Effect of substitution of soybean meal by detoxified karanja cake on diet digestibility, growth, carcass and meat traits of sheep

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A B S T R A C T

The non-conventional karanja cake is rich in protein (around 30% CP) and can be used in livestock feed as a protein source instead of conventional protein supplement cake like soybean meal (SBM), groundnut cake, etc. The present study was carried out to research the effect of partially substituted soybean meal with detoxified karanja cake (dKC) on performance of ram lambs. Twenty-four ram lambs were randomly divided into four groups (n = 6) and fed different levels (%) of detoxified karanja cake (0% replacement, control; 25% replacement, dKC-25; 50% replacement, dKC-50 and 75% replacement, dKC-75) in concentrate mixtures for 140 days. dKC was incorporated in the concentrate mixtures at the expense of soybean meal, maize grain and wheat bran at 9, 18 and 29% in dKC-25, dKC-50 and dKC-75, respectively on fresh basis. As the level of karanja in the diet increased, DMI was found to be decreasing significantly. Similar to these effects, N-retention was reduced leading to significant reduction of body weight in high karanja cake replaced groups. Similar trend was observed in OM, CP, and ADF digestibilities and reason attributed to increased dietary level of karanja cake. However, detrimental effects were not observed on the levels of total protein, albumin, globulin, serum urea, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) indicating residual ANF present in dKC did not exert any adverse effects. The effects on hot carcass weight, weights of liver and testes are following a decreasing trend while that weight of kidney is increasing with level of karanja in the diet. Our findings highlights that the detoxified karanja cake can be added as replacement of soybean meal (SBM) at low levels. However, higher levels of replacement (above 9 per cent of concentrate mixture) warrant caution due to its adverse effect on studied parameters.

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1. Introduction

Karanja (Pongamia spp.) is grown in parts of humid tropical regions of Asia and Oceania. The seed contains 20–30% protein, 27–39% oil and a group of furano-flavonoids that constitutes 5–6% by weight of the oil (Bringi and Mukerjee, 1987). In a recent study, large variations were observed in seed size, composition in terms of protein and fat, incriminating factors like karanjin, pongamol and trypsin inhibitor activity (TIA) collected from different regions of Karnataka (Dineshkumar et al., 2011). The seed kernel after extraction of oil is rich in protein (around 30% CP) which can be used in animal and poultry feed as a protein source (Konwar et al., 1987; Vinay and Kanya, 2008). However, raw expeller karanja cake (rKC) is not commonly used as

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a feed for livestock due to its poor palatability and presence of antinutritional factors (ANFs), i.e. furanoflavones like karanjin, pongamol and certain other polyphenolic compounds (Bringi and Mukerjee, 1987; Prabhu et al., 2002) leading to depression in performance of livestock (Srivastava et al., 1990; Nagalakshmi et al., 2011; Panda et al., 2004). Various methods, namely refluxing with 2% HCl (Mandal, 1985) water leaching, solvent extraction, acid and alkali treatment, autoclaving were adopted to improve palatability and nutritive value of detoxify karanja cake. Among all the methods, solvent extraction was found to be more efficient to remove karanjin (Prabhu et al., 2002) and is being commonly used as a method to detoxify karanja cake. Singh et al. (2006) reported that long term feeding of expeller karanja cake or solvent extracted karanja cake had deleterious effects on the nutrient utilization, blood biochemical profile, rumen fermentation pattern, carcass characteristics and manifested clinico-pathological changes in bone and tissues of vital organs. Further studies indicated that inclusion of expeller karanja cake at 12% in complete diets constituting 390 mg karanjin per kg depressed the performance in lambs (Nagalakshmi et al., 2011). Keeping in view the adverse effects exerted by feeding of karanja cake, present study aimed to fill the gaps in scale up of detoxification methodology of karanja cake at industrial scale and its possible utilization in livestock rations replacing soybean cake. The effects on physiological responses in terms of gene expression of LH receptor and IGF-I genes related to testicular function, testicular architecture and hormones was already reported (Dineshkumar et al., 2013). The objective of the particular experiment is to test different levels of detoxified karanja cake in rations of growing lambs based on its effects on intake, digestibility, growth, carcass and meat traits.

2. Materials and methods

2.1. Source of detoxified karanja seed cake (dKC)

Bulk production of detoxified meal required for feeding trial was collected from industrial partners (M/s Ayurved Pvt. Limited, Baddi, Himachal Pradesh, India and M/s Ganesh Scientific Research Foundation, New Delhi, India). A process was developed to detoxify karanja seeds initially by crushing and removing the oil using hexane. Then the meal was further detoxified by soaking the seeds in aqueous methanol mixture and drying.

2.2. Feed preparation

The requirements of crude protein (CP) and total digestible nutrients (TDN) suggested by Indian Council of Agricultural Research (ICAR, 1998) formed the guidelines for feeding lambs. The required quantities of feed ingredients like finger millet (Eleusine corocana) straw, maize (Zea mays) grain, soybean (Glycine max) meal, wheat (Triticum aestivum) bran, mineral mixture and salt were procured from commercial source for the entire duration of the experiment. Maize grain and soybean meal were ground in hammer mill and mixed with wheat bran, mineral-vitamin premix and salt in horizontal mixer. Four iso-nitrogenous and iso-calcic concentrate mixtures were prepared by making minor adjustments in the proportions of wheat bran and maize grain were made in the formulation (Table 1).

2.3. Experimental animals and housing

24 ram lambs were used in this experiment (body weight: 13.7 ± 0.5 kg; aged around 6 months) for a period of 140 days in a permanent open type shed having provision for tying the animals in separate enclosures and also feeding trough. Ram lambs were fed individually and reared under hygienic and uniform managerial conditions throughout the experiment. Ram lambs were offered clean water 2–3 times daily for the entire duration. They were dewormed using broad spectrum anthelmintic (albendazole®) at the rate of 10 mg per kg body weight twice at 21 days interval at the beginning of the trial and all the animals were confirmed to be parasite free by faecal examination. Ram lambs were randomly divided into four groups (n=6) and were offered concentrate mixture incorporating dKC as a replacement of SBM. Different levels (%) of karanja cake were fed (0% replacement, control; 25% replacement—9% dKC in concentrate mixture on fresh basis, dKC-25; 50% replacement—18% dKC in concentrate mixture on fresh basis, dKC-50 and 75% replacement—29% dKC in concentrate mixture on fresh basis, dKC-75). dKC was incorporated in concentrate mixtures (on fresh basis) at 9, 18 and 29% in dKC-25, dKC-50 and dKC-75, respectively.

The lambs were offered the respective concentrate mixtures daily between 9:00 and 9:30 h, to meet protein requirements (ICAR, 1998) for maintenance and expected daily gains of 75 g. The lambs were fed concentrate mixture around 1.6–1.7 percent of bodyweight. The remaining requirements were met through feeding of chaffed finger millet (Eleusine corocana) straw (~1.6% of body weight), which was offered after 2:00 h of feeding concentrate mixture fed to ensure its maximum consumption. On an average lambs consumed around 250–350 g each of concentrate and ragi straw across different treatment groups. All lambs were weighed individually at weekly intervals to assess body weight changes and growth.

Table 1 Ingredients and chemical composition of feeds used in the experiments.

<table>
<thead>
<tr>
<th>Item</th>
<th>dKC 0</th>
<th>dKC 25</th>
<th>dKC 50</th>
<th>dKC 75</th>
<th>Ragistraw</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ingredients (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maize grain</td>
<td>31</td>
<td>31</td>
<td>33</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Soybean meal</td>
<td>30</td>
<td>22.5</td>
<td>15</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Karanja detoxified cake</td>
<td>0</td>
<td>9</td>
<td>18</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Wheat bran</td>
<td>36</td>
<td>34.5</td>
<td>31</td>
<td>26.5</td>
<td></td>
</tr>
<tr>
<td>Mineral mixture*</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Salt</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Dry matter (%)</strong></td>
<td>96.84</td>
<td>97.26</td>
<td>97.51</td>
<td>97.01</td>
<td>93.53</td>
</tr>
<tr>
<td>Organic matter (% DM)</td>
<td>91.70</td>
<td>92.13</td>
<td>93.28</td>
<td>93.69</td>
<td>91.58</td>
</tr>
<tr>
<td>Ether extract (% DM)</td>
<td>2.61</td>
<td>3.00</td>
<td>3.73</td>
<td>3.35</td>
<td>1.18</td>
</tr>
<tr>
<td>Crude protein (% DM)</td>
<td>22.75</td>
<td>22.57</td>
<td>22.30</td>
<td>21.72</td>
<td>4.05</td>
</tr>
<tr>
<td>Acid detergent fibre (% DM)</td>
<td>8.89</td>
<td>8.63</td>
<td>9.05</td>
<td>8.57</td>
<td>43.35</td>
</tr>
<tr>
<td>Karanjin (%)</td>
<td>-</td>
<td>0.0027</td>
<td>0.0054</td>
<td>0.0087</td>
<td>-</td>
</tr>
<tr>
<td>Trypsin inhibitor activity (µg/g)*</td>
<td>-</td>
<td>35.1</td>
<td>70.2</td>
<td>113.1</td>
<td>-</td>
</tr>
</tbody>
</table>

dKC-0, detoxified karanja cake 0% replacement with Soybean cake; dKC-50, detoxified karanja cake 50% replacement with Soybean cake and dKC-75, detoxified karanja cake 75% replacement with Soybean cake.

* Commercial mineral mixture with the composition per kg: Cobalt-150 mg, copper-1200 mg, iodine-325 mg, iron-5000 mg, magnesium-6000 mg, potassium-1500 mg, selenium-100 mg, sodium-10 mg, sulphur-5.9 mg, zinc-0.942%, DL Methionine-9600 mg, L-lysine, mono hydrochloride-4400 mg, calcium-24%, phosphorous-12% was used.

* Calculated values on the basis of concentrations of detoxified karanja cake.
rate. The individual intake of nutrients such as DM, CP, DCP and TDN per unit gain was calculated by dividing intake of nutrients obtained from individual animals during sub trial for arriving values of nutrient conversion efficiency.

2.4. Metabolism trial

After 90 days of the experimental feeding, a 6-days metabolism trial was carried out on all lambs (n = 24) involving total faecal and urine collection. This collection was preceded by 2 days adaptation period for lambs’ acclimatization to faecal and urine bags. During the trial period, all the lambs were tied with cotton ropes. The faeces collection was facilitated by tying tarpaulin faecal bags and urine was collected in polythene bags. The contents of faeces and urine from bags were cleared at regular intervals manually in the airtight plastic containers contained known quantity of H2SO4. Daily feed offered, residues left and faeces and urine excreted was recorded on 24-h basis. Feeds, refusals and an aliquot of faeces were dried at 100 ± 5 °C for 24 h for the determination of DM. The dry samples were ground to pass through a 1-mm sieve and pooled for proximate analysis. Day to day fresh samples of faeces (1/10) was preserved with 1:4 sulphuric acid for N estimation.

2.5. Collection and analysis of rumen liquor and blood samples

After the metabolism trial, rumen liquor was collected from all the sheep with the help of stomach tube. Little suction was applied to collect the rumen liquor from the sheep (Rao et al., 2012). The pH of rumen liquor was recorded immediately after collection using a pre-calibrated digital pH meter. The strained rumen liquor was analyzed for ammonia-N (Conway, 1957), total-N and trichloroacetic acid precipitable-N (TCA ppt.-N) (AOAC, 2000). Blood was collected from jugular vein. Serum was separated and stored at –80 °C till analyzed. Biochemical profiles such as serum protein (g/dl), albumin (g/dl), glucose (g/dl), urea (mg/dl) and enzymes such as alanine amino tranferase (ALT) and aspartate aminotransferase (AST) (IU/l) were estimated using biochemical kits purchased from Span Diagnostics Limited, Surat, Gujarat, India. The globulin concentration was measured as difference between total protein and albumin.

2.6. Laboratory analysis

Proximate analysis of the concentrate mixtures, finger millet straw and faeces viz. CP, EE and ash were determined by the methods of AOAC (2000). Acid detergent fibre (ADF) was estimated using the procedure of Van Soest et al. (1991). The karanja was estimated by separation of components by TLC on pre-coated silica gel G 60 F254 plates developed on toluene: ethyl acetate (7:3 v/v) and detection at 260 nm in absorbance mode (Ravikanth et al., 2009) and Trypsin inhibitory activity (TIU/g) indirectly by inhibiting the activity of Trypsin. A synthetic substrate N- u-benzoyl OL-arginine p-nitroanilide (BAPNA) is subjected to hydrolysis by trypsin to produce yellow coloured p-nitroaniline. The degree of inhibition by the extract of the yellow colour production is measured at 410 nm (Chitra and Sadasivam, 1986).

2.7. Slaughter and carcass evaluation

Feed was withheld overnight with free access to water and animals were slaughtered in a local abattoir by Halal method (Gracey, 1981). After slaughter, the head and feet were removed and the animals were partially skinned lying on their back on the floor. Thereafter, the animals were suspended by the hind legs for further skinning. Carcass and non-carcass components were weighed immediately after slaughter. Lungs, trachea and heart were weighed as one piece and designated as pluck. Non-carcass components included head, skin, feet, digestive tract, liver, spleen, pancreas and pluck. Weight of digestive contents was computed as the difference between full and empty digestive tract. The empty live weight was computed as the difference between slaughter weight and weight of digesta content.

2.8. Meat quality evaluation

The longissimus dorsi muscle was collected, within 20 min of slaughter, trimmed of fat and frozen at ~80 °C till analyzed for meat quality traits. The pH of minced L. dorsi muscle was recorded by using a digital pH meter. Proximate composition of longissimus dorsi was determined on muscle samples according to AOAC (2000). The sensory evaluation of pressure-cooked meat samples for colour, odour, juiciness, tenderness and overall palatability was performed by a taste panel consisting of 10 panelists using 9 point scale (9 = like extremely, 1 = dislike extremely).

2.9. Statistical analysis

Individual sheep data was considered as a replicate and a one-way analysis of variance (ANOVA) was done using completely randomized design (Snedecor and Cochran, 1994) by a mathematical model of Harvey (1975). SPSS is a software package used for statistical analysis (SPSS Inc., Chicago, IL, USA) for analysis of variance assuming for independent constant variance structure with post-hoc tukey to find the pair wise significance between treatments. A P-value of less than or equal to 0.05 was accepted to indicate statistical significance. Repeated measure analysis was performed on for body weights recorded at different periods (weeks) using JMP® 11.2.0 software by fitting a model with a role variable as body weights, constructing model effects (treatment and period) and interactions (Treatment × Period) and generated least square means were subjected for significance using tukey post-hoc. Linear regression analysis was performed on different parameters such as dry matter intake, N excretion (faeces) and urine, N retained, hot carcass weight, organ weights (y variable) with % of karanja in the diet to construct a linear bivariate fit.

3. Results

3.1. Chemical composition of concentrate mixtures

CP content (%) of concentrate mixtures was found to be 21.7–22.8 in all groups (Table 1). EE% was found to be ranging from 2.6 in control to 3.7 in dKC-50. Increased EE in case of dKC groups could be due to more EE content of dKC used in the experiment (3.85%). dKC had shown residual concentration of Karanjin, 0.03% W/W and TIA, 390 μg/g.

3.2. Intake, digestibility and balance of nitrogen

The daily dry matter intake of lambs was regressed against per cent of incorporation of Karanja in the diet indicated significantly negative correlation (Fig. 1) indicating as the level of karanja increased in the diet the DMI is following a decreased trend. This was also reflected on reduced DCP intake (g/d) in dKC-50 and dKC-75 groups compared to control and dKC-25. Compared to control, dKC-50 and dKC-75 groups had low digestibilities of DM, OM, ADF and T-CHO. CP digestibility was lowest in dKC-75 (Table 2).
Table 2
Intake, digestibility in different groups.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Diet</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dKC 0</td>
<td>dKC 25</td>
</tr>
<tr>
<td>Dry matter intake (g/d)</td>
<td>684.81</td>
<td>643.92</td>
</tr>
<tr>
<td>DOM intake (g/d)</td>
<td>437.04</td>
<td>407.84</td>
</tr>
<tr>
<td>DCP intake (g/d)</td>
<td>73.02</td>
<td>69.36</td>
</tr>
<tr>
<td>TDN intake (g/d)</td>
<td>436.50</td>
<td>411.49</td>
</tr>
<tr>
<td>Nutrient digestibility (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic matter</td>
<td>69.71</td>
<td>68.97</td>
</tr>
<tr>
<td>Crude protein</td>
<td>79.29</td>
<td>79.79</td>
</tr>
<tr>
<td>ADF</td>
<td>47.66</td>
<td>44.62</td>
</tr>
</tbody>
</table>

dKC-0, detoxified karanja cake 0% replacement with Soybean cake; dKC-50, detoxified karanja cake 50% replacement with Soybean cake and dKC-75, detoxified karanja cake 75% replacement with Soybean cake.

Means bearing different superscripts (a and b) in a row differ significantly (P<0.05).

3.3. Body weights during experimental period

The least square means of body weights across different treatments presented (Fig. 2). The average body weights recorded across different treatments were similar only up to 25% of replacement. At higher levels of replacements (50 and 75%), body weights were significantly (P<0.05) reduced.

3.4. Rumen metabolites and serum biochemical profiles

Rumen fermentation profiles such as pH, ammonia-N, TCA-ppt N, total-N were similar (P>0.05) in all treatment groups (Table 3). Differences in total protein, albumin, aspartate aminotransferase (AST), alanine aminotransferase (ALT) (IU/l) and serum urea (mg/dl) were observed to be same in all groups indicating the residual ANF’s (Karanjin, pongamol, TIA and others) have not exerted any systemic effects in elevating or affecting any of the profiles studied.

3.5. Carcass characteristics, composition of Longissimus dorsi and organo-leptic evaluation of meat

Hot carcass weight was following declining trend as level of karanja cake increased in diet (Fig. 3). Similar to hot carcass weight, liver, heart and testes weights following declining trend. However, weight of kidney was following a increasing trend. Analyzed parameters like dry matter, fat, protein and ash were found to be similar in all treatment groups indicating no adverse effect of feeding dKC on chemical composition of meat. Organoleptic evaluation in terms of like appearance, colour, texture and consistency, aroma and flavor and overall acceptability were found to be same in all tested groups (Table 4).

4. Discussion

4.1. Chemical composition of concentrate mixtures

Karanjin contents of expeller/solvent extracted Karanj seed cake reported by various workers 0.32% by
Table 4
Carcass characteristics, composition of Longissimus dorsi and organo-leptic evaluation of meat by semi-trained panelists.

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Diet</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dKC-0</td>
<td>dKC-25</td>
</tr>
<tr>
<td>Live body weight (kg) after 12 h of fasting</td>
<td>24.08b</td>
<td>24.75b</td>
</tr>
<tr>
<td>Hot carcass weight (kg)</td>
<td>11.04a</td>
<td>11.10a</td>
</tr>
<tr>
<td>Weight of vital organs (g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>391b</td>
<td>384a</td>
</tr>
<tr>
<td>Kidneys</td>
<td>57</td>
<td>60</td>
</tr>
<tr>
<td>Heart</td>
<td>122</td>
<td>144</td>
</tr>
<tr>
<td>Testes</td>
<td>172</td>
<td>250</td>
</tr>
<tr>
<td>Spleen</td>
<td>51</td>
<td>57</td>
</tr>
<tr>
<td>Chemical composition (% on fresh basis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>27.30</td>
<td>28.32</td>
</tr>
<tr>
<td>Total fat (%)</td>
<td>5.22</td>
<td>5.28</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.10</td>
<td>1.06</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>19.82</td>
<td>21.17</td>
</tr>
<tr>
<td>pH</td>
<td>6.54a</td>
<td>5.73b</td>
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<tr>
<td>Organoleptic evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appearance</td>
<td>6.63</td>
<td>6.13</td>
</tr>
<tr>
<td>Colour</td>
<td>6.63</td>
<td>6.13</td>
</tr>
<tr>
<td>Texture and consistency</td>
<td>5.50</td>
<td>6.13</td>
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<tr>
<td>Aroma and flavour</td>
<td>5.94</td>
<td>5.88</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>6.38</td>
<td>6.38</td>
</tr>
</tbody>
</table>

dKC-0, detoxified karanja cake 0% replacement with Soybean cake; dKC-50, detoxified karanja cake 50% replacement with Soybean cake and dKC-75, detoxified karanja cake 75% replacement with Soybean cake. Means bearing different superscripts (a,b,c) in a row differ significantly (P<0.05).

4.2. Intake, digestibility and balance of nitrogen

Many studies involved with feeding of either solvent extracted karanja cake or expeller karanja cake were reported (Konwar et al., 1987 in crossbred bull calves; Srivastava et al., 1990 in growing kids; Singh et al., 2006; Ravi et al., 2000; Prabhu, 2002; Soren and Sastry, 2009; Nagalakshmi et al., 2011 in growing lambs). As observed in present study reduction in feed intake was observed in cross-bred bulls fed 26.5% deoiled karanja cake based concentrate mixture (Konwar et al., 1987) and in lambs fed with concentrate mixtures containing either 24% expeller karanja cake or 20% deoiled karanja cake (Singh et al., 2006) or 22.5% processed deoiled karanja cake (Soren and Sastry, 2009) or 12% expeller karanja cake (Nagalakshmi et al., 2011). On the contrary, no effect on DMI has been reported in goat kids receiving deoiled karanja cake at 40% level in concentrate mixture (Srivastava et al., 1990). Other workers (Ravi et al., 2000; Prabhu, 2002) also reported similar observations on dry matter intake in growing lambs receiving de-oiled karanja cake at 20% level. Similar to our results, reduction in nutrient digestibility was observed (Srivastava et al., 1990) in goat kids receiving 12% de-oiled karanja cake and 24% expeller karanja cake in lambs by Ravi et al. (2000). However, no effect on DM, OM digestibilities (Soren
and Sastry, 2009) and nutrient retention (Panda et al., 2004) was observed with incorporation of raw or processed expeller or solvent extracted karanja cake in lambs and broilers, respectively. The negative effects of karanja cake feeding on intake, digestibility and subsequent nutritive value of diet mainly because of residual ANFs like karanjin, trypsin inhibitors, pongamol, pongapin and lanceolatin B present in residual oil portion of karanja cake which might have affected the digestibility of these nutrients because karanjin possesses the insecticidal and antibacterial properties and also phenolic compounds which are well known for depressing the nutrients digestibility (Rangasamy and Seshadri, 1940; Roy et al., 1977). The reduction in protein digestibility observed the present study might be due to residual trypsin inhibitors and tannins present in karanja cake. The adverse effect of trypsin inhibitors is mainly on the pancreas, which responds to the inhibitors by enhanced synthesis and secretion of proteolytic enzymes. The pancreatic enzyme secretion is regulated by a negative feedback mechanism mediated by intestinal trypsin and chymotrypsin, and complex formation of trypsin with the inhibitors leading to a reduction of free trypsin in the small intestine (Alumot and Nistan, 1961). This reduction activates the pancreas-stimulating hormone, cholecystokinin, the release of which from the intestinal mucosa is inhibited by free trypsin (Wilson et al., 1978).

Regression analysis of N-retained (g/day) with % dietary incorporation of dKC indicated amount of N-retained is linearly decreased as the level of dKC increased in the diet. This is primarily due to low intake and subsequent urinary excretion of nitrogen (Fig. 4). However, faecal excretion is not affected by level of Karanj in the diet. Feeding of expeller processed karanja cake at 24% of concentrate mixture caused adverse effect on N balance in lambs (Ravi et al., 2000). Even deoiled karanja cake feeding also caused reduction of N balance in growing calves (Konwar et al., 1987) and growing kids (Srivastava et al., 1990). Lower nitrogen intake was compensated by reduced urinary excretion due to increased demand of nitrogen and subsequent more recycling of urea across rumen epithelium (Kennedy and Milligan, 1980). It was further opined by these workers that mechanism by which this transfer occurs remain obscure. In contrary, Soren and Sastry (2009) observed positive N-balance in lambs received differently processed karanja cake (water washing, lime treated or binder addition).

4.3. Body weights during experimental period

The results obtained in the present experiment are consistent with earlier similar experiments involved with feeding karanja cake (Ravi et al., 2000; Soren et al., 2008; Nagalakshmi et al., 2011) in growing lambs fed either expeller or processed karanja cake.

4.4. Rumen metabolites and serum biochemical profiles

In line with the current study, Singh et al. (2006) found no significant differences in pH, NH₃-N, total-N and TCA ppt.-N in the rumen liquor of lambs fed expeller pressed (24.0%) and solvent extracted karanja cake (20.0%) for a period of 255 days. Differences in total protein, albumin, aspartate aminotransferase (AST), alanine aminotransferase (ALT) (IU/I) and serum urea (mg/dl) were observed to be same in all groups indicating the residual ANFs (Karanjin, pongamol, TIA and others) have not exerted any systemic effects in elevating or affecting any of the profiles studied. In contrast, Singh et al. (2006) observed higher activity of serum AST in lambs fed expeller and solvent extracted karanja cake. Earlier studies on unconventional oil cakes (Sal seed meal/Mahua seed cake) showed that activity of serum transaminases increased in cow calves and sheep fed on concentrate mixtures containing such oil cake/meal for longer period (Garg et al., 1984; Singh et al., 1994). The values of serum protein observed in the present study are in normal reference values (Kaneko et al., 2008), however, albumin values were little higher than the reference range.
4.5. Carcass characteristics, composition of Longissimus dorsi and organo-leptic evaluation of meat

Similar to the study, hypertrophy of kidneys was observed by Singh et al. (2006) and Nagalakshmi et al. (2011) due to feeding of expeller and solvent extracted karanj cake. The reason attributed by them is due to effect of karanjin. Though, karanj did not elevate serum transaminases, it was good enough to cause hypertrophy of kidneys. It was already observed by feeding of detoxified karanj cake at higher levels affected the expression genes related to testicular function and testicular architecture (Dinesh kumar et al., 2013).

Similar to our results, protein and fat content in meat was not affected in lambs (Prabhu, 2002) and broilers (Panda et al., 2007) which were fed either raw or NaOH-treated solvent extracted karanj cake based diets. However, Soren et al. (2008) observed lower protein in the meat of lambs which were fed water-washed karanj seed cake compared to control lambs.

5. Conclusions

The present study suggests that the detoxified karanj cake can be added as replacement of soybean meal (SBM) at low levels (more than 9 per cent of concentrate mixture). However, higher levels of replacement (above 9 per cent of concentrate mixture) warrant caution due to its adverse effect on growth performance, nutrient digestibility and important carcass trait like carcass weight. The effects are primarily caused due to residual ANFs present in the cake which has affected the studied parameters.

Conflict of interest

We wish to confirm that there are no known conflicts of interest associated with this publication.

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