Influence of breed, production system and fecundity on serum antioxidant profiles of goats reared in the tropical Island conditions

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Goats are considered as ‘poor man’s cow’ and are ideal livestock for poor and marginal farmer’s communities (Nair et al. 2021). They are better tolerant to different environmental conditions (Nair et al. 2021), drought (Stone et al. 2020), limited pastures (Sejian et al. 2021) and diseases (Pal and Chakravarty 2020) than other livestock species. Andaman and Nicobar Islands (ANI) has mainly two breeds of goat, viz. Andaman local goat (ALG) and Teressa goat, which are reared for meat purpose (Perumal et al. 2019). It is a unique island where goats are the primary livestock species and are considered as an insurance source during disaster periods similar to the mainland region (Regar et al. 2020).

Excessive production of pro-oxidants due to oxidative stresses causes an imbalance of antioxidant defense mechanism (Giorgio et al. 2020) and damages biological molecules (Juan et al. 2021). Oxidative stress causes multiple diseases in ruminants (Ayemele et al. 2021, Huang et al. 2021). Thus recognizing their importance, antioxidant profiles were studied in various conditions such as in pregnancy (Nawito et al. 2016), postpartum periods (Tanvi et al. 2017), different rearing systems (Karthik et al. 2021) and in various season stresses (Kumar et al. 2019, Perumal et al. 2019). The present study aimed to evaluate the influence of variations of the rearing system, breed and fecundity of indigenous goats of Andaman by estimating the level of antioxidant markers, viz. total antioxidant capacity (TAC), superoxide dismutase (SOD), total glutathione (TG) and catalase (CAT). To the best of our knowledge, studies on the antioxidant profiles of island-adapted goats are not available in the literature. Such studies will be helpful to understand the effect of these antioxidant markers on this tropical Island ecosystem.

The present study was conducted on goats reared at institutional goat breeding farm and farmer’s fields in South Andaman district. On the Institutional farm, the goats were reared under a semi-intensive system. Animals were allowed to browse on natural vegetation in the morning (07:00 to 11:00 h), fed commercially available concentrate pellets @ 250-300 g/day/animal mixed with a mineral supplement, AGRIMIN® (Virbac, India). They were also provided with locally available jackfruit and breadfruit leaves. At farmers’ flock, the goats were maintained under the extensive system where animals were allowed to graze loosely for 6-7 h and hand-fed with coconut, jackfruit and breadfruits leaves. Neither balanced concentrate feeding nor mineral mixture supplementation was practiced in farmers’ flock. Twenty five healthy multiparous non-pregnant Andaman Local goat (ALG) (n=13) and crossbred (n=12) does reared under a semi-intensive (n=11) and extensive system (n=14), with high fecundity (n=18), and low fecundity (n=7) records were studied. Fecundity was estimated as the ratio of the number of kidding records with higher litter size (>1) to the total number of kidding records. Blood samples were collected and serum was separated by centrifugation. Antioxidants, viz. total glutathione (Cayman kit 703002), superoxide dismutase (Cayman kit 706002), catalase (Cayman kit 707002) and total antioxidant capacity (Cayman kit 709001) were estimated from serum samples as per the instruction of the manufacturer. All the procedures were followed after the ethical approval of the Institute Animal Ethics Committee (IAEC) as per the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA) guidelines.

The antioxidant data was analyzed for outliers using the box-plot method and assessed for normality using the Kolmogorov-Smirnov normality test. All antioxidants test data were normally distributed. Homoscedasticity of variances, tested using Leven’s test, were equal. The breed effects, effect of the production system (rearing system) and effect of fecundity were analyzed using the PROC GLM multivariate model of Statistical Analysis Software (SAS Institute Inc., USA, 2002).

The following model was used for analysis

\[ Y_{ijk} = \mu + A_i + P_j + M_k + e_{ijk} \]

where \( Y_{ijk} \) antioxidant parameter of the doe; \( \mu \), overall
Table 1. Descriptive statistics of antioxidants (TG, CAT, SOD, TAC)

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean±SEM</th>
<th>Std. Deviation</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Glutathione (µM)</td>
<td>25</td>
<td>4.46</td>
<td>3.44</td>
<td>7.90</td>
<td>5.04±0.18</td>
<td>0.94</td>
<td>0.19</td>
</tr>
<tr>
<td>CAT acti (nmol/min/ml)</td>
<td>25</td>
<td>77.49</td>
<td>22.39</td>
<td>99.88</td>
<td>57.14±5.11</td>
<td>26.05</td>
<td>0.46</td>
</tr>
<tr>
<td>SoD activity in (U/ml)</td>
<td>25</td>
<td>0.13</td>
<td>0.03</td>
<td>0.15</td>
<td>0.08±0.01</td>
<td>0.03</td>
<td>0.38</td>
</tr>
<tr>
<td>TAC (mM)</td>
<td>25</td>
<td>1.89</td>
<td>2.49</td>
<td>4.38</td>
<td>3.36±0.10</td>
<td>0.50</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Table 2. Effect of breed, rearing system and fecundity on antioxidant profiles*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Group</th>
<th>Total Glutathione (µM)</th>
<th>SoD activity (U/ml)</th>
<th>TAC (mM)</th>
<th>CAT activity (nmol/min/ml)</th>
<th>Wilks’ lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breed</td>
<td>ALG</td>
<td>5.13±0.29</td>
<td>0.078±0.01</td>
<td>3.37±0.14</td>
<td>50.65±7.54</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>Rearing system</td>
<td>OTH</td>
<td>4.92±0.28</td>
<td>0.079±0.01</td>
<td>3.37±0.13</td>
<td>63.59±7.35</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FL</td>
<td>5.17±0.27</td>
<td>0.075±0.01</td>
<td>3.11±0.13</td>
<td>66.27±7.01</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>FR</td>
<td>4.87±0.30</td>
<td>0.082±0.01</td>
<td>3.63±0.14</td>
<td>47.97±7.79</td>
<td></td>
</tr>
<tr>
<td>Fecundity</td>
<td>High</td>
<td>4.98±0.24</td>
<td>0.073±0.01</td>
<td>3.46±0.11</td>
<td>54.82±6.14</td>
<td>p&lt;0.05</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>5.07±0.35</td>
<td>0.084±0.01</td>
<td>3.29±0.16</td>
<td>59.42±9.022</td>
<td></td>
</tr>
</tbody>
</table>

ALG, Andaman local goats; OTH, crossbred of ALG with Teressa and Malabari; FR, Semi-intensive Production system-Farm; FL, Extensive Production system-Field. *Values are expressed as least square means±SEM. Superscripts indicate significance at 5% level.

The study results are presented in Tables 1, 2 and 3. Breed, rearing system and fecundity were not significantly associated with the TG, SOD and CAT estimates. However, TAC level was highly associated with the rearing system, where significantly high TAC level was detected in the semi-intensive (Farm rearing) than extensive system (Field rearing) (Fig. 1). The high TAC value might be due to dietary supplementation of protein, lipids, etc., through concentrate feeding in farm animals. It is reported that proteins and lipids supplementation contribute to total antioxidant capacity (Edrees and Teama 2018, Nemec et al. 2000) by supplying essential amino acids and fatty acids (Wang et al. 2019). Similar to this study, pregnant and non-pregnant goats grazed on natural pasture had lower TAC values than concentrate-fed pregnant and non-pregnant Egyptian local goats (Nawito et al. 2016). TG decreased in control and starch diets but increased with high fat diet in ewes (Sgorlon et al. 2008) which contradicts the present study, as extensively reared goats had higher TG value. We observed that the extensive production system showed a higher CAT and SOD activity than the semi-intensive system which is supported by a study on WAD goats (Adenkola et al. 2018). These reports and the findings of this study indicate that, of all the four markers used, TAC is influenced by dietary supplementations and may be utilized as a reliable antioxidant marker for assessing the effect of nutritional manipulations. It also indicates that the diet needs to be considered while considering the TAC as an antioxidant marker.

The present study results indicate a lack of association of fecundity with any of the studied antioxidants. Similar to the present study, goats showed no variations for SOD, GSH, GSH-Px during different stages of pregnancy (Cetin et al. 2021). In contrast, TAC values were higher during the fourth to fifth months of pregnancy in multiple-bearing goats than singleton bearing goats (Abdel-Ghani et al. 2016). In comparison, low SOD, CAT and TAC levels were reported in multiple-bearing goats (Abd El Hameed et al. 2018). The inconsistent findings of these antioxidant statuses on pregnancy indicate the involvement of other factors such as the level of nutrition, stage of pregnancy etc. in the antioxidant profiles. The present study was conducted on non-pregnant does, compared to other reports. This may contribute to the findings of insignificant variation between high and low fecundity groups.

The lack of variation in the antioxidant profiles between breeds may indicate a similar adaptive mechanism. A study conducted at high altitude areas showed that crossbred goat develops an effective body adaptive mechanism against high-altitude-induced oxidative stress on prolonged exposure (Kumar et al. 2019). They reported high values of CAT, FRAP, DPPH%, GSH and β-carotene in crossbred goats and a higher body weight gain on prolonged exposure (Kumar et al. 2019). TAC value of the current study was lower than with the three different reported goat breeds Changthangi, Sirohi and Crossbred (Kumar et al. 2019). SOD concentration was slightly higher in goats reared under extensive than those in semi-intensive system in the present study; a similar result was obtained in WAD goats (Adenkola et al. 2018).

This study detected a positive correlation between CAT and TAC, SoD and TAC, and CAT and SoD. Spearman’s correlation is significant at the 0.05 level (2-tailed).

Table 3. Pearson’s correlations between different antioxidants

<table>
<thead>
<tr>
<th>Variable</th>
<th>CAT activity</th>
<th>SoD activity</th>
<th>TAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Glutathione</td>
<td>0.237</td>
<td>-0.105</td>
<td>0.068</td>
</tr>
<tr>
<td>CAT activity</td>
<td>.420*</td>
<td>.559**</td>
<td>-0.341</td>
</tr>
<tr>
<td>SoD activity</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.001 level (2-tailed).
and SOD but was not influential, as seen by the lack of a significant regression coefficient. It may indicate that CAT and SOD activities may be weakly associated or influenced by other factors that modulate redox homeostasis, as suggested by Lykkesfeldt and Svendsen (2007). The significant negative correlations and regression between CAT and TAC might indicate that the higher TAC activities negatively influence CAT activity. In bovine follicular fluid, it was shown that CAT activity is elevated in small bovine follicles, while TAC levels were lowest (Gupta et al. 2011). The TAC assay estimates multiple antioxidants such as albumin, uric acid, ascorbic acid, α-tocopherol, and bilirubin (Erel. 2004, Rubio et al. 2016). Hence levels of individual components of TAC need to be estimated and correlated with CAT which has not been taken up in this study. It is also plausible that these markers (CAT and TAC) do not work simultaneously or act on different target sites. Negative correlations between other antioxidants (GPx with SOD and Albumin) have been reported (Giorgio et al. 2020).
SUMMARY
The present study assessed the physiological antioxidant status of goats reared under the humid tropical island ecosystem of the Andaman and Nicobar Islands (ANI). From 2019 to 2020, 25 multiparous non-pregnant does with three to six kidding records maintained in the organized farm of Central Island Agricultural Institute (CIARI) and farmer’s field flocks from South Andaman district were selected for the study. Antioxidant markers such as total antioxidant capacity (TAC), superoxide dismutase (SOD), TG (Total glutathione) and catalase (CAT) were analyzed in blood serum with respect to rearing systems, breeds and level of fecundity. Correlation analyses of all dependent variables were performed using Pearson’s correlation. The endogenous antioxidant systems, viz. CAT, TG and SOD was non-significant with respect to rearing systems, breeds and fecundity. Similarly, TAC was non-significant among the breeds and with fecundity; however, semi-intensively managed goats showed significantly higher values than goats under the extensive condition. Correlation analysis showed that CAT was positively correlated with SOD and negatively correlated with TAC. TG showed no correlation with any of the studied antioxidants. Regression analysis of CAT as dependent variable and SOD and TAC as independent variables showed significance. It is concluded that values of antioxidant in the study can be considered as a baseline data for the ALG and other goat breeds of Andaman and Nicobar Islands and other islands or topographies with similar ecosystems for further studies.

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REFERENCES


