Proximate and Mineral Compositions, Mineral Safety Index (MSI) of Ten Organs of African Giant Pouch Rat

Adeyeye Emmanuel Ilesanmi1,a∗ and Adesina Adeolu Jonathan2,b
1,2Department of Chemistry, Ekiti State University, Ado – Ekiti, Nigeria
a*e-mail: eiadeyeye@yahoo.com, bunclejoshua2012@gmail.com

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Abstract. An investigation into the proximate composition, mineral composition and the mineral safety index of heart, skin, muscle, lungs, tongue, kidney, spleen, brain, liver and eyes of African giant pouch rat was carried out using standard methods, calculations of metabolizable energy, percentage energy contribution due to: protein, fat and carbohydrate; utilizable energy due to protein; Ca/P, Na/K, [K/(Ca+Mg)], Ca/Mg ratios and mineral safety index. In the proximate composition, the followings were discovered: samples were good in muscle (ash), kidney (protein), muscle (crude fat), skin (carbohydrate) and also contributed the highest energy. Highest level of proportion of energy due to protein (PEP %) came from the kidney, highest level of energy due to fat (PEF %) came from muscle whilst highest energy contribution due to carbohydrate (PEC %) came from the skin. The utilizable energy due to protein (UEDP %) assuming 60% utilisation had the highest level in the kidney. In the mineral composition muscle was good in Na; muscle was best in K; kidney was highest in Ca; tongue was rich in Mg; spleen was high in zinc; liver was high in Fe; muscle was rich in Mn; kidney was rich in P; muscle was good in Ca/P; skin was best in Na/K; spleen was best in [K/(Ca+Mg)] and spleen was best in Ca/Mg. In the mineral safety index (MSI) values: Zn with MSI of 33 was lower than heart, spleen and in Fe with MSI of 6.7 was lower than heart, muscle, lungs, brain, liver and eyes. The following parameters were significantly different at α = 0.05 among the samples: crude protein, carbohydrate, PEP %, PEF %, PEC %, UEDP %, Na, K, Ca, Mg, Zn, Fe and P. This report will give nutritional information on the various organs analysed.

Introduction

The giant rat Cricetomys gambianus (Okete) is a common rodent found around buildings and gardens in many parts of Nigeria. It digs long deep burrows with several entrances and stores food there. It eats roots, bulbs, young shoots and fruits. Other types of rats prefer grains. The female and young are communal and live in burrows. Each community consists of about thirty individuals; male giant rats live apart by themselves. Nests prepared from vegetable matter occur in the terminal chamber of the burrow [1].

The Gambian pouch rat can grow to be as big as a raccoon and can weigh up to 4 kg. It has very poor eyesight and so depends on its senses of smell and hearing. Its name comes from the large, hamster-like pouches in its cheeks. It is omnivorous, feeding on vegetable, insects, crabs, snails and other items, but apparently preferring palm fruits and kernels [2].

The African giant pouch rat belongs to the Order Rodentia, Superfamily Muroidea, Family Nesomyidae, Subfamily Cricetomyinae, Genus Cricetomys, Species C. gambianus, Binomial name: Cricetomys gambianus Waterhouse, 1840. In Africa it is routinely eaten as bush meat. It (and other mammals) is referred to by the pidgin name of “beef”.

A study carried out in Nigeria showed that the giant rat produces about the same amount of meat as the domestic rabbit [3]. The African giant pouch rat is a delicacy in Africa; however, no literature is available on proximate, mineral compositions and mineral safety index of the heart, skin, muscle, lungs, tongue, kidney, spleen, brain, liver and eyes. These literature reports are available on the African giant pouch rats; amino acids composition of liver and heart [4]; amino acids profile of the brain and eyes [5]; amino acids composition of the muscle and skin [6].
Among the various sorts of offal, heart is unusual in that it consists almost entirely of muscle. Smaller hearts are suitable for stuffing and then being baked. Lungs often form part of the pluck (an expression which covers heart, liver, lungs and windpipe) and are cooked as part of item in various dishes, mostly stews. Rabbits’ tongues, cooked, have been served in France as an hors d’oeuvre or as a garnish for dishes. In the world of seafood, various fish, such as cod, have tongues which are eaten with enthusiasm. Kidney soups are found in N. and W. Europe (Russia, Poland, Germany, England). Spleen (or melt or milt), a spongy organ found near the stomach or intestine of most vertebrates, has the function of maintaining blood in good condition. The spleen may also appear in mixed offal dishes and occasionally has a lead role, as in an interesting street food of Palermo in Sicily, guastelle (spleen sandwiches) of which Sokolov wrote in a 1994 issue of the Natural History Magazine [7]. Jane Grigson [8] observes that spleen usually disappears in England, as in France—with the rest of the pluck [heart, liver, lungs] into faggots, sausages and pâtés. Generally, brains are a very rich food, of which a little goes a long way. Livers lend themselves well to the making of pastes, stuffing’s, sausages and the like. Many game animals yield good livers, which are usually among the first items to be consumed. Eyes of certain animals and fish are considered a delicacy in some culinary cultures but regarded horrifying morsels by most people in the western world [7].

This work was therefore set out to evaluate the proximate and mineral compositions and other parameters in the various meat organs of the African giant pouch rat. The information derived here may also improve the information on food composition Tables.

Materials and Methods

Sampling and sample treatment

Cricetomys gambianus matured female samples (two of them) were caught in the wild by a local hunter commissioned for the purpose at Iworoko Ekiti, Nigeria; identified, immersed in hot water (10 min), hair removed and the animals dissected. The body parts and organs were then separated, washed with distilled water and dried to constant weight; milled into flour and kept in a freezer, pending analysis.

Proximate analysis

Moisture, total ash, fibre and ether extract of the samples were determined by the methods of the AOAC [9]. Nitrogen was determined by a micro-Kjeldahl method and the crude protein content was calculated as N (per gram) x 6.25 [10]. Carbohydrate was determined by differences. All the proximate results were reported in g/100 g dry weight. The energy values obtained for carbohydrates (x 17 kJ per gram), crude protein (x 17 kJ per gram) and crude fat (x 37 kJ per gram) for each of the samples. Determinations were in duplicate. Representative aliquots of 2 – 4g were taken for analysis.

Mineral analysis

The mineral elements were determined in the solutions obtained above-Na and K by flame photometry, Model 405 (Corning, Halstead Essex, UK) using NaCl and KCl to prepare standards. Minerals were analysed using the solutions obtained by dry ashing the samples at 550 °C and dissolving it in 10 % HCl (25 ml) and 5 % lanthanum chloride (2 ml), boiling, filtering and making up to standard volume with deionized water. Phosphorus was determined colorimetrically using a Spectronic 20 (Gallenkamp, London, UK) instrument, with KH2PO4 as a standard. All other elements (Ca, Mg, Zn, Fe, Mn, Cu and Cr) were determined by atomic absorption spectrophotometry, Model 403 (Perkin-Elmer, Norwalk, Connecticut, USA). All determinations were made in duplicate. All chemicals used were of analytical grade, and were obtained from British Drug House (BDH, London, UK).

The detection limits for the metals in aqueous solution had been determined just before the mineral analyses using the methods of Varian Techtron, giving the following values in µg/ml: Fe (0.01), Cu (0.002), Na (0.002), K(0.005), Ca(0.04), Mg(0.002), Zn (0.005), Mn (0.01) and Cr (0.02) [11]. The optimal analytical range was 0.1 to 0.5 absorbance units with coefficients of variation from 0.9-2.2 %.
Statistical analyses and other calculations

The coefficients of variation per cent were calculated [12]. The percentage contribution to energy due to protein (PEP), due to total fat (PEF) and due to carbohydrate (PEC) as PEP %, PEF % and PEC % respectively were calculated. The percentage utilisable energy due to protein (UEDP %) was also calculated. Ca/P, Na/K, Ca/Mg and the millequivalent ratio of \([K/(Ca + Mg)]\); the mineral safety index (MSI) of Na, Mg, P, Ca, Fe and Zn were also calculated [13].

To calculate MSI, we have:

\[
\text{MSI (standard)} \times \frac{\text{RAI (standard)}}{\text{Data (research) or result}}
\]  

(1)

RAI is recommended adult intake; CV in the Table will represent calculated value (CV) of calculated MSI from research results.

The differences between the standard MSI and the MSI of the samples were also calculated. The chi-square was compared with (\(\chi^2\) T) setting the level of confidence at \(\alpha = 0.05\) [12].

Results

Proximate composition

Results in Table 1 show proximate compositions of the samples. Crude fibre was not detected in any sample. The coefficient of variation per cent (CV %) was highest at carbohydrate with a value of 108 % and lowest in energy distribution at 1.73. In the samples the chi-square results (\(\chi^2\)) were not significantly different in the ash, moisture, fat and total energy whereas the following parameters were significantly different at \(\alpha = 0.05\): crude protein, carbohydrate, PEP %, PEF %, PEC % and UEDP %. Best results of each parameter were found as follows (g/100 g): ash (heart, 3.52), crude protein (liver, 83.9), fat (muscle, 4.86), carbohydrate (eye, 88.7), energy (kJ) (skin, 1704), PEP % (liver, 84.3), PEF % (muscle 11.0), PEC % (skin, 94.4) and UEDP % (kidney, 51.9).

Mineral composition

Table 2 shows the mineral compositions of the samples. Copper and Cr were not detected in all the samples whereas Mn was only detected in skin (0.01 mg/100 g) and muscle (1.86 mg/100 g). In the minerals the highest CV % was in Mn (140 %) and lowest in K (43.5 %). Minus Cu, Cr and Mn, all other minerals in the samples were significantly different at their various levels. Highest contributions of the minerals as food were (mg/100 g): Na (muscle, 44.9), K (muscle, 50.2), Ca (kidney, 49.8), Mg (tongue, 42.1), Zn (spleen, 37.6), Fe (liver, 66.8), P (kidney, 61.3). The highest Ca/P was 1.76 in muscle; most favourable Na/K was 0.601 in skin; highest \([K/(Ca+Mg)]\) was 1.97 in spleen and highest Ca/Mg was 1.73 in spleen. All the ratio values were not significantly different in all the samples. The CV % levels in the ratio parameters were lower than in the minerals with values range of 19.8 and 62.2.

Mineral safety index (MSI)

The mineral safety index values are depicted in Table 3. Mineral safety index (MSI) were not calculated for K, Mn and Cr because no MSI standards were available for them whereas Cu was not detected in all the samples. Na, Ca, Mg and P results were all within the standard MSI whereas some values of calculated MSI in Fe and Zn were greater than their corresponding standard MSI. For Zn, this greater MSI was observed in heart (47.1 or -14.1) and spleen (82.7 or -49.7); in Fe we have heart (29.4 or -22.7), muscle (29.5 or -22.8), lungs (22.3 or -15.6), brain (14.6 or -7.91), liver 29.8 or -23.1 and eyes (8.12 or -1.42).
### Table 1. Proximate and some calculated parameters in the *Cricetomys gambianus* samples

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Heart</th>
<th>Skin</th>
<th>Muscle</th>
<th>Lungs</th>
<th>Tongue</th>
<th>Kidney</th>
<th>Spleen</th>
<th>Brain</th>
<th>Liver</th>
<th>Eye</th>
<th>Mean</th>
<th>SD</th>
<th>CV%</th>
<th>$\chi^2$</th>
<th>TV</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash</td>
<td>3.52</td>
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<td>5.10</td>
<td>2.32</td>
<td>2.50</td>
<td>0.450</td>
<td>0.250</td>
<td>0.300</td>
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<td>1.67</td>
<td>101</td>
<td>15.20</td>
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<tr>
<td>Moisture</td>
<td>4.32</td>
<td>1.05</td>
<td>4.75</td>
<td>5.22</td>
<td>2.67</td>
<td>1.04</td>
<td>0.350</td>
<td>6.23</td>
<td>4.38</td>
<td>2.25</td>
<td>3.23</td>
<td>2.02</td>
<td>62.7</td>
<td>11.40</td>
<td>16.92</td>
<td>NS</td>
</tr>
<tr>
<td>Crude protein</td>
<td>74.8</td>
<td>2.70</td>
<td>78.5</td>
<td>75.5</td>
<td>75.3</td>
<td>85.8</td>
<td>54.0</td>
<td>78.1</td>
<td>83.9</td>
<td>7.11</td>
<td>61.6</td>
<td>31.1</td>
<td>50.5</td>
<td>141.0</td>
<td>16.92</td>
<td>S</td>
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<tr>
<td>Fat</td>
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<td>1.34</td>
<td>4.86</td>
<td>3.07</td>
<td>1.23</td>
<td>0.550</td>
<td>0.210</td>
<td>2.50</td>
<td>4.32</td>
<td>1.50</td>
<td>2.42</td>
<td>1.72</td>
<td>71.1</td>
<td>11.00</td>
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<td>CHO</td>
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<td>6.82</td>
<td>13.9</td>
<td>18.4</td>
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<td>45.2</td>
<td>12.9</td>
<td>6.17</td>
<td>88.7</td>
<td>31.2</td>
<td>33.7</td>
<td>108</td>
<td>329.0</td>
<td>16.92</td>
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<tr>
<td>Energy kJ</td>
<td>1660</td>
<td>1704</td>
<td>1630</td>
<td>1633</td>
<td>1638</td>
<td>1668</td>
<td>1694</td>
<td>1640</td>
<td>1691</td>
<td>1684</td>
<td>1666</td>
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<td>1.73</td>
<td>4.480</td>
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<tr>
<td>PEP%</td>
<td>76.6</td>
<td>2.69</td>
<td>81.9</td>
<td>78.6</td>
<td>78.1</td>
<td>86.5</td>
<td>54.2</td>
<td>81.0</td>
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<td>63.1</td>
<td>31.9</td>
<td>50.6</td>
<td>145.0</td>
<td>16.92</td>
<td>S</td>
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<tr>
<td>PEF%</td>
<td>10.3</td>
<td>2.91</td>
<td>11.0</td>
<td>6.96</td>
<td>2.78</td>
<td>1.21</td>
<td>0.459</td>
<td>6.54</td>
<td>9.45</td>
<td>3.30</td>
<td>5.40</td>
<td>3.85</td>
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<td>25.00</td>
<td>16.92</td>
<td>S</td>
</tr>
<tr>
<td>NEC%</td>
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<td>94.4</td>
<td>7.11</td>
<td>14.5</td>
<td>19.1</td>
<td>12.3</td>
<td>45.4</td>
<td>13.4</td>
<td>6.20</td>
<td>89.5</td>
<td>31.5</td>
<td>33.7</td>
<td>107</td>
<td>330.0</td>
<td>16.92</td>
<td>S</td>
</tr>
<tr>
<td>UEDP%</td>
<td>46.0</td>
<td>1.62</td>
<td>49.1</td>
<td>47.2</td>
<td>46.9</td>
<td>51.9</td>
<td>32.5</td>
<td>48.6</td>
<td>50.6</td>
<td>4.31</td>
<td>37.9</td>
<td>19.2</td>
<td>50.6</td>
<td>87.20</td>
<td>16.92</td>
<td>S</td>
</tr>
</tbody>
</table>

*PEP = Proportion of total energy due to protein.*

*PEF = Proportion of total energy due to fat.*

*PEC = Proportion of total energy due to carbohydrate.*

*UEDP = Utilizable energy due to protein.*

*α = df of $\chi^2$, S = Significant, NS = Not significant, TV = Table value, $\chi^2 =$ Chi square.

### Table 2. Composition and some calculated mineral ratios in the *Cricetomys gambianus* samples

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Heart</th>
<th>Skin</th>
<th>Muscle</th>
<th>Lungs</th>
<th>Tongue</th>
<th>Kidney</th>
<th>Spleen</th>
<th>Brain</th>
<th>Liver</th>
<th>Eye</th>
<th>Mean</th>
<th>SD</th>
<th>CV%</th>
<th>$\chi^2$</th>
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<th>Remark</th>
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<tbody>
<tr>
<td>Na</td>
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<td>1.01</td>
<td>44.9</td>
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<td>31.7</td>
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<td>15.2</td>
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<td>81.80</td>
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<td>K</td>
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<td>48.5</td>
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<td>34.9</td>
<td>15.2</td>
<td>43.5</td>
<td>58.90</td>
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<td>Ca</td>
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<td>40.2</td>
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<td>12.3</td>
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<td>37.6</td>
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<td>11.1</td>
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<td>103.0</td>
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<td>10.8</td>
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<tr>
<td>Ca/P</td>
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<td>0.319</td>
<td>1.76</td>
<td>0.731</td>
<td>1.19</td>
<td>0.812</td>
<td>0.292</td>
<td>1.19</td>
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<td>0.090</td>
<td>0.834</td>
<td>0.518</td>
<td>62.2</td>
<td>6.670</td>
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<td>Na/K</td>
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<td>0.894</td>
<td>0.878</td>
<td>0.656</td>
<td>0.779</td>
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<td>0.479</td>
<td>0.865</td>
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<td>19.8</td>
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<tr>
<td>(K/Ca+Mg)*</td>
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<td>0.345</td>
<td>1.35</td>
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<td>1.17</td>
<td>0.966</td>
<td>1.97</td>
<td>1.66</td>
<td>1.43</td>
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<td>1.39</td>
<td>0.474</td>
<td>34.1</td>
<td>1.450</td>
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<td>1.73</td>
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<td>1.33</td>
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<td>0.579</td>
<td>51.2</td>
<td>2.670</td>
<td>NS</td>
<td></td>
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</tbody>
</table>

* = Milliequivalent ratio.

*+ Chi square Table value = 16.92*
Table 3. Mineral safety index of Na, Mg, P, Ca, Fe, and Zn for the various Cricetomys gambianus samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Na</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>Zn</th>
<th>Fe</th>
<th>Mn</th>
<th>Cu</th>
<th>Cr</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart</td>
<td>0.33</td>
<td>4.8</td>
<td>4.46</td>
<td>-</td>
<td>0.27</td>
<td>10</td>
<td>9.73</td>
<td>0.75</td>
<td>15</td>
<td>14.3</td>
</tr>
<tr>
<td>Skin</td>
<td>0.01</td>
<td>4.8</td>
<td>4.79</td>
<td>-</td>
<td>0.01</td>
<td>10</td>
<td>9.99</td>
<td>0.30</td>
<td>15</td>
<td>14.7</td>
</tr>
<tr>
<td>Muscle</td>
<td>0.43</td>
<td>4.8</td>
<td>4.37</td>
<td>-</td>
<td>0.34</td>
<td>10</td>
<td>9.67</td>
<td>1.30</td>
<td>15</td>
<td>13.7</td>
</tr>
<tr>
<td>Lungs</td>
<td>0.41</td>
<td>4.8</td>
<td>4.39</td>
<td>-</td>
<td>0.25</td>
<td>10</td>
<td>9.75</td>
<td>0.80</td>
<td>15</td>
<td>14.2</td>
</tr>
<tr>
<td>Tongue</td>
<td>0.29</td>
<td>4.8</td>
<td>4.51</td>
<td>-</td>
<td>0.30</td>
<td>10</td>
<td>9.70</td>
<td>1.58</td>
<td>15</td>
<td>13.4</td>
</tr>
<tr>
<td>Kidney</td>
<td>0.30</td>
<td>4.8</td>
<td>4.45</td>
<td>-</td>
<td>0.42</td>
<td>10</td>
<td>9.58</td>
<td>1.30</td>
<td>15</td>
<td>13.7</td>
</tr>
<tr>
<td>Spleen</td>
<td>0.11</td>
<td>4.8</td>
<td>4.69</td>
<td>-</td>
<td>0.10</td>
<td>10</td>
<td>9.99</td>
<td>0.30</td>
<td>15</td>
<td>14.7</td>
</tr>
<tr>
<td>Brain</td>
<td>0.15</td>
<td>4.8</td>
<td>4.65</td>
<td>-</td>
<td>0.19</td>
<td>10</td>
<td>9.81</td>
<td>0.60</td>
<td>15</td>
<td>14.4</td>
</tr>
<tr>
<td>Liver</td>
<td>0.36</td>
<td>4.8</td>
<td>4.44</td>
<td>-</td>
<td>0.29</td>
<td>10</td>
<td>9.71</td>
<td>0.97</td>
<td>15</td>
<td>14.0</td>
</tr>
<tr>
<td>Eyes</td>
<td>0.20</td>
<td>4.8</td>
<td>4.46</td>
<td>-</td>
<td>0.03</td>
<td>10</td>
<td>9.97</td>
<td>1.22</td>
<td>15</td>
<td>13.8</td>
</tr>
</tbody>
</table>

CV = Calculated Value. TV of MSI = Table value. D = Difference. No MSI Standard for K, Mn, Cu and Cr.

Discussion

Proximate composition

The proximate values are in Table 1. A calculation of the organic matter (OM) gave values ranging from 94.9 g/100 g in muscle to 99.8 g/100 g in the spleen. These OM values were higher in most cases than 98.97 g/100 g in ostrich muscles [14], 91.07 g/100 g in trunk fish [15] and the values reported for four fresh water fishes of Mormyrops delicious (86.4 g/100 g), Bagrus bayad (75.0 g/100 g), Synodontis budgetti (84.0 g/100 g) and Hemichromis fasciatus (76.0 g/100 g) [16]. The protein content of the samples particularly for heart, muscle, lungs, tongue, kidney, brain and liver with value levels of 74.8 to 85.8 g/100 g were better than 72.89 g/100 g reported for trunk fish as well as another report on trunk fish (74.5 g/100 g [17]); 76.2 g/100 g (lean pork) and 72.5 g/100 g (lean meat of sheep) [18]; lower than 89.0 g/100 g (ostrich) [14]; higher than 73.7 g/100 g (beef) [19] and lower than 87.2 g/100 g (chicken) [20]. Very low levels of crude protein were observed in skin (2.70 g/100 g), eyes (7.11 g/100 g) but appreciable in the spleen (73.7 g/100 g) [19]. The crude fat levels ranged from 0.210 to 4.62 g/100 g in the samples. From literature, the value of fat in the muscle of turkey was 2.12 g/100 g and the skin of turkey was 12.1 g/100 g [21]; ostrich muscle (with skin) was 2.74 g/100 g [14], chicken muscle (with skin) was 12.6 g/100 g [20] and beef (22.3 g/100 g) [19].

The ash content was generally high in heart (3.52 g/100 g), muscle (5.10 g/100 g), lungs (2.32 g/100 g) and tongue (2.50 g/100 g) with expected corresponding higher mineral levels in them compared with the other samples. The energy levels in the samples ranged from 1.63 MJ to 1.70 MJ which were better than in turkey muscles and skin (1.33-1.37 MJ) [21], close to the levels in sheep lean meat (2.06 MJ) and lean pork (2.29 MJ) [18]. The lower level of fats in present samples could have been responsible for lower levels of energy than in some literature results. The energy levels of 1.63 to 1.70 MJ were better than 1.3 to 1.6 MJ/100 g from cereals [22] showing the samples to be reasonable sources of energy. The CV % of the carbohydrate was the highest at 108 %; while most members had carbohydrate levels lower than 20.0 g/100 g (e.g. 6.17 to 18.4 g/100 g) except spleen (45.2 g/100 g) whereas skin (94.6 g/100 g) and eyes (88.7 g/100 g) had exceptionally high levels and this resulted into the skin being highest in energy concentration (1.704 MJ).

Table 1 still contains other parameters calculated from the proximate values. It shows the various energy values as contributed by protein, fat and carbohydrate. The daily energy requirement for an adult is between 2500 to 3000 kCal (10455 to 12548 kJ) depending on his physiological state while that of infants is 740 kCal (3094.68 kJ) [23]. This implies that while an adult man would require between 641 to 769.8 g (taking minimum energy of 1630 kJ/100 g) of his energy...
requirement, infants would require 189.9 g (taking the minimum energy for the calculation). On the whole this meant that samples with higher energy value would require lower quantity of sample to satisfy the energy needs of man and infants. The utilizable energy due to protein (UEDP %) for the samples (assuming 60 % utilization) ranged from 1.62 to 51.9 %. The UEDP % in skin (1.62 %) and eyes (4.31 %) are much lower than the recommended safe level of 8 % for an adult man who requires about 55 g protein per day with 60 % utilization. Other samples had UEDP % values of 32.5 to 50.6 showing the greater percentage of the samples have protein concentration in terms of energy that would be more than enough to prevent energy malnutrition in children and adult fed solely on the samples as a main source of protein (except skin and eyes). The PEF % values were generally low in the samples (0.459 to 11.0 %) and far below the recommended level of 30 % [24] and 35 % [25] for total fat intake, this is useful for people wishing to adopt the guidelines for a healthy diet.

**Mineral composition**

Table 2 contains the results of the minerals and other calculated parameters. Among the major minerals, muscle had the highest levels of Na (44.9 mg/100 g) and K (50.2 mg/100 g), kidney had the highest levels of Mg (34.5 mg/100 g), Ca (49.8 mg/100 g) and P (61.3 mg/100 g). In minor minerals, spleen contained the highest levels of Zn (37.6 mg/100 g), best source of Fe was liver (66.8 mg/100 g) and muscle had the highest value of Mn (1.86 mg/100 g). Mn has always been found low in the foods consumed in Nigeria. For example, it was 1.9±0.04 mg/kg (meat pie), 1.0±0.00 mg/kg (doughnut), 2.9±0.01 mg/kg (moin-moin) and cake 2.8±0.01 mg/kg [26]. It is well known that minerals are necessary for life. Cu and Cr were not detected in any of the samples at the present detection limits. Cu and Fe are present in the enzyme cytochrome oxidase involved in energy metabolism. Since Cu and Cr are needed in the diet, the present samples would need to be supplemented in those minerals when they serve as the only food sources. Iron was high in all the samples except skin (0.92 mg/100 g) and spleen (2.09 mg/100 g). About 1-10 % of Fe from plant sources is normally absorbed by the body although this value can be improved upon when plants are consumed with meat [26].

Zinc is present in all the samples at high levels except in skin (2.61 mg/100 g), tongue (1.76 mg/100 g) and kidney (3.16 mg/100 g). Zinc is present in all tissues of the body and is a component of more than 50 enzymes [26]. The minimum Zn allowance (about 15-20 mg) per day would be met by the heart, spleen and closely by lungs, brain and eyes. The low concentration of Mn was in agreement to what obtains generally in meat [27].

Calcium concentration was high in most of the samples with eight samples being 12.3 to 49.8 mg/100 g. Calcium is an important constituent of body fluids. It is a coordinator among inorganic elements particularly K, Mg or Na where calcium is capable of assuming a corrective role when such metals are in excessive amount in the body [27]. Calcium, P and vitamin D combine together to avoid rickets in children and osteoporosis (bone thinning) among older people [26]. A dietary regime of adequate dietary Ca over the years should be a deterrent to this condition. All the phosphorus levels in the samples were high (19.2 to 61.3 mg/100 g) except in the skin where a value of 4.20 mg/100 g was reported. Phosphorus is always found with Ca in the body, both contributing to the supportive structures of the body. It is present in cells and in the blood as soluble phosphate ion, as well as in lipids, proteins, carbohydrates and energy transfer enzymes [26].

The samples were good sources of K, Mg and Na except in skin (Na = 1.01 mg/100 g) and K (1.68 mg/100 g) as well as in Mg (8.40 mg/100 g) and the spleen (Mg = 7.12 mg/100 g). Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves. Potassium is primarily an intercellular cation, in large part this cation is bound to protein and with Na influences osmotic pressure and contributes to normal pH equilibrium [26].

Table 2 further depicts the various mineral ratios that were calculated. The Ca/P was generally greater than 0.5 which is the minimum ratio required for favourable Ca absorption in the intestine for bone formation [28]. However Ca/P values in skin (0.319), spleen (0.292) and eyes (0.090) were lower than 0.5 whereas other Ca/P values ranged from 0.712 to 1.24. The high Ca/P values would
enhance strong bone development since absorption under this condition would be high. The Ca/P ratio is reported to have some effect on Ca in the blood of many animals [26]. All the Na/K values were greater than 0.60 although skin (0.601) and spleen (0.602) values were very close to 0.60 and brain was lower at 0.479. The value of 0.60 is the ratio that favours none enhancement of high blood pressure disease in man [28]. To bring this ratio low, foods rich in K should be more consumed except in the brain which is going to be a reverse. The Ca/Mg values ranged between 0.093 and 1.73 whereas the recommended value is 1.0. Both Ca and Mg would need adjustment for good health. The milliequivalent ratios of [K/(Ca+Mg)] were all less than 2.2. This meant our samples would not promote hypomagnesaeima in man [29].

Bender [30] had affirmed that meat and offals contain a wide variety of mineral salts with the contents of Fe, Zn, Cu varying considerably in different species, liver being by far the richest source of these minerals compared with muscle tissue. Whilst this assertion is true of Fe, it is not so in Cu (where ND was recorded in both muscle and liver in the samples) and Zn where it was 4.84 mg/100g (in muscle) > 4.33 mg/100g (in the liver). Result of typical analyses of various types of meat show that results for Ca and Zn were better in the present samples than in the animals listed below whereas it is vise versa in Cu, P, Na and K but comparable in Mg: ox lean (av), sheep (av); pig lean (av); calf, fillet; rabbit lean (av); chicken, light meat (av), dark meat (av) [31]. This variation in sample results could have been due to different feed sources [30].

Mineral safety index (MSI)

The mineral safety index (MSI) values of the samples are shown in Table 3. The standard MSI for the elements are Na (4.8), Mg (15), P (10), Ca (10), Fe (6.7) and Zn (33). For Na, the MSI values ranged from 0.01 (skin) - 0.43 (muscle), with all the differences between the standard and calculated MSI values being positive at 4.39 to 4.79 all less than 4.8. This meant that no sample might be overloaded the body with sodium that can lead to secondary hypertension. For Ca, Mg and P all the calculated MSI were lower than standard MSI and hence within the USRDA [13]. For Fe and Zn, the odd samples out, respectively were heart (-22.7), muscle (-22.8), lungs (-15.6), brain (-7.91), liver (-23.1) and eyes (-1.42); heart (-14.1) and spleen (-49.7). The implication of the above is that abnormally high levels of Fe and Zn were abnormally present in some samples. Some of the samples could cause the reduction of Zn absorption in the small intestine and Fe poisoning particularly in children by some of the samples. The Zn MSI greater than 33 are above the recommended adult intake. The minimum toxic dose is 500 mg, or 33 times the RDA [13]. High doses of Zn can be harmful. Zinc supplements can decrease the amount of high density lipoprotein (HDL) circulating in the blood, increasing risk of heart disease. Excess Zn interacts with other minerals, such as Cu and Fe, decreasing their absorption. In animals, Zn supplements decrease the absorption of Fe so much that anaemia is produced [26]. When patients are given 150 mg of Zn per day, Cu deficiency results. Intakes of Zn only 3.5 mg/day above the RDA decrease Cu absorption [28]. In animals, Cu deficiency causes scarring of the heart muscle tissue and low levels of Ca in the bone [26]. Excess Zn also decreases the functioning of the immune system. The Zn overload would come from 20 % of the present samples whereas in 25 samples of fish 96 % had Zn overload [32] and four samples of fast foods 100 % had Zn overload; in Fe overload would come from 60 % of the present samples whereas in 25 samples of fish 16 % had Fe overload and four samples of fast foods 100 % had Fe overload [26].

Conclusions

This study indicates that the proximate and mineral profiles of heart, skin, muscle, lungs, tongues, kidney, spleen, brain, liver and eyes of Cricetomys gambianus have varied compositions. In the results UEDP % was poor in skin and eyes; all samples were good in PEF % (<30 to 35 %); PEC % was very high in skin and eyes. Eyes, spleen and skin were all poor in Ca/P but both good in Na/K; all samples were good in [K/(Ca+Mg)] (<2.2); all samples were outside Ca/Mg of 1.0. Overload of Fe were in muscle, lungs, brain, liver, eyes and heart; overload of Zn occurred in heart and spleen.
Conflict of Interest

The authors declare that there is no conflict of interest.

References


