of Fruc was 272 ± 83 $\mu\text{mol/l}$ (mean \pm SD). In another study on 10 crossbred dairy ewes, the concentrations of Fruc were between 142 to 156 $\mu\text{mol/l}$ during 10 days before lambing to 130 days post-partum [17]. The results of our study were in agreement with the previous report for Corriedale sheep and dairy cows [12, 13], and higher than findings of other studies for

sheep and dairy cows [17, 18, 19]. Probably, composition of diet, rate of protein turn-over during gestation and lactation, and difference in Glu metabolism or negative energy balance were responsible for this controversy.

In the present study Fruc and Glu concentrations showed similar time related changes at pre- and post-partum periods. This was in contrast with Sorondo and Cirio [13] and Filipović et al. [17] reports. Filipović et al. [17] suggested that the reduction in the amount of Fruc at 10 days after lambing is probably due to the concurrent reduction in the amount of Alb and TP. Based on their report, the amounts of TP and Alb progressively decreased during lactation period but Fruc did not follow similar pattern as Alb or TP. In our study, despite the reduction of Fruc from 12 hours to two weeks after the parturition, the serum concentrations of Alb and TP were significantly increased, so the reduction in the amount of Fruc cannot be related to the amounts of serum protein and Alb. Accordingly, we did not find any correlation between Fruc and Alb or TP concentrations in Saanen goats. Sorondo and Cirio [12, 13] reported similar findings in dairy cow and sheep, but Mostafavi et al. [19] reported significant correlation between Fruc and Alb amounts in 506 cows.

There are numerous studies that suggested a correlation between Fruc and Alb or TP amounts in dogs. Coppo and Mussart de Coppo [20] found that the concentration of Fruc in normoglycemic dogs with chronic hypoproteinemia is below the reference interval and so the density of serum Fruc can be affected by changes in blood protein concentration. Loste and Marca [16] reported high correlation in hypoproteinemic and hypoalbuminemic dogs between Fruc with TP and Alb concentrations. Jensen [21] in dog suggested that chronic hypoproteinemia or hyperproteinemia could affect the concentration of serum Fruc. It seems that further studies with more number of animals will be needed for better understanding of Fruc changes during late pregnancy and lactation in dairy goats and sheep.

In the present study, there were significant correlations between Fruc and Glu concentrations at post-partum period and overall time of the study. Linear regression analysis revealed significant positive correlation only between Glu with Fruc of first sampling time thereafter. Our result is consistent with biochemical pathway resulted to formation of Fruc and is in agree with previous reports for small animals [4, 9, 14, 15], dairy cows [19], and sheep [18]. On the other hand, Sorondo and Cirio [12, 13] reported no correlation between Glu with Fruc in retrospective

approach in sheep and cow. The authors believed that in ruminants, fluctuations of Glu concentration are lower than human and domestic carnivores in which Glu amounts and probable changes are higher during Fruc formation. Our results are in contrast with those because correlation between Glu and Fruc was seen along with normal blood serum Glu concentration and without any relations to TP and Alb amounts as previously described. In addition, most correlations were observed during post-partum period. It seems metabolic challenges primarily negative energy balance due to milk production in this dairy breed of goat at post-partum period are responsible for Glu and Fruc relationship.

Conclusion

According to the correlation between Glu and Fruc amounts during the study, especially in the post-partum period in Saanen goat, Fruc measurement could be used as a useful indicator of energy economy and probably stress in Saanen goats. However, to resolve the controversy between reports in ruminants and for better understanding of Fruc as an energy biomarker in dairy cows, sheep, and goats, further studies will be needed.

Materials and methods

The study was performed on 11 dairy Saanen goats aged between 2 and 9 years of age. The does were synchronized for estrus by using two injections of PGF2 α 11 days apart. Rams were introduced to does 3 days after the second dose. The rams remained with does for one week. Pregnancy was diagnosed by ultrasonography on days 60 and 80 after mating using a portable B-mode ultrasound scanner. The number of fetuses was recorded during the ultrasonographic diagnosis of pregnancy. The health of all goats was examined by clinical examination and CBC analysis before the beginning of the study. The animals were treated using ivermectin (0.2 mg/kg) and triclabendazol (10mg/kg) for parasite control. All animals transferred to individual pens and were fed twice daily and fresh water was available ad libitum.

The diets were formulated to meet all nutrient requirements for pregnant does at prepartum and lactating does during the postpartum period [22]. The ingredients of prepartum and postpartum diets are shown in Table 1. Daily diet of each goat was weighed prior to feeding and feed refusals were measured by digital scale weigher for accurate estimation of daily DMI of each animal. Blood samples were collected by the jugular vein in 30, 15 and 7 days before expected time of parturition (D-30, D-15, and D-7, respectively) and also 12 hours and 3, 7, 13, and 42 days post-partum (H+12, D+3, D+7, D+13, and D+42, respectively). All blood samplings were taken 3 h after first daily meal at the same time of the day for all animals. Blood samples were immediately transferred to the laboratory on ice.

After clotting and centrifugation (1800g for 10 min) the serum was aspirated and stored at -20°C. The concentrations of Fruc (Nitroblue tetrazolium), Glu (Glu oxidase), Alb (Bromocresol green), and TP (Biuret) were measured with automated biochemical analyzer (BT 1500, Biotechnica instrument,

Table 1.

Ingredients and chemical composition of the experimental diets in Saanen goats.

Ingredients	Pre-parturition	Post-parturition
Feed intake (kg DM /d)	1.7	2.054
DMI (% BW)	3.4	4.86
Ingredients (% DM)		
Alfalfa hay	25	45
Barely grain	20	30
Cottonseed meal	9	10
Wheat bran	20	13.5
Wheat straw	25	-
Vitamin	1	0.5
Mineral supplement		
Lime	-	0.7
Salt	-	0.3
Chemical composition		
Energy intake ME (Mcal/d)	2.40	2.60
CP (% DM)	13.1	15.5
ADF (% DM)	27.4	21
NDF (% DM)	44.9	34.5
Ca (% DM)	0.62	0.9
P (% DM)	0.61	0.6
EE (%)	2.4	2.3

Rome, Italy), using commercial kits (Pars Azmoon, Tehran, Iran for Glu, Alb, and TP; BioSystems, Barcelona, Spain for Fruc). Measurement accuracy was checked by using control serum (Randox control sera, Antrim, UK). All measured variables had a within-run coefficient of variation less than 10% (Total protein: 0.95%, Alb: 0.91, Glu: <3%).

Statistical analysis was done using SAS (The SAS system for Windows, version 9.1, Cary, NC). The skewness and kurtosis of data were used for normality test. A repeated measure ANOVA was used to assess the effect of time of sampling throughout the study, pre-partum, and post-partum. The correlation between serum amounts of Glu, total protein, and Alb of each sampling time and Fruc of similar time, and three consecutive sampling time was determined with the help of linear regression and Pearson test [12]. All differences were considered to be statistically significant at $p < 0.05$.

Acknowledgments

This work was supported by Ferdowsi University of Mashhad, grant number 3/20224.

Author contributions

Conceived and designed the experiment: MM, HAS. Performed the experiments: RP, MM. Analysed the data: MM, HAS. Research space and equipment: MM. Contributed reagents/materials/analysis tools: MM. Wrote the paper: RP, MM.

Conflict of interest

The authors declare that they have no conflict of interest.

References

- Herdt T.: Ruminant adaptation to negative energy balance influences on the etiology of ketosis and fatty liver. *Vet. Clin. North. Am. Food. Anim. Pract.*, 2000, 16, 215-230.
- Nazifi S., Saeb M., Asadzade S.: Serum concentration of lipids, lipoproteins and β hydroxybutyrate in iranian native goats in late pregnancy, at parturition and during the post parturition period. *Journal of Faculty Veterinary Medicine University Tehran.*, 2003, 58, 211-215 (In Farsi)
- Radostits O.M., Clive C.G., Kenneth W.H., Constable P.D.: *Veterinary Medicine: A text book of the diseases of cattle, Horses, sheep, pigs and goats.* 10 th Edition. Saunders Ltd. 2007
- Loste A., Marca M.C., Perez M., Unzueta A.: Clinical Value of Fruc Measurements in Non healthy dogs. *Vet. Res. Commun.*, 2001, 25,109-15.
- Kaneko J.J.: Carbohydrate metabolism and its diseases In: Kaneko J.J., Harvey J.W., Bruss M.L (Eds), *Clinical Biochemistry of Domestic Animals*, 6rd edn. Academic Press, San Diego, 2008, pp. 45–80.
- Coppo J.A.: Evaluation of fructosaminaemia and glucaemia during the growth of unweaned and early weaned half-bred zebu calves. *Vet. Res. Commun.*, 2001, 25, 449-59.
- Eckersal P.D.: Proteins, proteomics, and dysproteinemias. In: Kaneko J.J., Harvey J.W., Bruss M.L (Eds), *Clinical Biochemistry of Domestic Animals*, 6rd edn. Academic Press, San Diego, 2008, pp. 117–155.
- Thoresen S.I., Bredal W.P.: An evaluation of serum Fruc as amarker of the duration of hypoproteinaemic conditions in dogs. *Vet. Res. Commun.*, 1998, 22, 167-177.
- Denis A.E., Richard W.N., Claudia E.R.: Comparison of serum Fruc and blood glycosylated hemoglobin concentration for

- assessment of glycemic control in cats with diabetes mellitus. *J. Am. Vet. Med. Asso.*, 1999, 214,1794-1798.
10. Filipović N., Stojević Z., Prvanović N.: Serum Fruc concentrations in relation to metabolic changes during late pregnancy and early lactation in mares. *Berliner Und Münchener Tierärztliche Wochenschrift.*, 2010, 123, 116–173.
 11. Jensen A.L., Petersen M.B., Houe H.: Determination of Fruc concentration in bovine serum samples. *J. Vet. Med. A.*, 1993, 40,111-117.
 12. Sorondo M.L., Cirio A.: Evaluation of the serum Fruc test to monitor plasma Glu concentration in the transition dairy cow. *J. Dairy Res.*, 2009, 76, 173-178.
 13. Sorondo M.L., Cirio A.: Evaluation of the serum Fruc test to monitor plasma Glu concentration in the late-pregnant sheep. *Anim. Prod. Sci.*, 2011, 51, 662-666.
 14. Jensen A.L., AAES H.: Reference interval and critical difference for canine serum Fruc concentration. *Vet. Res. Commun.*, 1992, 16, 317-325.
 15. Kawamoto M., Kaneko J.J., Heusner A.A., Feldman E.C., Koizumi I.: Relation of Fruc to serum protein, Alb and Glu concentrations in healthy and diabetic dogs. *Am. J. Vet. Res.*, 1992, 53, 851-855.
 16. Loste A., Marca M.C.: Study of the effect of total serum protein and Alb concentrations on canine Fruc concentration. *Can. J. Vet. Res.*, 1999, 63, 138-141.
 17. Filipović N., Stojević Z., Masek T., Mikulec Z., Prvanović N.: Relationship between Fruc with serum protein, Alb and Glu concentrations in dairy ewes. *Small. Rum. Res.*, 2011, 96, 46-48.
 18. Cantley C.E., Ford D.M., Heath M.F.: Serum Fruc in ovine pregnancy toxemia: a possible prognostic index. *Vet. Rec.*, 1991, 128, 525-526.
 19. Mostafavi M., Seifi H.A., Mohri M., Jamshidi A.: Evaluation of Fruc as a new biomarker for diagnosis of hepatic lipidosis in dairy cows. *Anim. Prod. Sci.*, 2015, 55, 1005-1010.
 20. Coppo J.A., Mussart de coppo N.B.: La glicosilacion de proteinas hematicas como evaluacion retrospectiva de la glucemia. *Aplicaciones en medicina veterinaria. Rev. de. Med. Vet.*, 1997, 78, 292-295.
 21. Jensen A.L.: Various protein and Alb corrections of the serum Fruc concentration in the diagnosis of canine diabetes mellitus. *Vet. Res. Commun.*, 1993, 17, 13-23.
 22. NRC (National Research Council): Nutrient requirements of small ruminants, sheep, goats, cervids, and new world camelids. The National Academic press, Washington DC, USA. 2007.