BLOOD PROFILE OF WEST AFRICAN DWARF (WAD) BUCKS FED RAW AND PROCESSED COCOA POD HUSK MEAL BASED – DIETS IN THE HUMID HIGH RAINFOREST ZONE OF NIGERIA

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ABSTRACT

A 12-week feeding trial was carried out using 30 West African Dwarf (WAD) bucks of age between six and eight months with mean initial body weight of 9.36±1.31 kg, to determine the effect of sun-dried, urea-treated and fermented dietary cocoa pod husk meal (CPHM) as well as dietary CPHM with protein supplementation (African yam bean meal) on blood characteristics. Five experimental diets: T<sub>1</sub> (0% CPHM-control), T<sub>2</sub> (40% sundried CPHM), T<sub>3</sub> (40% urea-treated CPHM), T<sub>4</sub> (40% fermented CPHM) and T<sub>5</sub> (40% CPHM and 10% African yambean) were formulated. Six animals per treatment were randomly assigned to the experimental diets using a CRD. Blood parameters (haematological and serum biochemical indices) were evaluated at the end of the feeding trial. Results of the study showed that the White blood cell counts, packed cell volume and red blood cell counts were significantly (P < 0.05) influenced by dietary treatments. In terms of serum chemistry, higher values of urea were recorded in sundried (6.57 mmol/l) and protein supplemented (6.57 mmol/l) groups, followed by the fermented group (6.17 mmol/l). Calcium (2.24 mmol/l) and total protein (7.44g/dl) were highest in urea-treated CPHM group followed by the protein supplemented group (1.84 mmol/l and 7.37g/dl) and lowest in the sundried CPHM group (1.14 mmol/l and 6.21g/dl) respectively. The study concludes that blood composition of WAD bucks was best in the urea-treated and protein supplemented groups respectively, and 40% cocoa pod husk meal supplemented with 10% protein (African yambean) can be incorporated in the diets of WAD bucks without fear of compromising haematological and serum biochemical indices.

KEYWORDS: Cocoa pod husk, Urea, Fermented, Protein supplemented, WAD bucks

INTRODUCTION

Goats play a significant role in supplying protein to humans and paying close attention to their feed supply will to a great extent increase their productivity. They are highly productive and are reared not just as a source of income to the farmers but also provide milk and meat (Jansen and Van Den Burg, 2004). Their feeding behaviour, fast maturity, reproductive efficiency, small body size (Adugna et al., 2000) and ability to thrive well in harsh weather conditions (Jansen and Van Den Burg, 2004) are important attributes that make goat keeping a choice venture. Fluctuations in weather, limited grazing lands, soil infertility, competition between human and animals for food and high cost of feed are some of the factors that hinder the productivity of goats. To reduce feed cost and solve the problem of feed availability, farmers have resorted to the use of non-conventional feed ingredients to maintain their animals and in some cases to totally replace maize as an energy source in animal feeds (Esong et al., 2015). This may be attributed to the nutrient qualities hidden in them. Supplementation with legume plants as well as the use of agro-industrial by-products have in recent times proven to be successful. Legumes are usually planted for use as supplements to improve animal productivity in periods of limited forage availability. Leucaena leucocephala and Gliricidia sepium have been reported to be widely used in supplementing animals on crop residue as well as by-products of agricultural processing (Norton, 1998). If the supplementation is done adequately there will be an efficient utilization of crop residues. The animals can either be allowed to browse these plants for a limited time (to avoid tree damage) or preferably fed with the already cut forages. The limitation in the use of most crop residues is that majority of them have a characteristically high crude fibre and low protein contents. However, their nutritional quality can be improved when subjected to various treatments (physical, biological and chemical treatments). The structural carbohydrates of the cell wall become more...
easily digestible by the action of rumen microbes and/or digestive enzymes when these crop residues are treated with urea (Khajarern and Khajarern, 1985). Fermentation as a process is used to break down larger molecules into simpler forms with alcohol as its end product and it has been an age long practice in the food and wine industry (Alber-Lois and Segal-Kischinevzky, 2010). In the cocoa industry, fermentation which usually lasts 5 days is employed on the beans for the production of chocolate and cocoa related products (ICCO, 1998). Cocoa (*Theobroma cacao*) is a tree crop of about 20 to 40 ft. in height. It originated in Mexico but has spread throughout Africa and found majorly in the tropical rainforest zone of Nigeria (Joachim and Felicitas, 2000). Cocoa pod husk is a by-product of cocoa processing and about 1.8 million tons are generated yearly in cocoa producing areas of Nigeria (Opeke, 2005). However, this crop residue constitutes nuisance to the environment because of poor waste management procedures. However, over the years, the development of new technologies, ideas and techniques have led to the use of this by-product as an alternative to conventional feeds for animals (Nwanze, 2014). Cocoa pod husks contain energy, fibre and minerals (Agunbiade et al., 2002) which are the choice nutrients in ruminate nutrition. The crude protein content is about 7.5%, crude fibre, 23.4 %; ash, 7.4%; ether extract 2.5 % (Fagbenro, 1995) and gross energy content of 3.990 Mcal/kg (Wong and Wan Zahari, 1997). Dried cocoa pod husk (pelleted) can be used as a substitute for maize and wheat bran in formulating rations for chickens, pigs and sheep and at optimal inclusion levels will not pose any risk to the animal (ICCO, 2000). Cocoa contains flavonoids, an antioxidant necessary for the proper functioning of the heart and brain (Coe and Coe, 1996). The nitrogen content of cocoa is made up of two water-soluble alkaloids; theobromine and caffeine which can be tolerated to an extent by humans but not so by animals (Oyadeyi et al., 2011). Because of the theobromine in the husk though in small amounts (Abiola and Tewe, 1991), as well as the high crude fibre and low protein contents (Sutkino, 1997), there is the need to subject the husk to different treatments, such as physical (sun-drying), chemical (urea treatment) and biological (fermentation) to improve not only the nutritional qualities but also the digestibility of this feed resource.

Blood contain a myriad of metabolites and other constituents which will provide a valuable medium for clinical investigation (disease prognosis) and nutritional status of animals. Dietary components have been reported to have measurable effects on blood profile; hence blood constituents are widely used in nutritional evaluation and survey of animals (Ewuola and Egbulike, 2008). Blood is a very important tissue of an animal’s body (Turner et al., 2008). It is a fluid that functions in oxygen, nutrients and waste transport and also involved in the mechanism of heat exchange. Merck manual (2012) defined haematology as the study of the number and morphology of the cellular elements of the blood - the RBCs (erythrocytes), WBCs (leukocytes) and platelets (thrombocytes) and the use of these results in the diagnosis and monitoring of diseases. Serum on the other hand is a fluid that is similar to plasma except for the absence of coagulation protein (Turner et al., 2008). It is seen only when there is a blood clot. It is an indication of the wellness or abnormality of organs and tissues as well as general metabolism of the body (Vetstreet, 2011).

The healthiness of haematological parameters to a large extent depends on the quality of feed ingested and the anti-nutrients present in the feed while serum chemistry is influenced by the toxic elements in the feed (Akinmutimi, 2004). This study was therefore designed to determine the effect of raw and processed cocoa pod husk meal on the blood profile (haematology and serum chemistry) of WAD goats (bucks) in a humid zone of Nigeria.

**Material and Methods**

**Location of the study**

The study was carried out at the Sheep and Goat Unit of the Teaching and Research Farm, Department of Animal Science, University of Calabar, Calabar, Cross River State. According to GeoNames geographical database (Goggle Earth, 2016), Calabar, a humid tropical region of Nigeria is located at 4.958° latitude and 8.326° longitude (decimal degrees) with an average of 37 metres above sea level. The mean rainfall is about 1830 mm/annum while average temperature is between 25 and 30 °C (NMA, 2018). The vegetation is majorly mangrove which consists of shrubs and trees (Okpilya et al., 2013).

**Processing of cocoa pod husk meal (CPHM)**

**Sources of cocoa-pod husk**

Composite fresh husks of cocoa pod of forastero variety were collected from Ndbiji village as well as Ojor and Owai communities of Uyangha, Akamkpa Local Government Area of Cross River State. The husks were washed, broken and subjected to different treatment procedures as follows:

**Sun-dried cocoa pod husk meal (SCPHM)**

A total of 200 kg of the already washed cocoa pod husks was measured using a 20 kg top loader weighing scale and were cut into pieces and sundried on a clean concrete slab to constant weight and afterwards milled with a hammer mill of 5 mm sieve size. The sun-dried cocoa pod husk meal was then stored in polythene bags for use in compounding the experimental diet as SCPHM.

**Urea - treated cocoa pod husk meal (UCPHM)**

A total of 200 kg of the already washed cocoa pod husks were cut into pieces, placed on a clean cemented floor and allowed to dry for 6 days. They were then milled with a hammer mill of 5 mm sieve size to obtain cocoa pod husk meal. The meal was then treated with urea on a volume/weight basis as stated by Iyayi et al. (2001). Exactly 1 kg of urea was dissolved in 25 litres of water. The solution obtained was thoroughly mixed with 25 kg of the cocoa pod husk meal after which the meal was put in a thick polythene bag and tied firmly so as to exclude air. The treated CPHM was kept under shade for 2 weeks after which the meal was then air-dried for
4 days and ready for use in compounding experimental diet.

Fermented cocoa pod husk meal (FCPHM)

A total of 200 kg of freshly broken and washed cocoa pod husks were dried for 6 days, milled (5 mm sieve size) and mixed with 60 percent of water as described by Bello et al. (2012). Thereafter the meal was put in polythene bags to ferment (anaerobically), labelled and kept in a room for 3 days after which the meal was dried under shade for 5 days, then bagged and stored for compounding of experimental diets.

Processing of the protein feedstuff (African yam bean)

African yam bean (Sphenostylis sternocarpa) seeds used in this study were boiled for 60 minutes as outlined by Ukachukwu and Obioha (2000) for mucuna seeds. Borehole water was made to boil at 100 °C before the seeds were poured in. Boiling continued for 60 minutes.

Experimental diets

Five (5) experimental diets were compounded to meet the goats’ nutrient requirements. The diets were designated as T1 (control), T2 (sun-dried), T3 (urea-treated), T4 (fermented) and T5 (protein supplemented – African yam bean meal). Diet T1 contained neither cocoa pod husk meal nor protein feedstuff, but rather contained conventional feedstuff like maize and soybean. Diets T2, T3, T4 and T5 contained differently treated cocoa pod husk meal at fixed rate (40 percent) with T5 containing protein feedstuff (10 percent African yam bean meal). All other basic ingredients were used to formulate the diets as shown in Table 1. Proximate compositions were determined based on AOAC (1990) methods. Each sample was analysed three times (triplicate determinations) per proximate parameter.

### Table 1: Gross composition of experimental diets

<table>
<thead>
<tr>
<th>Ingredient (%)</th>
<th>T1 (Control)</th>
<th>T2 (SCPHM)</th>
<th>T3 (UCPHM)</th>
<th>T4 (FCPHM)</th>
<th>T5 (Protein Supp.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCPHM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>40</td>
</tr>
<tr>
<td>UCPHM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FCPHM</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>AYB</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>Maize</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>SBM</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wheat offal</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>PKC</td>
<td>25</td>
<td>35</td>
<td>35</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Vit. Min. Premix</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Salt</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Calculated analysis:</td>
<td>17.86</td>
<td>13.31</td>
<td>13.69</td>
<td>13.06</td>
<td>13.68</td>
</tr>
<tr>
<td>% CP</td>
<td>10.81</td>
<td>16.96</td>
<td>15.96</td>
<td>15.66</td>
<td>15.85</td>
</tr>
<tr>
<td>%CF</td>
<td>2900.05</td>
<td>2424.13</td>
<td>2463.43</td>
<td>2476.12</td>
<td>2534.60</td>
</tr>
<tr>
<td>ME(Kcal/kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SCPHM– Sun-dried cocoa pod husk meal  
UCPHM – Urea-treated cocoa pod husk meal  
FCPHM – Fermented cocoa pod husk meal  
AYB- African yam bean  
SBM-Soybean meal  
PKC- Palm kernel cake  

Experimental animals and management

Thirty (30) WAD bucks of age between 6 and 8 months with mean initial weight of 9.36±1.54kg were used in this study. The animals were bought from local farmers at Akpabuyo, Cross River State, Nigeria. They were given anti-stress (lytavite) on arrival and were housed in concrete floored pens with two open sides provided with thick wire mesh for ventilation. The bucks were quarantined for 14 days and were fed sun-dried yam peels and forage materials (Pennisetum purpureum and Pueraria phaseoloides). At the beginning of the study, the animals were randomly allocated to different treatments after balancing for body weight with six animals per treatment and each serving as a replicate in a Completely Randomized Design (CRD) experiment. During the quarantine period, long-acting antibiotic (oxytetracyline) was administered intravenously and repeated after 4 days to take care of any infection. One bolus of albendazole was administered orally to each of the goats for the control of endo-parasites and ivermectin injection at 2 ml/goat was administered for the treatment and prevention of ecto parasites (mange). Also vaccination was done against Kata or PPR (Pestes des petites ruminants). The animals were given clean water ad-libitum and pens were cleaned on a daily basis.
throughout the duration of the study which lasted for 12 weeks.

Housing and equipment

The goat unit was partitioned into 30 pens of 1.8 x 1.75 m each using planks of 12 x 1ft, 2 x 2 inches wood and ply wood of 1.2 x 2.4 m, grouped according to the different treatments thereby providing an area of 3.15 m² for each of the goats. The floor was cemented but wooden elevation was provided to guard against cold. Air circulation was not a problem as the two sides of the unit were open but secured with a strong wire mesh to prevent thieves and predators from gaining access. Durable plastic watering and feeding troughs were made available for each goat.

Blood collection and determination of haematological and serum biochemical indices

At the end of the feeding trial (12th week), two sets of blood samples (10 ml) from each animal per treatment were taken from the jugular vein using a syringe and needle into clean bottles. One set was introduced in bottles containing anticoagulant, ethylene diamine tetraacetate (EDTA) for the determination of haematological parameters, while the second set of blood samples were in clean bottles devoid of the anticoagulant for the determination of serum biochemical parameters. Each haematological parameter was determined in triplicates using the methods of Baker and Silverton (1978). Serum biochemical indices were also determined in triplicates by methods described by Peter et al. (1982); Kohn and Allen (1995); Ochei and Kolhather (2007).

Statistical analysis

All data obtained in this study were subjected to one way analysis of variance for CRD. Significant means were separated using Duncan Multiple Range Test (Duncan, 1955).

Results

The result of the proximate composition of processed cocoa pod husk meal (CPHM) is shown in Table 2. The result revealed that the crude protein content of the sundried CPHM (8.53 percent) is not statistically different from that of the urea treated CPHM (9.47 percent). The lowest value was recorded in the fermented cocoa-pod husk meal (7.98 percent). Ether extracts had higher values in fermented cocoa-pod husk meal (3.59 percent), with a lower value in urea-treated cocoa pod husk meal (3.26 percent). Sundried cocoa-pod husk meal recorded higher value of 25.89 percent in crude fibre content with lower values recorded in fermented cocoa-pod husk meal (22.65 percent). The composition of ash in the sun-dried fermented and urea-treated CPHM were 4.95, 5.16 and 4.38 percent respectively and NFE values of 46.09, 50.05 and 51.76 percent, respectively.

The proximate composition of the diets containing CPHM is presented in Table 3. The crude protein, ether extract and NFE recorded significant differences (P< 0.05) across dietary treatments.

Table 2: Proximate composition of the processed cocoa pod husk meal (CPHM)

<table>
<thead>
<tr>
<th>Parameters (%)</th>
<th>SCPHM</th>
<th>FCPHM</th>
<th>UCPHM</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>88.87</td>
<td>89.33</td>
<td>88.76</td>
<td>0.14</td>
</tr>
<tr>
<td>Crude protein</td>
<td>8.53</td>
<td>7.98</td>
<td>9.47</td>
<td>0.36</td>
</tr>
<tr>
<td>Ether extract</td>
<td>3.41</td>
<td>3.59</td>
<td>3.26</td>
<td>0.08</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>25.89</td>
<td>22.65</td>
<td>23.41</td>
<td>0.80</td>
</tr>
<tr>
<td>Ash</td>
<td>4.95</td>
<td>5.16</td>
<td>4.38</td>
<td>0.19</td>
</tr>
<tr>
<td>NFE</td>
<td>46.09</td>
<td>50.05</td>
<td>51.76</td>
<td>2.37</td>
</tr>
</tbody>
</table>

All mean values were obtained from triplicate determinations

SCPHM– Sun-dried cocoa pod husk meal
UCPHM – Urea-treated cocoa pod husk meal
FCPHM – Fermented cocoa pod husk meal

Table 3: Proximate composition of diets containing CPHM

<table>
<thead>
<tr>
<th>Parameters (%)</th>
<th>T1 (Control)</th>
<th>T2 (SCPHM)</th>
<th>T3 (UCPHM)</th>
<th>T4 (FCPHM)</th>
<th>T5 (Protein supp.)</th>
<th>SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>90.35</td>
<td>89.27</td>
<td>89.21</td>
<td>89.17</td>
<td>89.37</td>
<td>0.27</td>
</tr>
<tr>
<td>Crude protein</td>
<td>18.42</td>
<td>12.75</td>
<td>13.21</td>
<td>12.83</td>
<td>13.84</td>
<td>0.96</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>10.85</td>
<td>26.80</td>
<td>25.89</td>
<td>21.84</td>
<td>23.78</td>
<td>3.08</td>
</tr>
<tr>
<td>Ether extract</td>
<td>4.75</td>
<td>2.67</td>
<td>2.74</td>
<td>3.13</td>
<td>3.26</td>
<td>0.33</td>
</tr>
<tr>
<td>Ash</td>
<td>7.02</td>
<td>6.43</td>
<td>6.40</td>
<td>6.36</td>
<td>6.51</td>
<td>0.11</td>
</tr>
</tbody>
</table>
All mean values were obtained from triplicate determinations

Haematological characteristics of WAD bucks fed diets containing CPHM

The result of the haematological parameters is shown in Table 4. All the parameters measured were significantly (P<0.05) different between dietary treatments except neutrophils, eosinophils, basophils and mean corpuscular volume.

Table 4: Haematological characteristics of WAD bucks fed diets containing CPHM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>T1 (Control)</th>
<th>T2 (SCPHM)</th>
<th>T3 (UCPHM)</th>
<th>T4 (FCPHM)</th>
<th>T5 (Protein supp)</th>
<th>SEM</th>
<th>Ref. ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBC (x10^9/L)</td>
<td>20.51</td>
<td>12.14</td>
<td>36.34</td>
<td>23.40</td>
<td>31.18</td>
<td>2.39</td>
<td>17.5-19.9***</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>10.87</td>
<td>8.07</td>
<td>15.87</td>
<td>9.17</td>
<td>19.51</td>
<td>1.28</td>
<td>21-35**</td>
</tr>
<tr>
<td>Haemoglobin (g/dl)</td>
<td>11.50</td>
<td>9.97</td>
<td>13.27</td>
<td>10.07</td>
<td>12.20</td>
<td>0.37</td>
<td>7-15**</td>
</tr>
<tr>
<td>RBC (x10^12/L)</td>
<td>3.41</td>
<td>2.51</td>
<td>4.85</td>
<td>2.89</td>
<td>5.52</td>
<td>0.34</td>
<td>8-18*</td>
</tr>
<tr>
<td>Platelets (x10^3/L)</td>
<td>3.10</td>
<td>2.87</td>
<td>2.27</td>
<td>2.19</td>
<td>3.61</td>
<td>0.24</td>
<td>3.0-6.0*</td>
</tr>
<tr>
<td>Lymphocytes (%)</td>
<td>16.83</td>
<td>19.64</td>
<td>30.11</td>
<td>20.00</td>
<td>16.40</td>
<td>1.51</td>
<td>50-70*</td>
</tr>
<tr>
<td>Monocytes (%)</td>
<td>9.44</td>
<td>7.61</td>
<td>4.71</td>
<td>7.14</td>
<td>6.27</td>
<td>0.49</td>
<td>0-4*</td>
</tr>
<tr>
<td>Neutrophils (%)</td>
<td>65.33</td>
<td>66.07</td>
<td>66.71</td>
<td>66.81</td>
<td>67.97</td>
<td>1.05</td>
<td>30-48*</td>
</tr>
<tr>
<td>Eosinophils (%)</td>
<td>5.30</td>
<td>4.80</td>
<td>4.77</td>
<td>6.11</td>
<td>5.44</td>
<td>0.25</td>
<td>1-7**</td>
</tr>
<tr>
<td>Basophils (%)</td>
<td>0.46</td>
<td>0.37</td>
<td>0.34</td>
<td>0.34</td>
<td>0.44</td>
<td>0.03</td>
<td>0.1-0.3***</td>
</tr>
<tr>
<td>MCV (fl)</td>
<td>32.04</td>
<td>30.90</td>
<td>31.67</td>
<td>31.67</td>
<td>31.44</td>
<td>0.23</td>
<td>16-25*</td>
</tr>
<tr>
<td>MCH (pg/cell)</td>
<td>35.14</td>
<td>36.97</td>
<td>26.81</td>
<td>34.84</td>
<td>23.04</td>
<td>1.57</td>
<td>36-43.2***</td>
</tr>
<tr>
<td>MCHC (g/dl)</td>
<td>113.40</td>
<td>119.17</td>
<td>83.34</td>
<td>110.40</td>
<td>71.34</td>
<td>5.42</td>
<td>30-36*</td>
</tr>
</tbody>
</table>

All mean values were obtained from triplicate determinations

a, b, c Means along the same row with different superscripts are significantly different (P<0.05)

Reference ranges by Fielder (2016)
Reference ranges by Daramola et al. 2005
Reference ranges by Opara et al. (2010)

Serum biochemical indices of WAD buck fed diets containing CPHM

The result of the serum biochemical indices is summarised in Table 5. Most of the parameters measured were significantly (P<0.05) different except albumin, triglycerides and glucose. The calcium content (2.24mmol/l) was significantly (P<0.05) higher in urea-treated group with the lowest value in the sun-dried (1.14mmol/l) group. Creatinine recorded higher values in all the groups when compared with the control (58.67µmol/l) with highest value recorded in the urea-treated group (91.67 µmol/l) and lowest in the sun-dried group (74.67µmol/l).
All mean values were obtained from triplicate determinations.

Proximate composition of processed cocoa pod husk meal (CPHM)

The proximate composition of sunried, fermented and urea-treated CPHM (Table 2) shows that these processing methods contributed to the slight differences in their nutrient contents, even though there were no significant (P>0.05) differences. The crude protein values for the sundried (8.53 %) and fermented (7.98 %) CPHM were lower and higher respectively from the values for the sundried (8.53 %) and fermented (7.98 %) in their nutrient contents, even though there were no processing methods contributed to the slight differences urea-treated CPHM (Table 2) shows that these

Table 5: Serum biochemical indices of WAD bucks fed CPHM diets

<table>
<thead>
<tr>
<th>Parameters</th>
<th>T&lt;sub&gt;1&lt;/sub&gt; (Control)</th>
<th>T&lt;sub&gt;2&lt;/sub&gt; (SCPHM)</th>
<th>T&lt;sub&gt;3&lt;/sub&gt; (UCPHM)</th>
<th>T&lt;sub&gt;4&lt;/sub&gt; (FCPHM)</th>
<th>T&lt;sub&gt;5&lt;/sub&gt; (Protein supp.)</th>
<th>SEM</th>
<th>Ref. ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (mmol/l)</td>
<td>1.17&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.14&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.63&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.84&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.12</td>
<td>1.15 – 2.4*</td>
</tr>
<tr>
<td>Creatinine (µmol/l)</td>
<td>58.67&lt;sup&gt;b&lt;/sup&gt;</td>
<td>74.67&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>91.67&lt;sup&gt;a&lt;/sup&gt;</td>
<td>88.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>80.00&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.07</td>
<td>88.4-159**</td>
</tr>
<tr>
<td>Urea (mmol/l)</td>
<td>4.57&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.57&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>6.17&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.57&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.26</td>
<td>0.8 – 9.7*</td>
</tr>
<tr>
<td>Sodium (mmol/l)</td>
<td>134.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>134.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>133.33&lt;sup&gt;a&lt;/sup&gt;</td>
<td>128.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>134.00&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.83</td>
<td>124 – 146*</td>
</tr>
<tr>
<td>Total protein (g/dl)</td>
<td>6.34&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>6.20&lt;sup&gt;c&lt;/sup&gt;</td>
<td>7.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.40&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.52</td>
<td>6.3 – 8.5*</td>
</tr>
<tr>
<td>Albumin (g/dl)</td>
<td>2.75</td>
<td>2.75</td>
<td>2.60</td>
<td>2.60</td>
<td>2.60</td>
<td>0.07</td>
<td>2.8 – 4.3*</td>
</tr>
<tr>
<td>Globulin (g/dl)</td>
<td>3.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.00&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>4.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.13</td>
<td>2.7-4.1**</td>
</tr>
<tr>
<td>A/G Ratio</td>
<td>0.75&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.80&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.54&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.54&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.09</td>
<td>1.03-1.05**</td>
</tr>
<tr>
<td>Cholesterol (mmol/l)</td>
<td>2.70&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.27&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.01&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.08&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2.67&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.09</td>
<td>2.07-3.37**</td>
</tr>
<tr>
<td>HDL (mmol/l)</td>
<td>1.34&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.77&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.91&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.61&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.70&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.06</td>
<td>0.48-0.53***</td>
</tr>
<tr>
<td>Triglycerides(mmol/l)</td>
<td>0.87</td>
<td>1.07</td>
<td>0.94</td>
<td>0.91</td>
<td>1.04</td>
<td>0.03</td>
<td>0.16 – 1.6*</td>
</tr>
<tr>
<td>Glucose (mmol/l)</td>
<td>4.67</td>
<td>3.30</td>
<td>3.90</td>
<td>3.37</td>
<td>3.47</td>
<td>0.21</td>
<td>2.78-4.16**</td>
</tr>
</tbody>
</table>

<sup>a, b, c</sup> Means along the same row with different superscripts are significantly different (P<0.05).

All mean values were obtained from triplicate determinations

Ref. ranges - Reference ranges

Reference ranges by Daramola et al. (2005)
Reference ranges by Fielder (2016)
Reference ranges by Kasumu (2011)

**DISCUSSION**

Proximate composition of processed cocoa pod husk meal (CPHM)

values are higher than the findings recorded by Adegunloye and Famolu (2016) for unfermented (15.55 %) and fermented (75.0 %) and lower than the result obtained by Erika and Anuraga (2015) who recorded 55.7 and 49.10 % for raw and fermented CPHM respectively. Crude fibre in this study for urea-treated CPHM (23.41 %) was higher than the value (21.0 %) recorded by Iyayi et al. (2001) and lower than that (50.9 %) of Erika and Anuraga (2015). The reduction in the crude fibre content of both fermented CPHM and urea-treated CPHM has been reported to be as a result of the processing methods employed (Erika and Anuraga 2015). This reduction in fibre content is an advantage when CPHM is being considered as feed for animals as the high fibre content serves as a hindrance to its utilization (Sutikno, 1997). The ash content of raw and fermented CPHM (9.37 %) recorded by Adegunloye and Famolu (2016) (4.95 %) are higher than the results (4.02 and 3.74 %) recorded by Iyayi et al. (2001) and lower than that (50.9 %) of Erika and Anuraga (2015). The reduction in ash content is a result of the increased action of the microorganisms on the heavier minerals, thereby, breaking them down into lighter ones (Adamafio et al., 2015). The ether extract and nitrogen free extracts for raw and fermented CPHM (3.59 and 49.95 %) respectively are higher than (2.55 %) and lower than (68.02 %) reported by Adegunloye and Famolu, (2016) while those of the

Ref. ranges by Kasumu (2011)
urea-treated CPHM (3.26 and 48.24 % respectively) are higher than the result obtained by Erika and Anuraga (2015) who recorded 25.00 % NFE and 2.20 % ether extract. These variations still points out the fact that the different processing methods affected the nutrient contents of CPHM.

**Proximate composition of diets containing CPHM**

The proximate composition of diets containing CPHM (Table 3) recorded significant differences (P<0.05) in crude fibre, crude protein, ether extract and NFE among the groups. The crude protein across the diets (12.75-13.84 %) was within the recommended range of 9.00 - 14.00 % for growing buck kids (Kieser, 2012). The higher protein contents in T3 (urea group) and T5 (protein supplemented group) could be linked to the additional protein supplied by the groups with the treatment materials. The crude fibre content of the sunried group (26.80 %) recorded highest value compared with the control diet. This could be attributed to the processing methods adopted in this study and the inherent high level of fibre in the cocoa pod husks. However, the values obtained for the experimental diets are higher than the minimum amount of crude fibre (12 %) needed in a goat’s diet (Hart 2008; Rashid 2008) and lower than the maximum amount of crude fibre (50 %) required in a goat’s diet (Goatgyan, 2015). For a healthy rumen activity, the minimum level of crude fibre must be maintained as lower values will distort the rumen activity and nutrient utilization.

**Haematological characteristics of WAD bucks**

The haematological characteristics of WAD bucks fed diets containing CPHM (Table 4) differ significantly among dietary groups with the exception of neutrophils, eosinophils, basophils and MCV. The WBC counts recorded for the T3 (UCPHM) and T5 (protein supplemented) groups in this study did not differ from each other but were higher than the values of the WBCs of the T1 (control), T2 (SCPHM) and T4 (FCPHM) groups. The WBCs of the T1 (20.51x10^3/L), T2 (12.14 x10^3/L) and T4 (23.40 x10^3/L) groups all fell within the recommended range (6.80 – 20.10 x10^3/L) reported by Daramola et al. (2005) for WAD goats in Nigeria. The higher WBC values in the urea treated and protein supplemented groups could be attributed to immuno-response which may have resulted from handling of the urea and antinutrient components of the protein feedstuff (African yambean) used. The values of lymphocytes (16.40 - 30.11 %) and monocytes (4.71-9.44 %) in this study were significantly (P<0.05) different between dietary treatments. This also indicated the presence of foreign bodies in the blood of the animals. The PCV values recorded in this study were lower than the range reported by Daramola et al. (2005) and Opara et al. (2010); while the haemoglobin contents recorded are within the range reported by the same workers. The PCV values of urea treated and protein supplemented groups were higher than the other treatment groups. This could be attributed to the increase in protein content of the test ingredients upon processing. The high haemoglobin values of the animals in this study could be linked to the observation made by Daramola et al. (2005) that WAD goats are known to have higher haemoglobin which gives them an edge over other breeds in the effective transport of oxygen in the blood. RBC shows the concentration of the red blood cell in the blood. The RBC values (2.51 – 5.52 x10^12/L) in this study decreased with decreasing value of the PCV and vice versa. This observation is supported by the reports of Chineke et al. (2006) who stated that the higher the PCV, the higher the red blood cell. Blood platelets are known for their role in the clotting of blood and low values are seen in the longer time it takes for clotting to occur (Etim et al., 2014). The platelets (2.19 - 3.61x10^11/L) were within the range (300-600 x10^9/L which is equal to 3.00-6.00 x10^11/L) reported by Fielder (2016) for goats. The MCH value for the sunried group (36.97) was higher than control (35.14 pg/cell), UCPHM (26.81 pg/cell), FCPHM (34.84 pg/cell) and 23.04 pg/cell) groups but not statistically different (P>0.05) from the MCH values of the control and FCPHM groups. However, the values recorded across the groups in this study were within the range (37.80±2.2 and 35.94±0.02 pg/cell) recorded by Opara et al. (2010) for WAD goats and Njidda et al. (2013) for Kano brown goat kids, respectively. Generally, the differences in all the parameters measured in all groups could be as a result of varied methods of the test ingredients.

**Serum biochemical indices of WAD bucks**

The serum biochemical indices of WAD bucks fed diets containing CPHM (Table 5) recorded significant differences (P<0.05) in most of the parameters measured. The calcium and creatinine contents recorded higher values in the urea treated groups. However, the calcium content (1.14-2.24 mmol/l) was within the range (1.15-2.4 mmol/l) reported by Daramola et al. (2005). Urea contents of the sunried (6.57mmol/l), fermented (6.17mmol/l) and protein supplemented (6.57mmol/l) groups were not significantly different. However, the low value of blood urea recorded in the urea treated group (5.57mmol/l) could be caused by over-hydration (Amber, 2016). Abdul Wahid (2000) agreed with this fact when he noted a high urea concentration and output in urine of animals on ad lib water regime. Total protein in the UCPHM (7.40 g/dl) and protein supplemented (7.40 g/dl) groups were not statistically different (P>0.05) from each other but were higher than the values in the control (6.34 g/dl), SCPHM (6.20 g/dl) and FCPHM (6.60 g/dl) groups. These values can be compared with the value (7.89 g/dl) reported by Kraidees (2005) for Najdi ram lamb fed urea treated straw and soya bean meal supplemented diets. However, Abdel Hameed et al. (2013) reported a slightly lower value of total serum protein for lambs fed urea treated groundnut hull supplemented with different protein sources (groundnut cake, cotton seed meal and fish by-products). These variations in protein contents could be traced to the varying protein contents of the diets as well as the different animals used. Globulin content of the protein supplemented (4.80 g/dl) group was the same with that of the urea group (4.80g/dl) and higher than the globulin of the control (3.65 g/dl), SCPHM (3.45 g/dl) and FCPHM (4.00 g/dl) groups. These higher levels in the globulin of the urea and protein supplemented groups could be linked to their dietary intake as reported by Tothova et al. (2016) who stated that albumin and globulin contents are dependent
on the amount of total protein in the serum. The cholesterol content of the sundried group was the highest (3.27 mmol/l) and the lowest was in the protein supplemented group (2.67 mmol/l). The values recorded in the different groups could have resulted from dietary treatments. This was so because the protein supplement (African yam bean) used in the study has a cholesterol reducing ability (Eneh et al., 2005). Total protein (TP), urea, sodium, cholesterol and triglycerides recorded in this study were within the ranges (TP, 6.30-8.50g/100ml; urea, 0.80-9.70 mmol/l; sodium, 124.00-146.00 mmol/l; triglycerides, 0.16-1.60 mmol/l and TP, 69.00±1.33g/L; urea, 8.50±0.01 mmol/l; sodium, 156.00±0.22 mmol/l; cholesterol, 3.10±0.27mmol/l) reported by Daramola et al. (2005) for WAD goats and Njidda et al. (2013) for Sokoto red bucks respectively. This means that the diets supplied the needed amount of protein, urea, cholesterol and triglycerides for the maintenance of their different levels in serum composition.

CONCLUSION

In conclusion, the CPHM (processed and unprocessed) could be included up to 40% in the diet of WAD bucks with best results obtained when supplemented with African yam bean (10%) as protein supplement. The blood characteristics (haematology and serum chemistry) were best in the urea-treated and protein supplemented groups, respectively.

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