The Development Of Lean Muscle, Bone And Fat In The West African Dwarf Goat Of Nigeria Maintained On Good Plane Of Nutrition.

A.A. Awah* & I.O.A. Adeleye**

Keywords: Dwarf goat – Lean muscle – Bone – Fat.

Summary
Thirty West African Dwarf goat kids were raised on good diets intensively from 5 days to 52 weeks of age. Six animals (3 males and 3 females) were serially slaughtered at 2, 8, 12, 24 and 52 weeks of age to study changes in liveweight and the development of lean muscle, bone and fat. Lean muscle and fat expressed as the percentage of empty body weight (E.B.W.) increased from 31.8% and 3.8% at 2 weeks to 43.2% and 14.2% at 52 weeks respectively. These increases at 52 weeks old were about 673.2% and 2090.8% over their respective weights at 2 weeks old. The bone tissue also increased to about 220.7% at 52 weeks old over the weight at 2 weeks of age, but decreased from 17.4% E.B.W. at 2 weeks to 9.8% E.B.W. at 52 weeks of age.

At 2 weeks old, muscle was the largest tissue, followed by bone, while fat was the least. The bone grew at a low impetus rate, muscle at intermediate rate and fat at high impetus rate so that at 52 weeks of age, fat became the second largest tissue and bone the least.

Male goat kids entered the rapid fattening phase later in life (about 43 weeks of age) and at heavier liveweight (about 12 kg liveweight) than the female goat kids (about 28 weeks of age and 9 kg liveweight respectively).

Résumé
Trente jeunes chèvres naines d’Afrique occidentale ont été nourries en aliments de qualité depuis 5 jours jusqu’à 52 semaines. Six animaux (3 mâles et 3 femelles) ont été abattus à 2, 8, 12, 24 et 52 semaines pour déterminer les modifications du poids vif et le développement du muscle de l’os et de la graisse. Le muscle (maigre) et la graisse exprimés en pourcentage du poids du corps vif ont augmenté de 31.8% et 3.8% à 2 semaines jusqu’à 43.2% et 14.2% à 52 semaines respectivement.

Ces augmentations à 52 semaines furent à peu près de 673.2% et 2090.8% par rapport à leur poids respectif à 2 semaines.

Le tissu osseux a augmenté à peu près de 220.7% à 52 semaines, mais a diminué de 17.4% à 2 semaines à 9.8% à 52 semaines sur base du poids du corps vif.

A 2 semaines le muscle était le plus important tissu suivi de l’os et enfin de la graisse. L’os poussait à une vitesse moindre, le muscle à un degré intermédiaire et la graisse à un taux élevé en sorte qu’à 52 semaines la graisse devint le deuxième tissu en importance et l’os le dernier.

Les jeunes chèvres mâles développèrent la graisse plus tard (environ à 43 semaines) et à un poids vif plus élevé (à peu près 12 kg de poids vif) que les jeunes chèvres femelles (à peu près 28 semaines et 9 kg de poids vif).

Introduction

The West African Dwarf goat (Fouta Djallon) is kept mainly for the provision of meat. Its capacity to produce milk is very low. They often slaughtered for meat in Nigeria from about 6 months old (6 to 8 kg liveweight) to any time later in life (8 to 20 kg liveweight). They attain mature liveweight of about 20 kg in the tropical forest belt, tending to be larger as the savannah zone is approached (5). The usefulness of the West African Dwarf (WAD) goat as meat type animal makes it necessary to understand their growth pattern in order to highlight the developmental sequence of the three major carcass tissues, lean muscle, bone and fat, relating the higher proportions of the more desirable components of the carcass at the expense of the less valuable ones. It is well known that only high amounts of lean muscle command higher prices because it is most desired by the consumer. Therefore, for economic reasons, it is necessary that the production and slaughter of the WAD goat for market should coincide with the period the carcass has a maximum of muscle, a minimum of bone and optimum amount of fat. Most studies so far reported on the body composition of ruminant animals have been made on exotic breeds of sheep and cattle (2,6,10). There is little known of the physical composition and growth of the carcass of the WAD goat from birth to maturity. The present study was designed to pro-
vide information on the growth pattern of the major carcass
tissues namely, lean muscle, bone and fat of the WAD goats
maintained on good plane of nutrition from 5 days to 52
weeks of age.

Material and Methods

Thirty WAD goat kids were obtained from the University of
Ibadan Teaching and Research Farm at 5 days of age after
they had suckled their dams to obtain colostrum.
They were separated into two groups consisting of 15 males
and 15 females to avoid indiscriminate mating at later age.
The management of the two groups of experimental animals
was the same.

| TABLE 1 |
| Ingredient and Chemical Composition of Pre- and Post-weaning
| creep feeds |

<table>
<thead>
<tr>
<th>Ingredient (%)</th>
<th>Pre-weaning feed</th>
<th>Post-weaning feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassava flour</td>
<td>31.5</td>
<td>39.0</td>
</tr>
<tr>
<td>Soybean meal (meal)</td>
<td>40.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Brewers grain</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Sucrose</td>
<td>2.5</td>
<td>-</td>
</tr>
<tr>
<td>Glucose</td>
<td>5.0</td>
<td>-</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>0.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Mineral / Vitamin Mix</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td></td>
</tr>
</tbody>
</table>

| b. CHEMICAL COMPOSITION |

<table>
<thead>
<tr>
<th>Constituent (%)</th>
<th>Pre-weaning feed</th>
<th>Post-weaning feed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>54.5</td>
<td>95.0</td>
</tr>
<tr>
<td>Crude protein (N x 6.25)</td>
<td>19.7</td>
<td>18.6</td>
</tr>
<tr>
<td>Ether extract</td>
<td>7.0</td>
<td>9.0</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>7.4</td>
<td>8.0</td>
</tr>
<tr>
<td>Ash</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Organic matter</td>
<td>91.0</td>
<td>91.5</td>
</tr>
<tr>
<td>Nitrogen free extractives</td>
<td>56.9</td>
<td>55.7</td>
</tr>
<tr>
<td>Gross energy (Kcal/100g)</td>
<td>384.1</td>
<td>410.4</td>
</tr>
</tbody>
</table>

From 5 days to 2 weeks of age, the kids were fed to satisfy
with fresh cow milk warmed to 37°C thrice daily (0800 and
1300 and 1800 hrs). From 2 weeks of age the milk diet was supple-
mented with pre-weaning creep feed (Table 1) and
chopped giant star grass (Cynodon nlemfuensis var
Robustus) ad libitum. A gradual withdrawal of milk from the
diet of the kids was embarked upon during the 5th week of
life. This was accomplished by feeding the kids with warmed
milk twice daily (0800 and 1300 hrs) for the first 4 days and
once daily (0800 hr.) for the last 3 days of week five. By the
end of the 5th week, milk feeding was completely stopped and
all kids were on pre-weaning creep feed and chopped
grass. All animals had free access to salt lick and fresh water.
From the 13th week of age, the pre-weaning creep feed was
replaced with post-weaning feed (Table 1).
Six animals (3 males and 3 females) were serially slaughtered
at 2, 8, 12, 24 and 52 weeks of age to study the growth of
lean muscle, bone and fat in the carcass.

Slaughter method

A day prior to slaughtering, all animals to be slaughtered
were weighed to obtain their liveweight. They were then sub-
jected to an 18 hr. fast, weighed and then slaughtered,
dressed, chilled and then dissected according to the stan-
dard muscle groups (4). Briefly, this involved separation of the
right side of the carcass into its individual muscle groups,
associated bones and four major fat depots (intermuscular,
subcutaneous, kidney and channel).

Analytical procedure

All dissected lean muscle, bones and fat were weighed ac-
cording to their anatomical locations, then combined, weighed
and multiplied by two for subsequent calculations of
total lean muscle, bone and fat.
The growth coefficients for the lean muscle, bone and fat were estimated by the use of the allometric growth equa-
tion, \( Y = aX^b \) (2).

Where \( Y \) = the respective tissue weight (or part); \( X \) = the cor-
responding weights of muscle plus bone (or whole); \( a \) = in-
tercept; \( b \) = the growth coefficient of the respective tissues.
Date obtained from this study were subjected to analysis of
variance. Significant differences were estimated by the use of
Duncan’s multiple range test (13).

Results

The growth of the WAD goats at the five different stages is
presented in Table 2. The mean liveweight at 52 weeks of
age was 13.8 ± 0.37 kg. The empty body weight (E.B.W.),
the dressing out percentage and all carcass tissues studied
increased with advancing age. Lean muscle increased from
566.7 ± 20.27 g (31.8% E.B.W.) at 2 weeks to 4382.0 ±

| TABLE 2 |
| Liveweight and weights to certain body components of the West African Dwarf goat as affected by age. |

<table>
<thead>
<tr>
<th>Parameters</th>
<th>2 weeks</th>
<th>8 weeks</th>
<th>12 weeks</th>
<th>24 weeks</th>
<th>52 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liveweight at slaughter (kg)</td>
<td>1.95±0.09</td>
<td>5.50±0.07</td>
<td>6.24±0.12</td>
<td>8.66±0.29</td>
<td>13.77±0.37</td>
</tr>
<tr>
<td>Empty body weight (E.B.W.) (kg)</td>
<td>1.78±0.02</td>
<td>4.65±0.07</td>
<td>5.15±0.05</td>
<td>6.49±0.28</td>
<td>10.15±0.31</td>
</tr>
<tr>
<td>E.B.W. as % of liveweight (%)</td>
<td>91.28</td>
<td>84.50</td>
<td>83.53</td>
<td>73.57</td>
<td>73.25</td>
</tr>
<tr>
<td>Dressing-out percentage (%)</td>
<td>46.95±0.40</td>
<td>47.49±0.26</td>
<td>47.62±0.60</td>
<td>48.11±0.61</td>
<td>48.53±0.67</td>
</tr>
<tr>
<td>Total lean muscle (side tissue x 2) (g)</td>
<td>566.72±20.27</td>
<td>1795.24±36.63</td>
<td>2125.69±18.69</td>
<td>2763.01±129.90</td>
<td>4382.51±158.62</td>
</tr>
<tr>
<td>As % of E.B.W. (%)</td>
<td>31.8±0.46</td>
<td>38.62±0.33</td>
<td>41.28±0.13</td>
<td>42.57±0.18</td>
<td>43.15±0.28</td>
</tr>
<tr>
<td>Total carcass bones (side tissue x 2) (g)</td>
<td>294.43±14.49</td>
<td>601.32±22.22</td>
<td>616.99±4.29</td>
<td>706.34±29.24</td>
<td>944.37±30.23</td>
</tr>
<tr>
<td>As % of E.B.W. (%)</td>
<td>17.43±0.13</td>
<td>13.69±0.06</td>
<td>11.98±0.03</td>
<td>10.88±0.05</td>
<td>9.80±0.03</td>
</tr>
<tr>
<td>Total dissectible fat (side tissue x 2) (g)</td>
<td>64.75±6.03</td>
<td>189.64±4.75</td>
<td>268.04±9.37</td>
<td>564.67±25.90</td>
<td>1418.54±65.87</td>
</tr>
<tr>
<td>As % of E.B.W. (%)</td>
<td>3.76±0.21</td>
<td>4.24±0.05</td>
<td>5.2±0.18</td>
<td>8.61±0.71</td>
<td>14.16±2.37</td>
</tr>
<tr>
<td>Muscle: Bone ratio</td>
<td>1.93±0.07</td>
<td>2.95±0.03</td>
<td>3.45±0.02</td>
<td>3.91±0.06</td>
<td>4.41±0.05</td>
</tr>
</tbody>
</table>

*Empty body weight (E.B.W.) = Live weight at slaughter minus the gut contents.
TABLE 3

<table>
<thead>
<tr>
<th>Age of goat kids</th>
<th>Live weight at Slaughter (kg)</th>
<th>Total loin muscle (g)</th>
<th>Total carcass bones (g)</th>
<th>Total dissectable fat (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>males</td>
<td>females</td>
<td>males</td>
<td>females</td>
</tr>
<tr>
<td>2 weeks</td>
<td>1.98</td>
<td>±0.10</td>
<td>1.91</td>
<td>±0.15</td>
</tr>
<tr>
<td>8 weeks</td>
<td>5.56</td>
<td>±0.04</td>
<td>5.40</td>
<td>±0.10</td>
</tr>
<tr>
<td>12 weeks</td>
<td>6.25</td>
<td>±0.25</td>
<td>6.18</td>
<td>±0.15</td>
</tr>
<tr>
<td>24 weeks</td>
<td>9.15</td>
<td>±0.15</td>
<td>9.58</td>
<td>±0.58</td>
</tr>
<tr>
<td>52 weeks</td>
<td>14.35</td>
<td>±0.33</td>
<td>13.16</td>
<td>±0.17</td>
</tr>
</tbody>
</table>

**Discussion**

The fastest growth rate of about 79 g/day by the goat kids was obtained at between 2 and 8 weeks of age. Values on the rate of gain after birth are extremely limited for goats. A range from 18 g/day for native goats to over 200 g/day post weaning for improved breeds on high plane of nutrition has been reported (9).

Results obtained for post weaning growth rate in this study were about 28 g/day for goat kids between 12 and 24 weeks of age and 27 g/day for those between 24 and 52 weeks of age. Differences among breeds in size at maturity, as well as other factors affect growth rate (9). The WAD goat a part from being small in size even at maturity, is a slow growing animal (9), reaching a mean live weight of only about 13.8 kg in 12 months in the present study.

This compared favourably with the live weights reported for small breed of goats at the same age: 12.9 kg for WAD goat of Ghana (11), 13.0 kg for Black Bengal goat of India (7), or about 14.0 kg for Barbari goat (medium breed) of India (12). Limited information shows the goat is not a strong competitor to lamb and beef because it does not excel in rate of growth or rate of gain (9). Nevertheless, the goat will obviously continue to be exploited by man in most of its current habitats for cultural and economic reasons.

The dressing out percentages changed very little with age from 46.96 ± 0.40% to 48.53 ± 0.67%. Many factors like age, sex, breed, level of feeding etc. are known to affect the dressing out percentage (6). The E.B.W. increased progressively with age, but when expressed as the percentage of live weight, E.B.W. showed consistent decrease from 91.3% at 2 weeks to 73.6% at 52 weeks of age. This is indicative of the fact that the digestive tract and its contents were increasing at a faster rate than the live weight. Early in life (2 weeks old), lean muscle comprised the major component of the carcass, then followed by the bone, while fat was the least. Later in life (52 weeks), lean muscle (673.2% increase) still comprised the major component of the carcass, followed by fat (2090.8% increase), while the bones became the least (220.7% increase). Information in the literature mostly from sheep and cattle show that muscle comprised the highest percentage of the carcass at birth, then followed by fat and that bone at no stage exerted a dominant role in the determination of the relative proportions of the three major tissues (3). Again at comparable E.B.W., lambs laid about 3.5 times more fat in the carcass than goats and lambs on similar feed appeared to lay on more fat than goats. Also at the best mar-

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**TABLE 4**

<table>
<thead>
<tr>
<th>Component (%)</th>
<th>Regression Coefficient (b)</th>
<th>Standard Error (SE)</th>
<th>Correlation Coefficient (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscle</td>
<td>-0.456</td>
<td>1.100</td>
<td>.004</td>
</tr>
<tr>
<td>Bone</td>
<td>0.322</td>
<td>0.718</td>
<td>.011</td>
</tr>
<tr>
<td>Fat</td>
<td>-2.896</td>
<td>1.586</td>
<td>.047</td>
</tr>
</tbody>
</table>

* = (P<0.01)
Kicking age goat meat is low in flavour, juiciness and tender-
ness compared to lamb and beef (8).

All of the above characteristics should explain in part why
there is basic variation in the proportions of fat in the car-
casses of goats compared with those of sheep and cattle
early in life.

Sex influence on the relative growth of carcass muscle, bone
and fat showed that male goat kids at 52 weeks old had
more (P < 0.05) lean muscle and bone than the females pro-
bably due to effect of gonadal androgen in the males which
is necessary to complete a full pattern of muscle develop-
ment (3). The female goat kids significantly (P < 0.05) ex-
ceeded the males in accretion of fat in the carcass and also
entered the rapid fattening phase earlier. The rapid fattening
phase refers to the period when carcass fat equals the bone
tissue in weight, being about 28 weeks of age (9.02 kg
liveweight) for the females and about 43 weeks of age (12.06
kg liveweight) for the males. The male goat kids thus, had
better desirable component of the carcass in terms of lean
meat yield, entering the rapid fattening phase later and en-
sabling them to reach optimum slaughter weight at heavier
liveweight. The WAD goat farmer can thus utilize these
growth advantages to either manage entire male goat kids
in a fattening programme for a market situation or feed ani-
mals of each sex in a manner appropriate to their growth
characteristics to achieve the best combination of slaughter
weight and carcass composition.

Due to early development of bone and later development of
muscle, the ratio of lean muscle to bone at 2 weeks of age
was about two parts of lean muscle to one part of bone.
During subsequent growth, bone tissue grew at a steady but
slow rate and muscle at a relatively fast rate so that at 52
weeks of age, the ratio increased to about four parts of lean
muscle to one part of bone. The results from the application
of the allometric growth equation, Y = aX^b, (1) further sub-
stantiated the above statements.

Thus, the growth coefficient for bone was below one (0.72)
and which infers that the bone was growing at a low impetu-
sus rate, intermediate for muscle (1.10), which was growing
at an intermediate impetus rate and high for fat (1.59), which
was growing at high impetus rate.

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