Effects of pregnancy and post-kidding stages on haematochemical parameters in cross-bred goats

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\textbf{ABSTRACT}

The effects of pregnancy and post-kidding stages, and the number of in utero developing foetuses on haematochemical parameters were evaluated in stabled cross-bred goats. Blood serum samples were collected biweekly during the late-pregnancy (−49 days) and post-kidding stages (21 days) (\(n = 34\) goats, including 17 Anglonubian and 17 Saanen × Anglonubian). Non-pregnant, cross-bred, adult does (\(n = 17\)) were used as controls. Blood serum glucose (GL), total protein (TP), albumin (AL), uric acid (UA), total cholesterol (TC), total bilirubin (TB), creatinine (CR), and alkaline phosphatase (AP) were measured using commercial kits. Average GL, TP, AL, and AP values were found to be different (\(p < .05\)) in pregnant, control, and post-kidding stages. Average GL level was found to be different (\(p < .05\)) in Anglonubian vs. Saanen×Anglonubian goats. Number of developing foetuses had no effect on any measured haematochemical parameters. In conclusion, both the late pregnancy and post-kidding stages of Anglonubian and Saanen×Anglonubian goats were accompanied by changes in blood serum GL, TP, AL, and AP. Breed effect was only observed on serum GL, while number of kids developing in utero did not affect the measured haematochemical parameters of goats.

1. Introduction

Concentrations of metabolites and enzymes in blood serum are biochemical values having strong relationships with physiological events in goats (Zulkifli et al. 2010). It has been reported that haematochemical parameters may be influenced by various factors, including temperature, reproductive status, metabolic disorders, age, sex, breed, season of the year, stress caused by management, road transportation (Sandabe & Chaudhary 2000; Zubčić 2001; Mellado et al. 2004; Barakat et al. 2007; Piccione et al. 2009, 2012a, 2012b, 2013; Sakha et al. 2009; Rumosa et al. 2010; Zulkifli et al. 2010; Arfuso et al. 2016), and infectious processes (Mahmood et al. 2015). Management practices, such as feeding, health condition and productivity, may influence the haematochemical parameters (Ismail et al. 2008; Waziri et al. 2010). Manat et al. (2016) pointed out the importance of determining whether normal reference haematochemical values are related to changes in physiological and metabolic stages (i.e. pregnancy, post-kidding, and number of developing foetuses). Particularly, blood physiological values may be influenced by genetic background and productive performance (Vallejo et al. 1991). Therefore, physiological blood serum-specific chemical reference parameters and their variation should be established in purebred and cross-bred dairy female goats under intensive farming systems (Tibbo et al. 2008; Mohammed et al. 2016). This knowledge can be used for purposes of diagnosis and prognosis of diseases, for criteria of adaptability, as well as to elucidate many other physiological mechanisms in goats (Gökdal 2013). Accordingly, the aim was to evaluate for the first time the effects of pregnancy and post-kidding stages, and the number of in utero developing foetuses on haematochemical parameters in stabled cross-bred dairy goats.

2. Materials and methods

2.1. Animals and management

The study was carried out at the Sheep and Goat Research Unit of the Autonomous University of Baja California Sur. The average annual rainfall of this region is 200 mm and mean annual temperature is 14–24°C. Healthy, adult goats (\(n = 34\); 17 Anglonubian and 17 Saanen (sire) × Anglonubian (dam)) were oestrus-synchronized and mated naturally with fertile Saanen bucks during June in order to have the kidding season during November. Adult, non-pregnant, cross-bred does (\(n = 17\)) were used as controls. Pregnancy and number of in utero developing kids were diagnosed by real-time ultrasonography (Preg-Alert®, Sis-Pro, Inc. 6 Valley Trail Round Rock, TX). The number of kids and litter weight were recorded at birth. Body condition score measured 3–4 (scale 1–5) during the trial in both breeding and control goat groups. All the experimental animals received a daily diet of alfalfa hay (3.5% of live body weight) plus 0.3 kg/goat of concentrate with 16% crude
protein. Fresh water and mineral blocks were offered ad libitum; mineral blocks included supplementary calcium, phosphorus, magnesium, manganese, sodium chloride, potassium, iron, iodine, and selenium. All goats were housed in open shaded allotments and provided access to sunny exercise areas.

2.2. Blood sampling

Blood samples were taken from the goats during the late-pregnancy and post-kidding stages by jugular venipuncture using Vacutainer tubes without additives (BD, 1 Becton Drive, Franklin Lakes, 07417 NJ, USA) and sterile needles. Pregnant goats were bled weekly from day –49 (n = 7 sampling dates) prior to kidding to day +21 (n = 3 sampling dates) post-kidding (day of kidding = 0). During this period, it was supposed that goat physiology adjusts in order to fulfil the foetuses’ demand for nutrients and, later, to reach the lactation peak production (Celi et al. 2008; Magistrelli & Rosi 2014; Radin et al. 2015). Control goats were sampled the same as pregnant/post-kidding goats. In all cases, withdrawal of feed and water was carried out 12 hours prior to the time of bleeding (07:00 am), since fasting has been recommended prior to the measurement of the haematocological parameters (Rezaei et al. 2013; Yatoo et al. 2015).

2.3. Haematochemical analyses

In order to keep the serum samples as fresh as possible, each blood sample was centrifuged between 1 and 2 hours after collection. Blood samples were centrifuged (Eppendorf 5804R, Eppendorf AG, Barkhausenweg 1, 22339 Hamburg, Germany) at 1000× g for 10 minutes. The obtained sera (total n = 510) were then placed in microcentrifuge tubes and stored at –20°C until analysis; the serum samples were analysed within one week of collection. All haematochemical analyses were carried out in triplicate, using commercially available kits (Randox Labs. Ltd, Crumlin, Co. Antrim, UK) according to the manufacturer’s instructions. The values of glucose (GL; Randox GL2614A), total protein (TP; Randox TP1630A), albumin (AL; Randox AB362A), uric acid (UA; Randox UA230), total cholesterol (TC; Randox CH198), total bilirubin (TB; Randox BR411), creatinine (CR; Randox CR510), and alkaline phosphatase (AP; Randox AP542) were evaluated. The analyses were conducted using light spectrophotometry (Genesys 20, Thermo Spectronic, Rochester, NY, USA).

2.4. Statistical analysis

Overall descriptive statistics (mean, standard deviation, and ± 95% confidence intervals of mean) for each blood constituent were calculated. The data were tested for normality (Shapiro–Wilk W normality test) and homogeneous variance (Levene test). The effects of the factors evaluated were tested by separate analyses of variance for a complete random design (Steel & Torrie 1960). For evaluating each factor, the model applied was as follows:

\[ Y_{ij} = \mu + \tau_i + \epsilon_{ij}, \]

where \( Y \) is the blood constituent response (blood serum concentrations of GL, TP, AL, UA, TC, TB, CR, or AP), \( \mu \) is the general mean, \( \tau \) is the factor tested (physiological stage, breed group, or number of in utero developing foetuses), and \( \epsilon \) is a random element of variation. Interactions (physiological stage × breed group × number of in utero foetuses) were formerly included in a factorial arrangement model, but were deleted later on due to a lack of significance demonstrated in an a priori analysis. When the effect of a factor was found to be significant, post hoc Tukey’s test was used to determine statistically significant differences (\( p < 0.05 \)). All statistical procedures were performed using the statistical software Statistica (StatSoft 1998).

3. Results

Overall mean and confidence intervals of the haematocological parameters of all goats are summarized in Table 1. Table 2 shows that mean serum concentrations of GL, TP, and AL were significantly different between pregnancy and post-kidding stages, and between experimental and control groups. Particularly, the GL level in pregnant goats was significantly lower than that in post-kidding and non-pregnant control goats. The mean TP level was lower (\( p < 0.05 \)) in post-kidding goats, but similar in pregnant and control goats. AL values were significantly (\( p < 0.05 \)) lower in pregnant compared to post-kidding and control goats. Average blood serum level of AP was higher (\( p < 0.05 \)) in control, followed by pregnant and post-kidding groups.

The haematochemical parameters of pregnant goats according to breed group are shown in Table 2. The mean blood serum GL level was higher (\( p < 0.05 \)) in Anglonubian in comparison to Saanen × Anglonubian goats.

Number of developing foetuses did not have a significant effect on the haematochemical parameters in pregnant goats (Table 2). The average number of kids at birth was 1.89 ± 0.57 (range = 1–3) and litter weight at kidding was 6.0 ± 1.75 kg (range = 2.3–9.82 kg).

4. Discussion

The majority of blood constituent levels were consistent with the general normal ranges reported for goats (Ismail et al. 2008; Magistrelli & Rosi 2014; Radin et al. 2015). Control goats were sampled the same as pregnant/post-kidding goats. In all cases, withdrawal of feed and water was carried out 12 hours prior to the time of bleeding (07:00 am), since fasting has been recommended prior to the measurement of the haematocological parameters (Rezaei et al. 2013; Yatoo et al. 2015).

### Table 1. Overall descriptive statistics of haematocological parameters in goats.

| Blood serum constituent | Mean ± SD | Confidence intervals | Normal reference values* |
|-------------------------|-----------|----------------------|--------------------------|
| Glucose (mg/dL)         | 68.2 ± 5.4| 67.1–69.4             | 60–100                   |
| Total protein (g/dL)    | 8.1 ± 0.8 | 7.9–8.2               | 6.4–7.8                  |
| Albumin (g/dL)          | 4.6 ± 0.2 | 4.5–4.6               | 2.4–4.4                  |
| Uric acid (mg/dL)       | 0.49 ± 0.3| 0.4–0.6               | 0.41–0.88                |
| Cholesterol (mg/dL)     | 77.4 ± 14.1| 74–80.4              | 64.6–136.4               |
| Bilirubin (mg/dL)       | 0.37 ± 0.2| 0.3–0.4               | 0–0.9                    |
| Creatinine (mg/dL)      | 1.18 ± 0.4| 1.1–1.3               | 0.9–1.8                  |
| Alkaline phosphatase (IU/L) | 100.7 ± 50 | 90–113.3           | 66–230                   |

*Mean values were calculated from all (n = 510) serum samples collected from the female goats included in the study (n = 51); samples were collected weekly for 10 weeks.

*UA reference values were taken from Devrim et al. (2010).
Table 2. Haematocional parameters in goats during the late-pregnancy and post-kidding stages (mean ± SD), and values in control (non-pregnant) goats.

| Blood serum biochemistry constituent | Physiological stage | p value | Breed group | p value | Number of in utero developing foetuses |
|-------------------------------------|--------------------|---------|-------------|---------|--------------------------------------|
|                                     | Pregnancy | Post-kidding | Control | Anglonubian | Saanen × Anglonubian | 1 | 2 | 3 | 4 |
| Glucose (mg/dL)                     | 66.0 ± 4a         | 70.6 ± 4.6b | 71.9 ± 6.2b | .01     | 69.7 ± 6.1a | 66.3 ± 3.7b | .003 | 68.0 ± 5.1 | 66.4 ± 4.1 | 64.7 ± 3.2 |
| Total protein (g/dL)                | 8.1 ± 0.58a       | 7.4 ± 1b | 8.2 ± 0.76a | .05     | 8.2 ± 0.7a | 7.9 ± 0.83a | .30  | 7.9 ± 0.6 | 8.0 ± 0.8 | 7.7 ± 0.6 |
| Albumin (g/dL)                      | 4.4 ± 0.3b        | 4.7 ± 0.2a | 4.7 ± 0.2a | .05     | 4.6 ± 0.23a | 4.5 ± 0.25a | .40  | 4.6 ± 0.2 | 4.5 ± 0.2 | 4.2 ± 0.3 |
| Uric acid (mg/dL)                   | 0.46 ± 0.27a      | 0.60 ± 0.59a | 0.56 ± 0.28a | .12     | 0.48 ± 0.26a | 0.51 ± 0.38a | .60  | 0.42 ± 0.19 | 0.51 ± 0.39 | 0.37 ± 0.14 |
| Cholesterol (mg/dL)                 | 76.8 ± 14.4a      | 73.7 ± 11.1a | 82.2 ± 14.2a | .10     | 79.1 ± 16.1a | 75.2 ± 10.8a | .20  | 74.9 ± 7.3 | 77.1 ± 16.2 | 71.5 ± 8.9 |
| Bilirubin (mg/dL)                   | 0.38 ± 0.23a      | 0.34 ± 0.16b | 0.37 ± 0.24a | .22     | 0.42 ± 0.2a | 0.34 ± 0.25a | .35  | 0.46 ± 0.3 | 0.35 ± 0.5 | 0.25 ± 0.4a |
| Creatinine (mg/dL)                  | 1.2 ± 0.5a        | 1.0 ± 0.3a | 1.2 ± 0.5a | .30     | 1.2 ± 0.36a | 1.2 ± 0.48a | .90  | 1.14 ± 0.42 | 1.14 ± 0.47 | 1.45 ± 0.33 |
| Alkaline phosphatase (IU/L)         | 96.5 ± 48.1a      | 45.2 ± 39.8b | 129.6 ± 36.4b | .05     | 102.7 ± 48.3 | 98.0 ± 52.9a | .20  | 77.1 ± 39.6 | 91.3 ± 56.2 | 83.9 ± 30.8 |

1Blood samplings were carried out weekly from −49 to 21 days post-kidding (day of kidding = 0). Mean values were calculated from the number of serum samples collected from the goats included in each group.
2Number of foetuses were detected by real-time ultrasound and confirmed at birth. Goats gave birth to 1 (n = 7), 2 (n = 21), or 3 (n = 6) kids. No significant statistical differences were found (p > .05).
3Values in columns with different superscripts indicate statistical differences; n = number of valid processed blood serum samples. p value, indicates statistical differences (p < 0.05).
In the present study, the haematocochemical parameters of Anglonubian and Saanen × Anglonubian cross-bred goats were found to be in the normal range for healthy goats of various breeds and production systems (i.e. Žubčić 2001; Mellado et al. 2006; Rios et al. 2006; Barakat et al. 2007; Ismail et al. 2008; Cook et al. 2008; Sakha et al. 2009; Okonkwo et al. 2010; Rumosa et al. 2010; El-Khodery et al. 2011; Oni et al. 2012). Values of the haematocochemical parameters were similar in both breed groups, with the exception of GL levels. Similar to the results obtained here, GL levels decreased during the pregnancy stage in Red Syrian, Sahel, Alpine, and Saanen breeds (Celi et al. 2008; Waziri et al. 2010; Laporte-Broux et al. 2011). In contrast, lower GL levels were recorded in cross-bred goats, suggesting that Saanen goats have a lower normal level of GL in blood than Nubians (Mellado et al. 2004, 2006; Laporte-Broux et al. 2011).

Conversely to what would be expected, the number of foetuses in utero did not cause significant differences in the haematocochemical parameters. This matches well with the finding that maternal metabolism throughout the pregnancy of dairy goats did not vary regardless of the breed or number of foetuses (single or twin pregnancies) (Castagnino et al. 2015). In contrast, ovine pregnancies with more than one foetus are often accompanied by changes in the metabolic profile, compared with single pregnancies (Hefnawy et al. 2011). Similar observations have been reported in bovine pregnancies (Bach, 2012; Alberghina et al. 2015). Overall, the peri-partum period is accompanied by marked changes in the haematocochemical parameters, but female goats appeared to adapt during these physiological stages by different physiological mechanisms (Azab & Abdel-Maksoud 1999; Iriadam 2007). Therefore, physiological adaptation mechanisms in Anglonubian and Saanen × Anglonubian cross-bred goats merit further research using a greater number of goats.

5. Conclusion

The late-pregnancy and post-kidding physiological stages of Anglonubian and Saanen × Anglonubian goats are characterized by changes in some haematocochemical parameters (GL, protein, and AL). A breed effect was only observed on serum GL parameter, while number of kids developing in utero did not affect the haematocochemical parameters of goats.

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