THE EFFECTS OF PLANE OF NUTRITION ON POST - WEANING GROWTH AND DEVELOPMENT IN YANKASA SHEEP

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THESIS APPROVAL

This thesis by Dr. Clarence A. Mawo Lakpini meets the regulations governing the award of the degree Masters of Science (Animal Science) of Ahmadu Bello University and is approved for its contribution to scientific knowledge and literary presentation.

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A B S T R A C T

24 weaned Yankasa lambs (12 males and 12 females) aped between 6 and 9 months and weighing between 10.3 kg and 27. 8 kg were used for the experiment. The animals balanced for weight were randomly alloted to four treatments with each treatment consisting 3 ram - and 3 ewe - lambs.

The four treatments were designated High-high (HH), High-low (HL), Low-high (LH) and Low-low (LL) respectively depending on the protein level in each ration. The HH and LL groups received high protein ration (12.1% crude protein) and low protein ration (ff.1%)crude protein) respectively for the entire period of the experiment. The HL and LH grOUPS received high protein ration and low protein ration during the first 100 days of the experiment but were switched over to low and high protein rations respectively for the remaining 84 days of the experiment,

The daily feed intake of each pen was determined. All the animals were weighed fortnighly.Two digestibility trials were carried out during the first half and two in the second half of experiment usinp the male animals.

At the end of the experiment, all the animals were slaughtered, dressed and jointed into 9 cuts. Each cut was completely dissected into muscle, fat and bone.

During the first half of the experiment, the animals on high protein diet treatment consumed less feed than those on low protein diet. After the change-over (Days 100 to 184), the LH animals, consumed more feed than, the HH animals. HL animals also had a higher feed intake than animals on LL treatment. For the entire period of the experiment, LH and HL animals consumed more feed than HH and LL animals respectively. The feed intake of the males was higher than that of the females throughout the period of experiment.

The drymatter, nitrogen and energy digestibility coefficients of the high protein ration were higher than those for low protein ration during the first half of the experiment but at the point of change-over (3rd digestibility trial), the low protein ration had higher drymatter and energy digestibility coefficients while there was no significant difference between the two rations in nitrogen digestibility. During the 4th digestibility trial which was conducted towards the end of the experiment, the hifrh protein

ration had higher digestibility of drymatter, nitrogen and energy than the low protein ration.

The efficiency of utilization of drymatter, crude protein and energy war, higher in the bigh protein diet treatments than in the low protein diet treatments. The overall efficiency of drymatter and energy utilization was highest for HH animals followed by the LH group while animals on LL treatment were least efficient. LH animals had the highest efficiency of crude protein utilization.

The high protein diet had about 3.3 times as good feed conversion as the low protein diet. LH and LL animals had a better feed conversion than animals on HH and HL treatments respectively during the second half of the experiment. In all, HH animals had the best feed conversion, followed by LH animals while animals on LL treatment had the lowest feed conversion. The males had a better feed conversion than the female animals throughout the experiment.

The cost of feed per kg liveweight gain for animals on low Protein diet was N2.1 more than for those on high protein diet during the first half of the experiment. HH animals cost N0.3 more than the LH group in Producing 1 kg liveweight pain durinp the second half.

However, on the whole, it cost N0.1 more in LH animals per kg liveweight gain than in HH animals. LL animals had the highest overall cost of production per kg liveweight gain while HL animals cost N0.4 more than the LH group in the production of 1kg liveweight gain.

The carcass weight of HH and HL animals were 1.2 times higher than those of animals on LH and LL treatments respectively. The dressing percentage, percents total fat and total muscle were higher in the high protein ration than in the low protein ration. Animals on HH treatment had 4.5% more Percentage of total fat than LH animals while HL animals had 3.1% more percent total fat than the LL groun. Also, relative to the carcass weight the LH animals had more muscle than the HH group. Thus, the LH animals proportionately had more muscle and less fat than the animals on HH treatment. There was more percentage of total muscle and total fat in the males than in the female animals.

A C K N O W L E D G E M E N T

Before any detailed research work can come to a successful conclusion, it is usual that expert assistance comes from experienced skilled personnel. This study has not been an exception in this regard.

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Sheep have an annual off-take of 25% (Adu, 1980). The increase in human population with its attendant increase in taste and affluence will put more pressure on the demand for meat in Nigeria. The comparative advantages of sheep or goat over other stock (Adu, 1980) emphasise the need to develop the small ruminant industry to enhance the country's self sufficiency in animal protein production and improvement in the quality of life of her people.

In Nigeria, sheep is reared primarily for meat. Hence, litter size or the number of lambs weaned as well as liveweight gain are considered to be the important traits. Growth rate depends on the environment, especially the nutritional component and its interaction with genotype. Animals grow rapidly when young until they approach physical maturity when growth rate decreases. Beyond this point, weight gain is due primarily to fat deposition. Nutrition is, perhaps the single factor that greatly influences growth rate.

In Nigeria, a major proportion (95% cattle, 75% goats and 70% sheep) of livestock is raised in the Savannah and Sahel regions where the quantitative and

qualitative availability of pasture vary considerably with season (ILCA, 1978). The severest period is the dry season when nutritionally deprived animals suffer retardation in growth. During the rainy season when more food is available, the animals resume a rapid rate of growth. The mechanism by which nutritionally deprived animals assume rapid growth rate when placed on an adequate nutrition to make up for their retarded growth during the period of deprivation is what the "compensatory growth" phenomenon attempts to elucidate.

This work is therefore designed to simulate this natural phenomenon by manipulating feeding management to investigate some aspects of energy and protein intake and the efficiency of their utilization for liveweight gain by Yankasa lambs.

CHAPTER I - LITERATURE REVIEW

CHAPTER 1

LITERATURE REVIEW

1.1. AN APPRAISAL OF STATE OF KNOWLEDGE ON COMPENSATORY GROWTH

Compensatory growth has been described as the phase of rapid growth, greater than normal or control growth rate, associated with adequate nutritional realimentation of animals, following a period of weight loss caused by undernutrition (Thornton, Hood, Jones and Re, 1979).

This phenomenon whereby an animal shows rapid growth rate relative to its age, was first observed by Osborne and Mendel (1915) but it was termed "compensatory growth" by Bohman, 1955. Prior to then, Ragsdale (1934) distinguished the effect of nutrition on the relationship between chronological age and physiological age, where he observed that the plane of nutrition affects physiologic ageing more than chronologic ageing. While undernutrition inhibits the rate of physiologic ageing, realimentation appears to spur the animal to grow in line with its physiologic

rather than chronologic age (Winchester and Ellis, 1957).

The relative extent to which different parts of the body respond to undernutrition and realimentation, determine the conformation and composition of the animal and its carcass respectively. Undernutrition suppresses the growth and development of the late maturing tissue and regions of the body more than the early maturing parts (Sussan, 1961; Needham, 1964).

1.2 FACTORS INFLUENCING RECUPERATIVE ABILITY

Several workers (Bohman, 1955; Winchester and Ellis, 1957; Wilson and Osbourn, 1960; Meyer and Clawson, 1964; Reid, Bensadoun, Bill, Burton, Gleeson, Han, Joo, Johnson, McManus, Paladines, Strond, Tyrrell, Van Niekerk and Wellington, 1968; Morgan and Owen, 1972a; Graham and Searle, 1975; and Thornton, Hood, Jones and Re, 1979) on compensatory growth have reported a wide range of observations on animals of the same species, following realimentation, after nutritional deprivation. Many factors which influence the recovering ability

of an animal from undernutrition are responsible for most of the variations in the results and observations of these workers. The following have been identified to influence the recovery of an animal from undernutrition:

(a) The nature of undernourishment:

The degree of response of an animal to undernutrition depends on what nutrient(s) is/are absent or deficient in the ration. However, the most important nutrients whose deficiency either singly or together gravely inhibit the growth of the soft tissues of an animal in particular and the entire animal in general, are energy and protein. There is some controversy as to whether energy or protein is more important for growth. Maynard and Loosli (1962) stated that energy requirement constitutes the largest of all the various nutrients needed for growth and it also governs the total food allowance. This idea seems to be supported by Blaxter (1962) who said that the caloric need of an animal is primarily linked to the requirements of other nutrients.

On the other hand, Winchester, Hiner and Scarborough (1957) and Wilson and Osbourn (1960) were of the view that very severe protein restriction may have more harmful effect than very severe energy restriction. This is because the body has little protein deficiency will result in the depletion of active tissues, resulting in a possible irreparable damage to the tissues. Nonetheless, Winchester, Hiner and Scarborough (1957) have demonstrated that it is possible for calves to completely recover after severe restriction of either dietary energy or protein. From these views, one can infer that for maximum metabolism and utilization of protein, an adequate amount of energy should be available while an adequate amount of protein is required to lay down muscle in the growing animal (Peterson, Hatfield and Garrigus 1973; and Olatunji, Mbah, and Olubajo, 1976).

(b) <u>The severity of undernutrition</u>:

The severity of undernutrition depends on the extent to which the nutrient content of the feed falls short of the requirements of maintenance and growth.

Hogan (1929) demonstrated that cattle placed on the severest nutritional restriction had the highest initial liveweight gain after realimentation while the least deprived attained the highest final weight.

(c) The duration of undernutrition:

The duration of undernutrition has an indirect relationship with the rate and extent of recovery. Hogan (1929) observed that the greatest weight gains and greatest ultimate mature weights, after realimentation, were attained by those cattle subjected to the least duration of undernutrition.

(d) The developmental stage of the animal:

The liveweight of an animal at the commencement of undernutrition, rather than its age, is indicative of this factor. The more mature animals have been shown (Black, Queensberry and Baker, 1940; Joubert, 1954; Bohman, 1955; Winchester and Howe, 1955) to show greater recovery from realimentation following nutritional restriction.

(e) The relative rate of maturation of the animal:

Different species and breeds of animals mature at different rates.

Slow maturing cattle have been observed (Wilson and Osbourn, 1960; Joubert, 1954; Winchester and Howe, 1955) to recover more rapidly than fast maturing ones indicating that the former have a better recuperative capacity.

(f) Nutritional plane during realimentation:

The rate and extent of recovery are also influenced by the plane of nutrition when realimented. Those animals placed on a high plane of nutrition make a more rapid and greater recovery (Bohman, 1955; Heineman and Van Keuren, 1956).

From the above discussion, it would seem that the recuperative capacity of a realimented animal, following nutritional deprivation, results from an interplay of a number of factors. In summary, an animal which has a high recuperative capacity to fully recover from undernutrition, followed by realimentation will appear to be that which is mature, grows slowly, has suffered from energy rather than protein deficiency, has undergone mild and short period of undernutrition and has been fed a high plane of nutrition during realimentation.

1.3 MECHANISM OF RECOVERY:

While there appears to be a consensus on the rate of recovery of realimented animals from nutritional deprivation, there is an apparent controversy on the mechanism and composition of recovery.

Nutritionally deprived animals have a lower intake of either quantity or quality of feed or both. McManus, Reid and Donaldson, 1972; Graham and Searle, 1975; and Thornton *et al.* 1979, observed that on the first day of realimentation, restricted animals consumed as much as three to four times their daily consumption rate during the period of undernutrition. From the 2nd day of realimentation, the feed intake declined, but for several days thereafter, the digestive capacity remained high with a consequent high digestible dry matter intake. The results of Orskov, McDonald, Grubb and Pennie,(1976), in contrast showed that there was no significant difference in the consumption rate of lambs when they were changed over from low protein to high protein.

A similar result was obtained by Winchester and Howe (1955). On the other hand, Andrew and Orskov (1970a) observed that sheep have a tendency to consume more feed as the protein content increased. However, Sheehy and Senior (1942) demonstrated that the quantity of food saved during restriction, was less than the additional feed requirement by the restricted groups to attain the same weight as the unrestricted groups.

The reports of Sheehy and Senior (1942); Quimby (1948); Winchester and Howe (1955); Osbourn and Wilson (1960), indicate a sifnificant increase in the appetite of animals during realimentation.

The capacity of the alimentary tract is more related to the chronological age rather than the physiological age of an animal and so its development has been shown (Wallace, 1948; Palsson and Verge, 1952a) not to be significantly affected by plane of nutrition. It will therefore seem that the growth of gastrointestinal tract is not greatly influenced by plane of nutrition.

However, this view is at variance with the observations of Ragsdale (1934); Winchester and Ellis (1957) who reported that growth was in line with physiologic age which depended on the plane of nutrition. Burton, Andrews and Reid (1974) observed about 56% increase in the gastrointestinal tract of realimented lambs over the unrestricted control animals.

McManus *et al.* (1972); Graham and Searle (1975) have reported a lower digestibility of feeds for animals undergoing compensatory growth than for the restricted controls. Waters (1908) and Quimby (1948) observed a higher digestibility in animals on a low plane of nutrition and extending into the period of realimentation. Complementarily, Mitchell and Hamilton (1932), Blaxter, Graham and McC (1955), Showed that digestibility decreased as the nitrogen-free extract and ether extract content of the ration increased with increased feed intake. Forbes, Braman and Kriss (1928, 1931), reported that there was decreased digestibility only when the food intake was extremely high or low in energy content.

The change in digestibility along with variation in energy intake was attributed to the rate of passage of food through the gastro-intestinal tract rather than the level of consumption *per se* (Forbes, Braman and Kriss, 1928, 1931; Blaxter, Graham, McC and Wainman 1955). On the other hand, Sheehy and Senior (1942) did not observe any difference in digestibility for both the restricted and realimented periods of their experiment.

The results of Moulton, Trowbridge and Haigh (1922) and Watson (1943) have shown that the efficiency of conversion of feed energy into calorie content of edible meat and the rate of weight gain are directly related. The animals that had the highest growth rate were shown to be the most efficient at any stage of development. Watson (1943) also concluded that there was a decrease in the life time efficiency of food conversion of an animal that suffered a period of nutritional deprivation at any time of its life.

The period of nutritional restriction in animals has been emphasised by Murray (1922) to be a period of inefficient utilization of body fat to maintain the animal. He calculated a 44% loss in the efficiency of utilization of body fat in restricted animals.

Palsson and Verges (1952); and Wilson (1957), observed that the period of growth of animals which have been either intermittently or continuously undernourished followed by realimentation, was prolonged over those with continuous adequate nutrition. On the other hand, Sheehy and Senior (1942) showed that it took the severely restricted animals between 25 and 45 days extra to reach slaughter weight than unrestricted animals. This extra time connotes extra labour and delay in turning the animals into the market.

Divergent views have been expressed to explain the increase in rate of weight gain during realimentation. McMeekan (1940) concluded from his experiment with pigs that the apparent increase in the rate of gain of realimented animals was due to an increase in gut content.

Other workers (Winchester and Howe, 1955; and Taylor, Alder and Rudman 1957) observed that there were substantially greater weight gains in the empty carcass of realimented cattle than those on continuous growth rate. Moreover, in practice, before animals are slaughtered, they are starved for 12 to 24 hours thus making the difference in weight due to gut content insignificant at slaughter. No doubt, the increase in gut content can exaggerate the weight gain in realimented animals but there is still some substantial weight gain.

Due to lower body weight and reduced activity of nutritionally restricted animals (Brody, 1945), such animals have less maintenance requirements than the unrestricted controls (Sheehy and Senior, 1942). This makes more net energy of food available to the animals for compensatory growth (Trowbridge, Moulton and Haigh, 1915; Hogan, Salmon and Fox 1922; Meyer and Clawson, 1964; Reid *et al.* 1968; Morgan, 1972; Graham and Searle, 1975) thus improving the efficiency of feed utilization.

The basal metabolism of animals declines as the energy intake falls (Hogan, 1929; Blaxter and Wood, 1951). A nutritionally deprived animal, upon realimentation gradually raises its basal metabolism to a level comparable to that of a continuously adequately fed animal. This makes the high efficiency of food utilization temporal, until the basal metabolism becomes normalized.

In comparing rate of weight gains between restricted animals which were then realimented, with unrestricted controls, and correcting for the reduced maintenance requirement of the restricted animals, Steensberg (1947); Winchester and Howe (1955), observed a greater and more efficient weight gain in the realimented animals than in the controls.

There are less calories involved in the formation of muscular tissue than for an increase of the same weight of adipose tissue. On the basis of this therefore, Haecker (1920); Sheehy and Senior (1942); Steensberg (1947); and Reid, Wellington and Dunn (1955) suggested that for animals of the same weight, proportionately

more muscle and less fat were formed in the realimented animals than in the unrestricted controls. However, some other workers (Wilson, 1960; Wilson and Osbourn, 1960) observed that realimented animals had more body fat than the unrestricted controls. This disparity in results may be due to a difference in the stage of development of the animals used, the intake, digestibility and utilization of the feed used for realimentation.

1.4 CARCASS COMPOSITION AND QUALITY:

High liveweight gain during compensatory growth has been reported by many workers (Hogan, 1929; Bohman, 1955; Winchester *et al.* 1957; Wilson and Osbourne, 1960; and Thornton *et al.* 1979). However, opinions markedly vary in the relative contributions made by the anatomical and biochemical components, especially fat, protein and water of the carcass. While Wilson and Osbourn (1960) concluded that the effect of compensatory growth appeared to have increased the fat content of the body, some others (Reid *et al.* 1968; Keenam and McManus 1969; Drew and Reid, 1975) observed a substantial increase in protein

deposition in sheep as a result of compensatory growth.

Thornton *et al.* (1979) reported that even though starved immature sheep lost weight, there was significantly less proportion of fat, water and protein in their carcass than in well fed sheep. Burton *et al.* (1974) also concluded that lambs which were nutritionally deprived and then realimented had less energy and fat but more water and protein than those with continuous growth.

(a) Fat Content:

In both the mature and immature starved sheep, there was proportionally less fat mobilized from the meat (muscular plus subcutaneous fat) than from the offal. This is especially so in mature sheep (Thornton *et al.* 1979). On the other hand, Russel, Gunn and Doney (1968) found that both the offal and meat fat were mobilized to a similar extent.

The fat depths at the 8th - 9th and 12th - 13th ribs increased linearly as the carcass weight increased.

The proportion of subcutaneous and intermuscular fat deposited in the trunk (thorax, flank and loin) of carcass either did not change or increased with increase in the total carcass fat while that in the limbs decreased (Atkins and Thompson, 1979; and Thompson, Atkins and Gilmour, 1979 a, b).

Increase in fat deposit is a result of hyperplasia and/or hypertrophy. Between the ages of 7 and 11 months, increase in fat deposit in sheep has been observed to be due to increase in the adipocytes (hyperplasia) while beyond that age, it is due to increase in the size of the adipocytes (hypertrophy). The weight of fat in boneless carcass was further observed to be reduced by starvation in live animals due mainly to a decrease in the size of the adipose cells (Hood and Thornton, 1979).

Burton *et al.* (1974) observed that the size of adipocytes in realimented lambs was smaller than in the continuously grown control. They further concluded that there was a more rapid utilization of fat and energy in partially restricted lambs than their deposition during

(b) Protein content:

Starved sheep lose not only body fat but also protein (Thornton *et al.* 1979). Mature animals incurred more loss of body fat than protein when starved, while in immature animals fat and protein were lost to a similar degree. Thornton *et al.* (1979) reported that animals generally mobilize body fat reserves for oxidation to provide energy under conditions of undernourishment or nutritional deprivation. The carcass crude protein content of lambs that were nutritionally restricted and then realimented was found to be significantly ($P<0.01$) lower than lambs that had continuous and *ad libitum* feeding (Morgan and Owen, 1972b). Conversely, when nutritional restriction was imposed at the final stage of finishing at a liveweight of about 35 kg, there was an increase in carcass crude protein content (Morgan and Owen, 1972b).

(c) Water content:

The water component of carcass from live sheep subjected to different planes of nutrition also vary (Orskov *et al.* 1976).

The water content in the carcass meat of starved mature sheep was less, though not significantly so, than that of unstarved control. The change from low-protein diet to high-protein diet resulted in an increase in the rate of accretion of body water content (Orskov *et al.* 1976; and Thornton *et al.* 1979).

Burton *et al.* (1974) observed that the rate of water retention was higher for partially restricted lambs than either realimented or the continuously grown lambs.

(d) Relationship between water, fat and protein in carcass:

The reports of Orskov *et al.* 1976; and Thornton and Re, 1975, show that there was more fat than water in the meat of a carcass weighing 50 kg or more while the fat to protein ratio in the meat was about 5 to 1. The percentage of water in the meat of the unrestricted sheep ranged from 39.5 to 70.1 while for the realimented animals it was between 55.55 and 49.3. Starved immature sheep lost about twice as much water as fat while the loss of fat and water

were about the same for the starved mature sheep. Similar amounts of fat and protein were lost in starved immature sheep while about twice more fat as protein was lost in the mature starved sheep. The carcass of lambs fed on a low protein diet had a consistently lower ratio of water to protein than those fed on a high protein as the dietary level rose in lambs up to 40 kg liveweight while the reverse occurred in lambs between 40 kg and 70 kg (Orskov *et al.* 1976).

There was a rapid accretion of fat, protein and water in the body as a spontaneous sequel to a change of diet from low to high protein. There was however, no marked variation in the ash content of lambs following this change (Orskov *et al.* 1976).

Tulloh (1963); and Reid *et al.* (1968) concluded that there is a relatively strong link between the weight of ruminants maintained on positive nitrogen and energy balance and the weight of the energy, fat, water and protein contents of their bodies.

Reid *et al.*.(1968); Burton and Reid (1969) reported that plane of nutrition, protein - energy ratio, frequency of feeding and age had little influence on either full-body - weight (FBW) or empty - body - weight (EBW). However, Orskov, Hayes and Penn (1971) held the view that the dietary protein consumed by growing lambs, especially during early growth can influence carcass protein content which in addition to water are the most sensitively influenced body components.

It is possible to precisely predict body water or fat from the highly significant prediction equations for body component and weight derived by Reid *et al.* (1955); and Reid *et al.* (1968).

1.5 ENERGY AND PROTEIN METABOLISM AND RELATIONSHIP

(a) Energy metabolism in ruminants:

The nutritional requirements of an animal should satisfy the body needs for maintenance, activity and production. Much work has been done to determine the nutritional requirements of temperate animals and to establish feeding standards,

Due to differences in breed and environmental conditions, it will be unrealistic to base ration formulation for tropical animals on temperate standards without some corrections for size and environmental conditions.

Mitchell (cited by Cramoton and Harris, 1968), formulated an equation for estimating maintenance requirement for energy, based on the basal metabolic rate with an addition of 25 percent for larger animal species and 50 percent for smaller animal species. Since the basal metabolic rate for different breeds within a species vary considerably under different local environments, these percentages will vary.

The tropical breeds of animals have been adapted to high environmental temperatures, parasites, disease and relatively more fibrous forages than temperate animals. Breeds of sheep indigenous to the tropics generally have a coat of hair or coarse wool and hence require minimum energy to get rid of excess heat from their body.

The metabolic energy that is used in temperate breeds to combat the cold of winter (Adeneye and Oyenuga, 1976a; and Ferrel, Kohlmeier, Grouse and Hudson Glimn 1978) and to grow wool (Adeneye and Oyenuga, 1976a) is a spill-over of the maintenance requirement which is harnessed for production in the tropical breeds. Consequently, the dry matter and metabolizable energy intake may be lower for tropical breeds than for temperate breeds.

Adeneye and Oyenuga (1976a) reported that West African dwarf sheep consumed $67.7/Wkg^{0.73}$ dry matter per day to gain 302g/day on the average while Preston, Schnakenberg and Pfander (1955) reported wethers in the temperate region to consume $107g/Wkg^{0.75}$ dry matter per day to gain 251g/day. Adeneye and Oyenuga (1976a) therefore concluded that the West African dwarf sheep utilized feed more efficiently than their temperate counterpart of similar weight and fed similar diets. But Adu and Olaloku (1976) reported that West African dwarf sheep consuming $70.41g/Wkg^{0.75}$ dry matter gained only 118g/day.

Furthermore, Adu and Brinckman (1981) also reported that Yankasa and Uda wethers on 96.1g and 11.5g/Wkg$^{0.75}$ dry matter and crude protein respectively had 183g and 150g gain per day, while growing Yankasa ram-lambs consuming about 42g/Wkg$^{0.75}$ dry matter gained 160g per day (Ikhatua and Adu, 1981). The performance of West African dwarf sheep reported by Adeneye and Oyenuga (1976a) appears high The duration of their experiment was too short to reach definite conclusions on the efficiency of feed utilization by West African dwarf sheep. Also, due to initial response of livestock to confinement (Duncan, 1966), the daily weight gain may not be as high. Moreover, the 200% improvement in performance accounted for by only an increase of 3.1g/kg metabolic weight between two of their best experimental rations appears unrealistic.

Using West African dwarf sheep, Olatunji *et al.* (1976) observed a negative linear relationship between digestible energy on one hand and crude fibre, cellulose and hemicellulose on the other. However, digestible energy showed a positive relationship in respect of starch and soluble carbohydrates.

As the amounts of digestible carbohydrates such as starch and water - soluble carbohydrates increased, there was also increase in rumen propionic, butyric and total volatile fatty acids while the p^H and the molar proportions of acetic acid decreased. This rumen biochemical composition is more suitable for weight gain.

Ferrel, Grouse, Field and Chant (1979) did not find any difference between sexes in the intake of metabolizable energy/metabolic weight but observed a higher daily ME requirement for maintenance by rams than ewes. They obtained similar metabolic energy for gain (175 vs 176 kcal/$W^{0.75}$kg) by rams and ewes respectively. However, the energy gain was higher in ewes (63 vs 54 kcal/$W^{0.75}$kg respectively).

Burton and Reid (1969) found that sheep on high energy intake had higher amounts of body components than those on low energy intake. They also reported that the body components have a fixed relationship with the body weight irrespective of the level of energy intake.

There was a slight association between body component and age (Reid *et al.* 1968; Burton and Reid, 1969). On the other hand, Paladines, Reid, Van Niekerk and Bensadoun, (1964) observed that there was 56% greater energy concentration in the body gain of older sheep than in that of lambs.

Ferrel *et al.* (1978) observed that dietary energy intake had a significant influence on liveweight, carcass weight, and percentages of fat, protein and water in steer carcass. Increase in dietary energy intake resulted in increase in carcass fat which was responsible for the increase in liveweight.

The utilization of energy by sheep also depends on the form in which the ration is fed. Paladines *et al.* (1964) observed that there was greater energy retention in sheep fed on pelleted, ground hay than those fed chopped hay. They attributed this apparent greater efficiency of feed utilization to the higher dry matter intake in the pelleted, ground hay which reflected its better nutritive value than chopped hay.

(b) Protein metabolism in ruminants:

Protein requirement for growth is such that it should be adequate for repair, replacement and building of new tissue. The size of the animal and the rate at which new tissue is being deposited govern the amount of dietary protein requirement.

Not much work has been done to determine the protein requirement of the indigenous breeds of sheep. For maintenance, Ikhatua and Adu (1981) estimated 0.65gN/day/$W^{0.75}$kg or 0.94gCP/day/$W^{0.75}$ kg to be adequate for weaned Yankasa lambs. But for both maintenance and liveweight gain of 160g/day, they reported 1.13gN/day/$W^{0.75}$kg to be adequate.

Ruminants have the physiologic capacity of converting proteins of poor quality into meat which is a high quality protein. This special attribute of ruminants is conferred on them by virtue of the microbial organisms in their rumen.

Ammonia is the product of nitrogen metabolism in the reticulo-rumen (Pearson and Smith, 1943). There is a higher concentration of ammonia in the rumen liquour after food has been ingested and the concentration depends on:

- the amount of feed ingested per unit time.
- the solubility of the protein taken and
- the nutritional balance of the diet, all of which are related to the various stages of microbial activity in the reticulo-rumen (Orskov *et al.* 1971; and Vaz Portugal, 1972).

The high concentration of ammonia - nitrogen after a meal is due to extensive deamination of free amino acids. Vaz Portugal (1972) enumerated the factors governing the degree of protein hydrolysis in the rumen resulting in the production of free amino acids initially and then ammonia to include:

(i) protein retention time in the rumen. This is proximately linked to the physical presentation of the food particle size, form (area) and specific weight;

(ii) degree of solubility and dispersion of the protein in the rumen fluid;

(iii) degree of natural or artificial resistance of the protein to microbial attack;

(iv) degree of contact of the feed particle with microflora;

(v) level and frequency of feed ingestion by the animal;

(vi) stimulating effect of the diet on growth of the bacteria;

(vii) factors related to the physiological idiosyncrasies of individual animals with rumen microbial population.

Virually all the free amino acids are extensively catabolized due to their solubility, dispersion and also the rapid activity of deaminases. Non-protein nitrogen sources produce variable amounts of ammonia in the reticulo-rumen and also stimulate bacterial growth. All the forms of exogenous and endogenous nitrogen lead to the formation and limited synthesis of microbial protein. There is an intimate link between the concentration of urea in blood and the concentration of ammonia in the rumen (Lewis, 1957). A balance between the nitrogen sources (nature and quantity) and the energetic sources has to be reached in order

to minimize, the drawbacks due to excessive ammonia production in the rumen because the energy source provides the carbon chains utilized for the synthesis of microbial protein. The absorption rate of rumen ammonia produced can be reduced by stimulating microbial utilization pathways. A marked reduction in ammonia absorption can be achieved by:

(a) a reduction in the quantity of nitrogen matter to be ingested per time unit.

(b) delaying the hydrolysis of the nitrogen compound.

Energetic insufficiency, deficient supply of carbon skeletons, changes in cell permeability and low concentration of co-factors all control the utilization of rumen produced ammonia for amino acid synthesis. Allison (1969) observed that a high concentration of nicotine - adenine - dinucleotide (NAD) and nicotine - adenine - dinucleotide phosphate (NADP) linked to glutamic acid dehydrogenase facilitates the metabolic utilization of the ammonia produced. Glutamic dehydrogenase, alanine dehydrogenase and the

transaminases play an important role in the fixation of non-protein nitrogen (NPN) Wallenius and Palmquist,(1970).

In order to possibly curtail the drawbacks due to losses that result from the waste incurred from the breakdown of food proteins of high biological value in the reticulo-rumen, technological attempts have been made to protect these proteins against microbial attack. The processes employed are based on the following operations:

(i) accelerating the flow rate or making the food particles to have the ideal dimensions in order to reduce, to the minimum, the retention time of the food protein (Vaz Portugal, 1972).

(ii) directly passing nitrogen source into the abomasum, by-passing the reticulo-rumen, by exploiting the oesophageal groove reflex (Orskov and Benzie, 1969).

(iii) using physical, thermal or chemical treatment to diminish the solubility of the protein (Vaz Portugal,1972).

(iv) eliminating or lowering the activity of the microbial population in the reticulo-rumen so that deamination process is likewise affected (Vaz Portugal, 1972).

(v) increasing the quantity of available carbohydrate.

The utilization of the other components of the diet is affected when retention time is reduced and microbial population selected.

The conversion of food protein into microbial protein is advantageous when proteins of low biological values are fed. The hydrolysis of high biological value proteins in the rumen is wasteful interms of energy and protein, and the wastes incurred are of three types:

- non-utilizable ammonia produced;
- a higher concentration of nucleic-nitrogen which is highly digestible and absorbable but of little nutritional value;
- energy wastage in the synthesis of urea at metabolic level.

It is always a profitable process when non-protein nitrogen is converted to microbial protein. Vaz Portugal (1972) proposed an ideal combination of two mechanisms:

- the first being that a sufficient quantity of non-protein nitrogen be included in the diet so as to enhance syntheses (stimulates the growth of the micro-organisms).
- the second is to administer a protein source which is not utilizable in the rumen and yet would increase the total amino acid content available for duodenum absorption.
- increasing the level of available carbohydrate.

The metabolic products produced from the catabolism of ingested food are utilized by the microbial population to synthesise new molecules and structures to incorporate other food components into its protoplasm. When rumen p^H is within tolerable limits, the growth of protozoa prevents hydrolysis in the reticulo-rumen of reasonable amounts of starch, especially in grain based dietary systems.

Allison *et al.* (1962), and Patton, McCarthy and Griel (1968) agreed that rumen micro-organisms appear to be active in microbial lipid synthesis.

There is a general belief that 60 to 70% of the feed nitrogen is transformed into microbial nitrogen but this value could be as low as 20 to 30% of the total nitrogen for groundnut meal, zein and fish meal because of their greater resistance to microbial attack (Vaz Portugal, 1972). For sheep, Pilgrim, Weller and Gray (1970) got conversion values of 73% and 58 - 59% for low nitrogen content diets and high nitrogen content diets respectively where the percentage of conversion into microbial nitrogen is related to the total nitrogen ingested. Pilgrim's (1970) result seems to suggest that sheep depend more on ammonia nitrogen for microbial protein synthesis in low-nitrogen diet than in high - nitrogen diets. The microbial population appears to depend on the outflow of food from the rumen (Roberts and Miller, 1969).

The microbial population utilizes the reticulo-rumen ammonia and the carbon skeleton in the medium to synthesise amino acids which are later incorporated into microbial protein. Only certain strains of microbial population demand simple forms of nitrogen, mainly ammonia, for this process. During early rapid growth of sheep and other farm ruminants there is a high demand for amino acid but the microbial protein synthesis may not cope with the requirement adequately.

As a result, Vaz Portugal (1972) advocates the protection of food protein in such a way as to guarantee its direct passage to the abomasum or even protect capsulated synthetic amino acids against catabolism in the rumen.

The micro-organisms in the rumen have the capacity of synthesising sufficient amounts of all amino acids for a growth rate of 1kg/day as long as the dietary energy level is adequate (Armstrong and Hutton 1972).

Summarizing, microbial protein synthesis depends on the balance between the different

forms of nitrogen and concurrently between rates of carbohydrate catabolism and hydrolysis of nitrogen compounds.

The digestion and assimilation of protein and energy occur more in the lower gastro-intestinal tract as the protein concentration and the levels of feeding increase (Andrews and Orskov 1970b).

The apparent digestibility of protein increases as the amount of protein in the ration increases (Whiting,Slen and Bezeau 1959).

There is evidence that there is no correlated relationship between protein digestibility coefficients and efficiency of protein utilization (Tagari, Dror, Ascarelli and Bondi, 1964; Dror, Tagari and Bondi, 1970; and Tagari, 1969). Dror, Tagari and Bondi, 1970 also showed no relationship between nitrogen retention and protein digestibility.

Fisher, 1968 (cited by Dror *et al.* 1970) observed a basic difference between protein metabolism in adult and growing sheep. There is a greater increase in the apparent nitrogen

digestibility as dietary protein concentration increased at all feeding levels when sheep are young and have lower body weight than when they are older and heavier (Whiting *et al.* 1959; and Andrews *et al.* 1970).

Jagusch, Norton, Walker (1970) observed that whether during protein deficiency or abundance, the skin and blood make the most inefficient use of available nitrogen.

An indication of the efficiency of metabolism of protein in an animal can be obtained based on:

- liveweight gain (Jagusch *et al.* 1970; Orskov, Davies, Dickson, Humphries, Rutter and Treacher, 1972).
- nitrogen retention (Miller, 1968).
- carcass composition (Andrews and Orskov, 1970 a,b; and Orskov *et al.* 1971).

Orskov *et al.* (1972) observed that there was a significant improvement in the performance of lambs fed increasing concentration of crude protein from 13.5 to 16.0%.

Whiting *et al.* (1959) has also observed an increase in weight gain when the amount of digestible crude protein consumed by lambs was increased from 0.045 kg to 0.059 kg but a further increase from 0.059kg to 0.073kg digestible crude protein did not cause any additional increase in body gains.

Male lambs were observed by Andrews *et al.* (1970a) to grow about 15% faster than female lambs and as they advanced in age the difference became more marked. Also, when the amount of feed fed is increased, the difference between the two sexes increased. Furthermore, Andrews *et al.* (1970b) observed that there was more nitrogen deposited in male lambs than in the females.

At slaughter weights of 27.5kg and 40kg Andrews *et al.* (1970b) found a significant positive linear relationship between nitrogen retention and the levels of feeding. There was also a linear relationship between nitrogen retention and crude protein concentration at 27.5kg but this relationship lost its linearity at 40kg liveweight.

The digestible crude protein concentration fed to lambs influences the carcass composition with respect to fat, water and protein contents.

With increase in dietary protein concentration, there is an increase in carcass water and protein content but a decrease in the fat content (Andrews *et al.* 1970b; and Norton, Jagusch and Walker, 1970).

Andrews *et al.* (1970b) found that there was less fat and more nitrogen deposited in male lambs than female lambs.

(b) Protein deficiency:

Deficiency of dietary protein has adverse consequences on the growth, development and carcass composition of sheep. Elliot and Topps (1963), Andrews and Orskov (1970a) observed a decline in food intake by sheep as the dietary protein content reduced. However, as the sheep became adapted to the low protein diet, they increased their voluntary feed intake. This same tendency was observed by Ikhatua and Adu (1981) using Yankasa sheep.

Whiting *et al.* (1959), Andrews and Orskov (1970) observed a decrease in the apparent digestibility of protein when dietary protein deficient feed was given to sheep. A similar result was obtained on cattle by Bond, Everson, Gutierrez and Warwick (1962) and Broster, Tuck, Smith and Johnson (1969). On the other hand, Elliot and Topps (1963) reported that there was no increase in digestibility as sheep increased their voluntary intake of low protein feed. The efficiency of feed utilization by West African dwarf sheep decreased when fed diets deficient in protein (Adeneye and Oyenuga, 1976).

The growth response of sheep placed on protein deficient diet, is poor. Jagusch, Norton, Walker (1970) obtained a small liveweight gain, 76% of which was fat, when they fed lambs with a protein deficient diet.

(d) Protein/Energy relationship:

The various component nutrients contained in a feedstuff, when ingested by an animal, have an interrelated metabolism in the body (Crampton, 1964).

In the light of this, it is improper to determine one nutrient requirement for maintenance or production in an animal without making reference to the other nutrient requirements. Kleiber (1961) emphatically puts it that the reference point for all other dietary requirements is energy metabolism.

Of all the common nutrients which support the life of an animal, energy and protein sources form the bulk component constituents in feed. The interrelationship between the requirements of these two nutrients is constant for maintenance. There is however, a steadily declining variation in the relationship between digestible energy,in a manner that follows the true growth rate of the young animal (Crampton, 1964).

In stressing the interrelationship between nutrients and the importance of energy in relation to other nutrients, Crampton (1964), concluded that energy intake directly or indirectly determines the amount of most nutrients that have to be taken for maximum efficiency of diet in the maintenance and productive performance of an animal body.

Using various protein: energy ratio diets, Epley, Hedrick, Mies, Preston, Krause and Thompson (1971) gave the indication that quality and yield grade of steer carcass were not influenced by the dietary nutrient interrelationship.

When cassava flour containing starch and soluble carbohydrates increased in the diet, Olatunji *et al.* (1976) observed that the digestibility of dietary crude protein increased. Their result indicates that the efficiency of digestion of crude protein increased when dietary energy was increased.

On the contrary, when Adeneye and Oyenuga (1976a) fed West African dwarf sheep with a basal forage ration and increased the levels of dietary energy in the supplementary concentrate ration, they observed that the intake and digestibility of the dietary crude protein decreased. Similar results were reported by (Head 1953), Tagari *et al.* (1964), Head and Murdoch (1965) and Broster *et al.* (1969).

Furthermore, Adeneye and Oyenuga (1976) observed that the dietary protein level limited the intake of digestible energy and metabolizable energy.

Moreover, increase in dietary protein as the dietary energy increases, modifies increase in liveweight, and efficiencies of utilization of digestible and metabolizable energy. Conversely, inadequate dietary energy limits the apparent protein digestibility and efficiency of utilization of digestible crude protein for maintenance and growth (Whiting *et al.* 1959; Adeneye and Oyenuga, 1976). For a 24kg West African dwarf sheep, they found that the optimum efficiency of utilization was attainable when the diet supplied 1.71 Mcal metabolizable energy and 49g digestible crude protein per day. They obtained a protein: energy ratio of 26.6g DCP per 1,000 kcal DE at the optimum efficiency of utilization. Preston *et al.*(1965) on the other hand reported a protein: energy ratio of 22g DCP per Mcal of DE for temperate breed wether lambs to get the optimum efficiency of utilization. Adeneye and Oyenuga (1976) also observed that there was an inverse relationship between the dietary energy levels and the protein: calorie ratio..

The reports of Jones and Hogue (1960); Rea and Ross (1960), Elliot and Topps (1963), Haskins,Wise, Craig and Barrick (1967), and Peterson *et al.* (1973), showed that a faster rate of liveweight gain is obtainable in animals fed high energy and high protein diet.

Consequently, the dietary energy and protein have to be in a specific relationship with one another in order to attain an optimum metabolism that will ensure maximum growth. The nature of the dietary carbohydrate is also an important factor.

1.6 COMMON FORAGES USED IN FEEDING LIVESTOCK IN NIGERIA:

Fresh and conserved fodder are the cheapest sources of feed for ruminants. Different species of grass and legumes vary vastly in their nutritive contents, more especially in crude protein. Even within species, the maturity and stage of growth, method of conservation, the fertility of the soil and the depth of the soil on which the species of fodder is grown, all affect its proximate composition and digestibility

(Minson, Harris, Raymond and Milford, 1964; and Butterworth, 1967).

The more mature a fodder is, the less digestible it becomes. The digestibility of regrowth following grazing vary, depending on the ratio of the new tillers to older mature shoots (Raymond, 1964).

The nutritive content of fodder, if properly handled, need not be considerably reduced by conservation. However, in silage preparation, excessive loss of effluent reduces digestibility (Wilson, 1962). In making hay, there results some reduction in digestibility due to loss by leaching, respiration and mechanical damage to the fodder. This loss in the digestibility of hay can be reduced by quick hay making techniques, barn drying and harvesting fodder at the proper time (Shepperson, 1960).

Miller and Blair Rains (1963) found that the higher the soil fertility, the higher the dry matter and apparent crude protein of Andropogon gayanus grown in Northern Nigeria. Also, the deeper the soil, the higher the dry matter content of A. gayanus.

Blaxter, Wainman and Wilson (1961), observed that fodder intake decreased with decrease in its digestibility.

The amount of fodder consumed and its digestibility determine the amount of nutrient available to an animal for utilization. Hutton (1962), determined the calorific value of pasture grass to be between 4.32 and 4.55 kcal/g dry matter. However, what primarily determines the metabolizable energy of a feed is the amount of energy lost in the faeces. This faecal energy loss usually lies between 15% and 60% of the gross energy of the grass. The losses through urine and methane, rarely exceed 9% and 10% respectively. For fodders with protein contents ranging from 5.1 to 22.6%, the metabolizable energy can be estimated by multiplying the apparent digestible energy by 0.82 (Armstrong, Blaxter and Waite 1964; Bateman and Blaxter, 1964; and Blaxter, 1964).

Various grass and legume fodders, either in the fresh or conserved forms, are commonly used to raise ruminant livestock in the tropics.

Some of the fodders have been evaluated for their nutrient content and adequacy in supporting livestock.

The common grasses available in Nigeria for feeding livestock include:

(a) Andropogon gayanus (Gamba grass):
It is palatable to livestock. Its nutritive value is relatively high in July but declines markedly in digestible organic matter (DOM) and digestible crude protein (DCP) by the end of September. The digestibility and intake are low when cut early in the season (Miller and Blair Rains, 1963).

(b) Brachiaria brizantha (Stapf): It is a persistently green grass even during the dry season. Its digestibility declines rapidly as it matures at a fast rate (Miller and Blair Rains, 1963).

(c) Chloris gayana (Rhodes grass): Its nutritive value is comparable to that of Andropogon gayanus. It thrives better in the wetter Southern Nigeria than in the North (Oyenuga, 1957; Miller and Blair Rains, 1963).

(d) Cynodon dactylon (L.) (Pers. Bermuda grass): It is a common grass considered to be a weed in many government farms. It has a high digestible crude protein content (Miller and Blair Rain, 1963).

(e) Hyparrhenia rufa (Stapf): Its digestibility in August is very low. As a result, it is unsuitable as a pasture grass (Miller and Blair Rains, 1963).

(f) Panicum maximum (Jacq),Guinea grass: It is very suitable for ensilage (Miller and Blair Rains, 1963).

(g) Pennisetum pedicellatum (Trin): It has a very low nutritive value (Miller and Blair Rains, 1963).

(h) Pennisetum purpureum (Schum), Elephant grass or Napier grass: It is commonly found along banks of streams and rivers in the north but more widespread in the southern part of Nigeria (Miller and Blair Rains, 1963).

(i) Bush foggage: It is the commonest grass available for grazing between January and May. Its digestible organic matter content is relatively high and this makes it a relatively good and cheap source of energy (Miller, Blair Rains and Thorpe, 1964).

(j) Sorghum vulgare (Sorghum): Its digestible organic matter content is much lower than that of bush

foggage and this makes it less valuable (Miller *et al.* 1964).

(k) Digitaria smutsii: Its proximate composition was determined by Ikhatua and Adu (1981). Its crude protein content is comparable with that of Andropogon gayanus hay while its digestible crude protein is almost as high as that of Chloris gayana.

Beside the common grasses, some legume pastures and legume crop residues play an important role in meeting the nutritive requirements of ruminant animals. Such legumes include:

(a) Centrosema pubescens (Centro): Its dry matter intake by livestock is lower than that of grasses. The digestibility of protein is higher than that of the digestible organic matter (Miller and Blair Rains, 1963).

(b) Desmodium scorpuris: It is not favourable to livestock. The proximate constituents are adequate but the digestible organic matter is low (Miller and Blair Rains, 1963).

(c) Stylosanthes gracilis (Stylo): Livestock discriminates against it when other more

palatable pastures are available but during the dry season when the palatability of gasses fall, animals consume it selectively. It is more nutritive than Desmodium and Centrosema (Miller and Blair Rains. 1963).

The legumes whose crop residues are commonly used as dried fodder for raising livestock in Nigeria include:

(a) Arachis hypogoea (Groundnut) haulms: In groundnut growing areas, the haulms of groundnuts can be a readily available source of good quality fodder. With good handling and protection against diseases, groundnut haulms can be of very high nutritive value in raising livestock (Miller *et al.* 1964; Brinckman, 1974).

(b) Glycine max (Soyabean): Its nutritive value is high and it is suitable in feeding young livestock. The crude protein and crude fibre contents increase from full bloom to when the pods are formed on the plant (Morse, 1929; Miller *et al.* 1964).

(c) Stizolobium sp (Velvet bean): It forms a good quality hay when the crop is harvested at the wax stage.

The hay is as good as that of groundnut haulms (Miller *et al.* 1964).

(d) Vigna sinensis (Cowpea): Its haulm is more valuable in feeding livestock and this is self evident from its composition (Miller *et al.* 1964).

(e) Stylosanthes guyanensis: The varieties, Cook and Endeavour were introduced from Queensland, Australia. Feeding trials on Yankasa rams and wethers show that S. guyanensis is of similar, if not better, nutritive value to that of other Stylo varieties (Adu, Agishi and Bricnckman, 1977).

How well an animal is able to perform on fresh or conserved fodder depends on the quantity and quality of the roughage and its efficiency of utilization by the animal. The nutritive value of a fodder to an animal is determined by the total dry matter intake, its digestibility and the efficiency of absorption and utilization of the feed by the animal (Raymond, 1964).

Fodder feed supply in Nigeria is subject to great seasonal variations and hence variable performance of animal. Grass is characterized by low organic matter digestibility (Miller and Blair Rains, 1963)and have low energy supply

which results in negative Nitrogen balance. Therefore efforts to keep animals in equalized or nearly equalized energy balance justify the feeding of concentrate supplement especially protein concentrates which usually are oil seed residues in the form of cakes or meals. The cakes are known to contain more protein than the seeds and so form a valuable by-product for feeding livestock (Oyenuga, 1959).

The common protein concentrates used in Nigeria include groundnut cake (decorticated or undecorticated), cotton seed cake or meal and soyabean cake.

(a) Cotton seed (Gossypium spp. Linn) cake or meal:

From the crude protein content, cottonseed cake can be regarded as one of the richest source of protein for cattle and sheep. Cotton seed cake contains a substantial amount of most of the essential amino acids hence it is a protein source of fairly high biological value (Oyenuga, 1959).

(b) Cowpeas (Vigna unguiculata Walp):

The seeds of this legume are not commonly

fed to livestock on a large scale because it is not economical to do so due to its low yield per acre of land and its high demand for human consumption (Oyenuga, 1959).

(c) Groundnut (Arachis hypogoea Linn) cake:

This is a commonly grown leguminous plant in the upper northern part of the country. About 50% of the kernel is oil and when this is extracted, the by-product is groundnut cake which is a very valuable protein supplement for livestock (Oyenuga, 1959). Results have shown that groundnut protein, as a source of dietary protein in rations of livestock, has one of the highest biological values among vegetable proteins (Blaylock and Richardson, 1950; Mitchell and Beadles, 1950).

(d) Soyabean (Glycine max Merr):

The oil and protein contents of soyabean range from 13.9% to 23.2% and 32.4% to 50.2% respectively, depending on the climate and temperature of the area where it is cultivated. Soyabean oil meal or cake results from extracting the oil and the protein content of these by-product

is of fairly high biological value. This makes the by-products valuable in feeding livestock.

The parameter which determines the protein value of a protein supplement most, is its digestible crude protein content. The higher the digestible crude protein content, the more suitable is the supplement for sheep. However, since in livestock production, profit is desired, the relative cheapness and availability of protein supplement also infuence the choice.

The composition and nutritive value of grass, legumes and cakes are shown in Tables 1,2 and 3.

TABLE 1

PROXIMATE COMPOSITION OF SOME GRASSES

GRASS	DM (%)	DOM (%)	CP (%)	DCP (%)	CF (%)	REFERENCES
Gamba hay	88.5	44.9	6.1	0.7	35.1	Miller and Blair Rains, 1963. Miller, Blair Rains and Thorne, 1964.
Brachiaria brizantha (fresh)	30.4	50.6	4.0	0.8	31.1	Miller and Blair Rains, 1963.
Rhodes grass (fresh)	20.0	48.4	7.6	3.0	32.7	Oyenuga, 1957 Miller and Blair Rains, 1963.
Pers Bermuda grass (fresh)	20.2	52.6	14.4	9.9	27.2	Miller and Blai Rains, 1963.
Hyparrhenia rufa (fresh)	24.5	39.6	4.4	0.8	32.3	Miller and Blair Rains, 1963.

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TABLE 1 CONTINUED

PROXIMATE COMPOSITION OF SOME GRASSES

		DM (%)	DOM (%)	CP (%)	DCP (%)	CF (%)	REFERENCES
6.	Guinea Grass (fresh)	25.7	52.4	7.8	4.7	33.4	Miller and Blair Rains 1963.
7.	Pennisetum pedicellatum (fresh)	13.3	59.8	7.5	4.9	25.5	Miller and Blair Rains 1963.
8.	Elephant grass (fresh)	14.7	53.4	18.4	14.3	26.0	Miller and Blair Rains 1963.
9.	Bush foggage hay	88.4	52.0	1.5	1.0	38.3	Miller, Blair Rains and Thorpe, 1964.
10.	Sorghum hay	94.0	44.0	3.0	0.2	35.0	Miller, Blair Rains and Thorpe, 1964.
11.	Digitaria Smutsii hay	87.6	44.0	5.14	2.7	37.1	Ikhatua and Adu 1981.

TABLE 2

PROXIMATE COMPOSITION OF SOME LEGUMINOUS FODDER

	LEGUME	DM (%)	DOM (%)	CP (%)	DCP (%)	CF (%)	REFERENCES
1.	Groundnut haulms	90.1	44.2	7.7	3.3	46.2	Miller, Blai Rains and Thorpe, 1964
2.	Soyabean	87.2	58.0	12.3	7.9	31.9	Morse, 1929, Miller, Blai Rains and Thorpe, 1964
3.	Velvet bean	95.3	57.0	11.6	6.1	29.7	Miller, Blai Rains and Thorpe, 1964
4.	Stylosanthes guyanensis (Cook stylo hay).	95.4	89.6	8.89	6.2	44.0	Adu, Agishi and Brinckman 1977.

TABLE 3

PROXIMATE COMPOSITION OF SOME PROTEIN SOURCE FEED

	FEED	DM (%)	DOM (%)	CP (%)	DCP (%)	CF (%)	REFERENCES
1.	Cotton seed cake	92.2	-	44.8	-	9.9	Oyenuga, 1959.
2.	Cowpeas	91.3	-	24.67	2.23	1.81	Oyenuga, 1955 and 1959.
3.	Groundnut cake	90.36	-	51.41	-	4.64	Oyenuga, 1959.

CHAPTER II - MATERIALS AND METHODS

CHAPTER II

MATERIALS AND METHODS

2.1 Location of the Experiment:

This study was undertaken in Shika in Kaduna State of Nigeria. Shika is located on the latitude 11°.11' N and longitude 7°.38' E within the northern guinea savannah zone. It is situated at an altitude of about 640 m above sea level. Its annual rainfall ranges from 800 to 1300 mm with an average of 1100 mm. The rainy season falls between late April and early October. Mean maximum temperature is between 27°C during the rainy season and 35°C in the dry season while the mean minimum temperature ranges from 20°C during the rainy season to 12°C during the dry season.

Shika farm was established under the old Shika Research Station in 1928; but in 1976, the National Animal Production Research Institute was established. The Institute conducts research on Livestock breeding, nutrition and management, forage production, pasture improvement and rural sociology.

All species of livestock (except pigs) and poultry are kept in the Institute for reasearch.

2.2. The Experimental Animals:

Weaned Yankasa lambs, 6 to 9 months of age were selected for the experiment. Yankasa breed of sheep is widely distributed and thrives within the Sahelo-sudan region which falls within north of latitude 14^{o}N. It is a medium sized sheep with a white hairy body coat except around the eyelids, ears, muzzle and at times feet, which have black patches. The birth weight varies from 2 to 3.5 kg while the mature weight ranges from 25 to 30 kg. Under good nutrition the animals could have a daily weight gain of 120 g per day. They are prolific and have good twinning and survival rates (Adu and Ngere, 1979).

2.3. Feed Ingredients:

The animals were fed on basal Digitaria smutsii hay, supplemented with compounded concentrate ration made from guinea corn, cottonseed cake, common salt and bone meal. The composition of the concentrate supplement is shown in Table 4.

TABLE 4

COMPOSITION OF EXPERIMENTAL RATIONS:

Feed Ingredients	Protein Level (%)	
	High	Low
Guinea corn	62.66	92.16
Cottonseed cake	36.0	6.5
Bone meal	1.07	1.07
Common salt	0.27	0.27

In the course of the experiment, the stored hay was exhausted and an alternative way of making hay during the rainy season was developed. This method termed the "barn dried" hay method entailed suspending freshly cut pasture on fencing wire protected from rains. Partially dried hay was usually obtained within two to three days. The proximate composition of the concentrate ration, field dried and barn dried Digitaria hay is given in Table 5.

TABLE 5

PROXIMATE COMPOSITION OF CONCENTRATE RATIONS, FIELD DRIED AND BARN DRIED DIGITARIA HAY

FEED	DM(%)	N(%)	CP(%)	EE(%)	ASH(%)	FIBRE(%)	ENERGY(Cal/g)
High Ration	95.3	2.29	14.32	3.60	4.24	11.67	3945.00
Low Ration	95.3	1.67	10.44	2.90	3.53	3.36	3831.91
Sundried *Digitaria smutsii* hay.	98.5	0.89	5.56	2.00	8.86	33.32	3680.13
Barn dried *Digitaria smutsii* hay	88.3	1.17	7.31	1.88	9.03	35.15	3688.5

2.4. Experimental Design and Procedures:

The design used for this experiment was the change - over type.

There were four treatments. Each treatment had 3 ram lambs and 3 ewe lambs.

The treatments were as follows:

Treatment A:

The animals were placed on a high plane of nutrition throughout the 184 days of the experiment.

Treatment B:

These lambs were given high plane of nutrition during the first 100 days while during the last 84 days of the experiment, they were changed over to low plane of nutrition.

Treatment C:

The lambs were fed on low plane of nutrition during the first 100 days and then changed over to high plane of nutrition during the last 84 days of the experiment.

Treatment D:

These were placed on low plane of nutrition for the entire period of experimentation.

The selection of animals for the experiment was based on age (6 to 9 months) and good apparent physical appearance. The animals classified into groups were balanced for age and liveweight.

Animals were weighed fortnightly. Body measurements - body length, height at withers, girth and loin - were also taken forthightly. Body length was from atlas to the last sacrum; height at withers was from the ground to the upper edge of the scapula; girth was the circumference around the thorax; loin was the circumference around the lumbar region.

2.5. Level of feeding and feed Intake:

There were two levels of feeding - the high (12.1% CP) and low/(6.1% CP) levels. Both levels of feeding were based on dry matter intake of 4 percent body weight. Animals on the high nutritional regime received 75% of the try matter from the high protein ration and 25% from Digitaria hay, while animals on low level of feeding obtained 25% dry matter from the low protein concentrate and 75% from Digitaria hay.

The feed residue after each day's feeding was weighed and the quantity consumed in each pen was obtained by difference. Individual average intake was obtained by dividing the group intake by the number of animals in the groups.

2.6. Metabolism trial:

Two digestibility trials were carried out during each phase of the experiment. During each of the metabolism trials, the 10 male animals were put in digestibility crates and allowed to get accustomed to the enclosures for two days before sample collections began.

The amount of feed given to each animals in the crate was measured based on 4 percent of its body weight. The actual amount of feed consumed was also obtained from the residue left over within a 24-hour period by difference.

The faecal ouput from each animal was weighed while samples were collected on each of the 7 days of collection in the trial. The dry matter of the samples collected each day was determined daily, bulked and stored at - $5^{o}C$ until required for proximate analysis.

2.7. Water Intake:

Fresh water was provided to the animals in each pen. The water intake of the animals while in the pen was not measured.

When animals were put in the crates for metabolism trial, the amount of water consumed by each animal was recorded using graduated plastic buckets.

The temperature of the room was noted on each day of collection while the daily evaporative loss of water in the room was determined during the trial. From this, the correction for water factor enables the error due to evaporative loss to be eliminated from the water intake.

2.8. Proximate analysis:

The proximate analyses were carried out with 4 replications following the AOAC (1975) procedure. The gross energy of feed and faeces were determined by the use of bomb calorimetry.

2.9. Carcass Analysis:

All the animals used were slaughtered at the end of the experiment. They were slaughtered in 3 batches with one from each group in each bath.

On each occasion, the randomly selected animals were starved of food overnight before being transported to the Animal Products laboratory of Ahmadu Bello University, Zaria, where they were slaughtered. Before slaughter, the live-weight of each animal was taken. The carotid arteries and jugular veins were then severed to bleed the animal to death. The carcass was decapitated at the occipito - atlas articulation. The carcass were flayed and their feet severed off at the joints of the cannon and pastern bones. The visceral organs except the kidneys were removed. The weight of the gastro-intestinal tracts were taken before and after clearing the contents. The warm carcass weight was taken. The body length (distance between the anterior and of atlas vertebra and the last sacrum), heart girth (widest circumference around the thorax), height at withers (distance between the distal end of radius and the upper edge of the scapula) length of the right leg (distal end of tibia to pubic symphysis) and width of leg (widest distance between the biceps femoris) were taken.

The kidneys plus renal fat were removed and weighed together while the kidneys alone were also weighed separately. The carcass was stored in a chilling room at 2°C for 18 hours. The head, heart, lungs, spleen, liver (without gall bladder), visceral fat and feet were weighed separately.

The cold carcass weight was then taken. The dressing percentage was determined as the percentage of the hot carcass weight to the starved liveweight before slaughter, while the shrinking loss was the difference between the weights of the hot carcass and cold carcass.

The cold carcass was then divided longitudinally along the vertebral column into two halves. Each half carcass was weighed. Nine standard cuts (National Livestock and Meat Board, 1973) were made from each left half carcass (Fig 1) and each of the cuts was completely dissected. The weights of the muscle, bone and fat of each cut were determined.

A cut between the 10th and 12th intercostal muscles of the right half carcass was made and the lean meat severed from the bone.

The lean meat retrieved was subjected to chemical analysis to determine the protein and fat contents.

CHAPTER III - FEED INTAKE, DIGESTIBILITY, FEED CONVERSION AND UTILIZATION

CHAPTER III

FEED INTAKE, DIGESTIBILITY, FEED CONVERSION AND UTILIZATION BY YANKASA SHEEP

3.1 - *Feed Intake and Digestibility:*

The experiment started with 24 yankasa weaned lambs (12 males and 12 females) but two lambs were lost, one on the 30th and the other on the 44th day of the experiment.

The concentrate and hay intakes during each of the 3 phases of the experiment were significant ($P/0.01$) for treatment. The overall total dry matter intake was also significant ($P/0.01$) for treatment.

During the first 100 days, the concentrate intake of the animals on high protein ration treatment (HH and HL groups) was about 53/Wkg $^{0.75}$. This was much higher than those of the LH and LL low protein ration treatment groups which ate about 15g/Wkg $^{0.75}$. Animals on the low protein treatment groups had a hay intake of 58g/KgW$^{0.75}$ which was about 4 times higher than for those on the high protein treatment groups.

The total drymatter intake of animals on high protein treatments was 6.9% lower than for those on low protein treatment (Table 6b).

During the second half of the experiment (Day 101 to 184), HH animals consumed 10.5% less concentrate than the LH group of animals. The HL animals consumed 10.1% more concentrate than the LL group, even though both were on low protein ration. Generally, the animals on high protein ration consumed 67.4% more concentrate than those on low protein ration. The animals on low protein feed took between 74.0% and 68.2% more hay than those on the high protein treatments. HH animals had 10.9% more hay intake than LH animals. LH treatment group animals ingested 5.1% more total feed drymatter than HH while the HL group of animals consumed 23.7% more total dry-matter than LL animals (Table 6b)

The overall concentrate intake by HH animals was 1.6 times higher than that of the LH group. LH animals on the other hand took 62.4% more concentrate than the LL group.

The total hay consumption by LH animals was 1.9 times higher than that of the HH group while that of LL animals was 1.1 times that of the animals on HL treatment (Table 6a). In terms of metabolic weight, the total feed drymatter intake during the entire period of experiment was 0.7% less for HH animals than for the LH group while the animals on HL were 15.0% more than for those on LL treatment (Table 6b). Table 6a shows that in each stage of the experiment, the males consumed more feeds than the females. In the first half, the differences was 18.0% which reduced to about 7.0% during the second half. For the entire 184 days, the males consumed 12.8% more feeds than the females.

Tables 7a,b show the gross nutrient intake. The crude protein and energy intakes were significant ($P \leq 0.01$) for treatment in the 3 phases of the experiment. During the first 100 days, animals on the high protein ration treatments (HH and HL) ingested about 1.5 times more crude protein than those on the low protein treatments. After the change-over, LH animals took 7.8% more crude protein than the HH group while animals on HL

treatment took 20.5% more crude protein than the LL group. The overall total crude protein consumption showed that animals on the LH treatment took 19.6% less per metabolic weight than the HH group while HL animals took 33.1% more per metabolic weight than those on LL treatment.

The energy intake of low protein diet treatments was 1.1 times that of the high protein diet treatments in the first 100 days of the experiment. LH animals took 1.1 times more energy that the HH group during the second half while animals on HL treatment took 1.3 times that of the LL group. Overall, LH animals took less energy than those on HH treatment while the HL group took more than LL animals. The male animals consumed more crude protein and energy than the females in the first 100 days and the entire period of the experiment.

There were four metabolism trials (two within the first 100 days and two within the last 84 days of the experiment) conducted during the experiment.

treatment took 20.5% more crude protein than the LL group. The overall total crude protein consumption showed that animals on the LH treatment took 19.6% less per metabolic weight than the HH group while HL animals took 33.1% more per metabolic weight than those on LL treatment.

The energy intake of low protein diet treatments was 1.1 times that of the high protein diet treatments in the first 100 days of the experiment. LH animals took 1.1 times more energy that the HH group during the second half while animals on HL treatment took 1.3 times that of the LL group. Overall, LH animals took less energy than those on HH treatment while the HL group took more than LL animals. The male animals consumed more crude protein and energy than the females in the first 100 days and the entire period of the experiment.

There were four metabolism trials (two within the first 100 days and two within the last 84 days of the experiment) conducted during the experiment.

During the first two metabolism trials, the digestibility coefficients were significantly ($P<0.01$) higher in the high protein ration than in the low protein ration. The digestibility coefficients of drymatter, nitrogen and energy in the first trial were 6.7%, 9.5% and 7.5% respectively higher in the high protein diet than in the low protein diet (Table 8). In the second trial, the differences between the high and low protein diets were even more marked, the differences being 13.1%, 14.5% and 22.0% for energy, drymatter and nitrogen coefficients respectively (Table 9).

The third digestibility trial was at the point of treatment change-over (Table 10). The drymatter and energy in high protein diet were 4.0% and 5.5% respectively less digestible than in the low protein ration while the nitrogen was 0.8% more digestible. The difference in energy and drymatter coefficients were significant at $P<0.01$ and $P<0.05$ respectively.

However, during the fourth digestibility trial, the drymatter coefficient of low protein

diet was 14.8% less than for the high protein diet (Table 11). The nitrogen and energy coefficients were also 18.0% and 13.1% respectively higher in the high protein diet than in the low protein diet. The difference between the two treatments was significant ($P < 0.01$).

The digestible organic matter intake of LH animals was 3.6% lower than that of animals on HH treatment while that of HL animals was 8.4% higher than the LL group. The digestible crude protein intake was 50.4% higher in high protein treatments than in the low protein treatments during the first period of the experiment. During the second half of the experiment, LH animals had 7.9% more digestible crude protein than that of the HH group while animals on HL treatment was 20.5% higher than those of LL treatment animals. The intake of digestible crude protein for LH animals was 28.5% less than for the HH group while that of HL animals was 43.2% higher than animals on LL treatment for the overall period of experiment (Table 12b). During the first period and the entire period of the experiment, LH animals had

less digestible energy intake than the HH group while in the 2nd phase, LH animals had more digestible energy than the HH group. Animals on HL treatment took more digestible energy than those on LL treatment. There was more intake of digestible crude protein and energy by the males than the females throughout each phase of the experiment.

3.2 Feed conversion and utilization:

The mean daily weight gain of the animals on high protein diet was about 3.6 times that of those on the low protein diet during the first 100 days (Table 13). The difference between the two groups was significant ($P < 0.01$). During the second half, the rate of gain by the LH group was 16.0% higher than that of animals on HH treatment though both groups received the same diet. The animals on high protein treatments were at least 59.9% higher in rate of weight gain than those on low protein treatments. The overall weight gain for the entire experimental period (Table 13) showed that HH animals had the highest daily weight gain and this was 28.3% higher than for the LH group while animals on HL was 51% higher than the LL group.

The efficiency of feed conversion during the first 100 days (Table 13) was about 3.6 times higher in the high protein treatments than in the low protein treatments. During the second half, LH animals were 24.5% more efficient than the HH group while LL animals were 35.4% more efficient than those on HL treatment. Generally, the high protein treatments were about 3.0 times more efficient than the low protein treatments. The overall efficiency of feed conversion showed that animals on HH treatment were most efficient with 24.2% higher efficiency than the LH group which was next. The LL animals had the least efficiency and this was 36.5% lower than the HL group. The LH animals were more efficient in feed conversion than the HL group by 19.6%. The male animals showed a higher efficiency of feed conversion than the females throughout the experiment.

Table 14 shows the efficiency of nutrient utilization. Animals on the high protein treatments were 2.9 and 1.5 times more efficient in drymatter and crude protein utilization respectively

than those on the low protein treatments. For energy, the high protein treatments were 2.8% higher than that of low protein treatments. During the last 84 days, the LH animals were 24.5%, 22.5% and 24.4% more efficient in utilizing drymatter, crude protein and energy respectively than the HH group. The LL animals on the other hand were 1.5 times more efficient than HL animals in utilizing each of the three nutrients. On the whole, the LH animals were 1.2 times less efficient in utilizing drymatter and energy but were 6.8% more efficient than the HH group in crude protein utilization. Animals on the HL rations were 30.9%, 2.0% and 30.5% more efficient in utilizing drymatter, crude protein and energy respectively than those on the LL treatment.

Table 15 shows the cost of feed consumed and the cost per kg liveweight gain. During the first phase, the cost of feed for animals on the high protein diet was 16.7% higher than that for low protein diet. It cost ₦2.1 less to produce 1 kg of liveweight gain in the high protein diet treatments than the low protein diet treatments.

The costs of production in HH, HL and LL groups were 16.7% less than for LH treatment during the second 84 days of the experiment. The cost of production of 1 kg liveweight gain in the LH group was 20% less than for HH animals. Animals on LL treatment gained 1 kg liveweight at ₦0.7 less cost than the HL group. The low protein treatments cost ₦1.6 more to produce 1 kg liveweight gain than the high protein treatments.

The overall cost of feed per kg liveweight was 16.7% more in HH and HL groups than in LH and LL groups (Table 15). However, it cost ₦0.1 more to produce 1 kg liveweight gain in LH group than in HH treatment but cost ₦0.8 less in animals on HL treatment than in the LL group. The cost of production was the same for both male and female animals but to gain 1 kg liveweight, it cost slightly less in the males than in the females.

3.3 Body measurements:

Table 16 shows that the difference between body lengths was not significant for treatments during the first half of the experiment. The highest mean body length (77.5 cm) was attained by

HL animals while LH group had the least (73.0 cm). Generally, the high protein animals were longer, higher at withers and had wider girth and loin than animals on the low protein diet treatments during the first half.

During the second half of the experiment, the HH animals were higher at withers, longer and had wider girth and loin than the LH group while animals on HL treatment were larger than LL animals in all these body parameters.

The males during the first 100 days gained more in length (3.8 cm to 2.9 cm), height at withers (5.3 cm to 3.2 cm) and girth (9.3 cm to 8.8 cm) than the females while the females gained more in loin (7.0 cm to 1.7 cm).

During the second half, the females gained more in length (7.5 cm to 6.9 cm) and height at withers (5.2 cm to 3.4 cm) while the males increased more in girth (5.8 cm to 2.9 cm) and loin (4.2 cm to 1.7 cm).

However the overall increase in length, height at withers and girth were marginally higher in the

males than in the females but the increase in the loin of the females was 39.1% higher than that of the males.

DISCUSSION

Animals on high protein diet during the first half of the experiment, had less total feed dry-matter intake due to the quality of the diet, which made the animals require a lesser amount of feed to meet their nutritional requirements. Animals on low protein diet required more feed to meet their nutritional requirements. This was contrary to the observations of Andrews *et al* (1970a) who noted that sheep had a tendency to consume more feed as the protein content increased. The difference in observation might be due to difference in the feeding systems. Andrews *et al* (1970a) fed their animals *ad libitum*, while in this experiment, the animals were fed according to their liveweights.

When animals were switched over, LH animals took more total drymatter than HH animals. This may be due to the fact that the higher protein content of the feed stimulated better appetite and

voluntary feed intake in order to compensate for the previous undernutrition as reported by Sheehy and Senior (1942); Quimby (1948); Winchester and Howe (1955); Osbourn and Wilson (1960). The higher digestibility of drymatter crude protein and energy in LH animals facilitated the flow of ingesta in the gastro-intestinal tract contributing to the greater total dry matter intake than animals on HH treatment. This was in agreement with the observations made by Sheehy and Senior (1942); Quimby (1948); Osbourn and Wilson (1960) who reported that the rate of feed dry matter intake by realimented animals was higher than for the continuously well fed animals. This result did not agree with the reports of Orskov *et al.* (1975) Winchester and Howe (1955) who observed no change in feed intake by realimented animals. The mean total drymatter intake by LH animals was higher than that for the HH group during the entire period of experiment, showing that the quantity of feed that may have been saved by LH animals during the period of undernutrition was less than what they consumed during realimentation when they compensated for the earlier treatment.

The HL animals were adjusted to high protein diet during the first phase when they took less total dry matter, but when they were switched over to low protein diet, they increased their intake requirements. Since HL animals had a higher liveweight than the LL group, they had to take more feed to make up for the difference in liveweight.

The feed intake for the entire duration of the experiment (184 days) showed that because of the compensatory feeding during the second half of the experiment, LH animals had a higher rate of feeding than the HH group. On the other hand, the overall higher feed consumption by HL animals compared to LL group may be explained on the assumption that the former group which had a higher liveweight, attempted to meet its nutritional requirement to which its animals were adjusted to during the earlier phase (high plane) thus eating more.

The definite pattern of feed intake where in concentrate intake was high in the high protein group while hay intake was high in the low protein

group was due to adjustment of intake in the low group to compensate for inadequate concentrate intake. Since the drymatter intake requirement of the animals had to be met, the deficit in concentrate intake by the low protein diet treatments had to be balanced by increased hay intake.

Since LH animals took more feed during realimentation than the HH group, they invariably consumed more crude protein and energy. In the same manner, HL animals consumed more of the nutrients than animals on LL treatment.

The digestibility of coefficients of crude protein was higher for the high protein diet than for the low protein diet because the former had more concentrate of richer nutritive components and lesser hay intake. The high crude fibre content of the hay perhaps inhibited the digestibility of feed crude protein and energy. This pattern of result agreed with the findings of Whiting *et al.* (1959) who reported that apparent digestibility of protein increased as the amount of dietary protein increased. This is also in agreement with the results of Mitchell (1955) which

showed that digestibility of feed decreased as its nitrogen-free extract and ether extract content increased.

Since during the last 84 days of the experiment, LH animals had a higher efficiency of nutrient utilization, feed conversion and compensatory feeding than the HH group, they had to exhibit a higher growth rate than the HH group.

LH animals utilized more feed of the same ration to gain more liveweight per day than the HH group during the second half of the experiment, indicating that LH animals utilized the high protein feed more efficiently to gain weight than the HH group. LH animals due to prior nutritional deprivation had a lower mean liveweight than the HH group thus making nutritional requirements less than for HH animals (Hogan, 1929; Sheehy and Senior, 1942; Blaxter and Wood, 1951). Consequently, upon realimentation, LH animals had more nutrients available to them for growth and development than HH animals. The overall effect of this was that LH animals had a more efficient feed utilization than HH animals.

Thus, LH animals exhibited compensatory growth where-in the rate of weight gain of previously nutritionally deprived animals was higher on realimentation than those continuously well nourished (Trowbridge *et al.* 1915; Hogan *et al.* 1922; Meyer and Clawson, 1964; Reid *et al.* 1968; Morgan, 1972; Graham and Searle, 1975; Thornton *et al.* 1979). The highest growth rate was obtained with LH animals during the second phase. This performance was comparable to what Adu and Olaloku (1977), Adu and Brinckman (1981) obtained for West African Dwarf Sheep and Yankasa sheep respectively. But Adeneye and Oyenuga (1976); Ikhatua and Adu (1981) obtained higher growth rate per unit of drymatter intake for West African dwarf sheep and Yankasa sheep respectively.

Animals on LL treatment utilized nutrients more efficiently than the HL group of animals during the second half of the experiment probably because they were already adjusted to the low protein feed while the change-over of HL animals from high protein diet to low protein diet caused

some depression in the efficiency of nutrient utilization by them.

The close similarity between HL and LH groups in their overall liveweight and liveweight gain imply that it is not important whether low protein proceeds high protein feeding or vice versa in these parameters. Thus, the time of weaning of lambs is not critical since whether they are weaned during the dry or wet seasons, their ultimate liveweights would be similar.

The male animals had a higher liveweight gain than the females during the first 100 days and the overall period of experiment because they had a higher feed nutrient and digestible nutrient intakes coupled with higher efficiencies of feed conversion and nutrient utilization. Even though feed and nutrient intakes were lower in the males during the second half of the experiment than the females, the males still exhibited a higher growth rate due to their higher efficiency of feed conversion.

Whatever the management practice adopted, the cheapest means in making the highest liveweight

gain within the shortest time possible is most desirable in livestock enterpreneurship. The unit weight cost of the low protein ration was higher than that of the high protein ration because guinea corn cost about 1.5 times more than the cotton seed cake. Since the low protein diet contained 1.5 times more guinea corn than the high protein diet, it was imperative for the former to be more expensive. As concentrate ration cost at least 1.7 times more than hay and the high protein treatment animals took about 3 times more concentrate than those on low protein treatments, it becomes apparent as to why the cost of production was higher in the high protein treatment animals than low protein treatment animals. However, due to the high degree of efficiency of utilization of feed, the HH animals on continuously well nourishing diet had the least cost per unit liveweight gain. In view of the poor nutritional quality of low protein diet, the animals on this treatment needed more feed, which meant more money, to derive enough nutrients so as to meet their nutritional requirements for growth

Beside the high cost incurred in gaining weight by the treatments on low protein diet, the rate of growth which was much lower than for the treatments on high protein diet, meant that more time was needed by them to attain the same live-weight as their counterpart on high protein diet and this ultimately meant a higher cost of production. Even the LH animals that exercised some compensatory growth during the second phase, cost more on the whole, than the HH group to gain weight due to the over-whelming effects of the high cost of production during the first 100 days of the experiment.

Due to higher efficiencies of nutrient utilization and feed conversion in the males than in the females, it cost less to produce 1 kg liveweight gain in the males during the first and overall periods of the experiment. However, the effect of the lower feed and nutrient intakes coupled with lower efficiency of nutrient utilization in the males during the second half of the experiment negated the higher efficiency of feed conversion resulting in a higher cost of

production per kg liveweight gain.

The results on body measurements indicate that plane of nutrition influenced the physical conformation of animals. While the animals on high protein ration (HH and HL groups) made the highest increase in body length, height at withers, girth and loin during the first half of the experiment, those on low protein diet made correspondingly lower increase. This finding was also true during the second phase of the experiment when HH and LH animals received the high protein diet. Except for increase in body length and loin, LH animals made more increase in height at withers and girth than HH group, though the difference was not significant. This showed that there was some compensation in height at withers and girth by LH animals during the second phase of the experiment when compared to the HH group.

The difference in the period of greater increase in body length, height at withers, girth and loin between sexes may have been due to sex differences in stage and type of development.

The greater increase in body length, height at withers and girth contributed to the males being heavier than the females generally. The greater increase in the loin of the females when compared to the males was probably due to the influence of oestrogen and absence of testosterone (Hafez, 1969) in facilitating increase in the pelvis of the female animals. The greater increase in the girth of males was probably due to the inherent secondary male characteristic to have larger thorax than females, under the influence of testosterone (Hafez, 1969).

TABLE 6a: MEANS OF DAILY DRY MATTER INTAKE (kg) PER ANIMAL

Treatment	No of replicates *	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Concentrate	Hay	Total	Concentrate	Hay	Total	Concentrate	Hay	Total
HH	6	0.539^{a}	0.167^{a}	0.706	0.604^{a}	0.239^{c}	0.843^{e}	0.569^{a}	0.200^{a}	0.769^{ab}
HL	6	0.537^{a}	0.159^{b}	0.696	0.199^{b}	$0.2\,0^{a}$	1.019^{e}	0.383^{b}	0.461^{b}	0.844^{a}
LH	5	0.155^{b}	0.549^{a}	0.704	0.750^{a}	0.182^{c}	0.757^{ef}	0.346^{b}	0.381^{be}	0.727^{ab}
LL	5	0.139^{b}	0.506^{a}	0.645	0.150^{b}	0.511^{b}	0.661^{f}	0.144^{c}	0.508^{b}	0.652^{b}
SE		0.027	0.027	0.0001	0.047	0.094	0.118	0.038	0.054	0.061
Male	10	0.375^{a}	0.381^{a}	0.756	0.421^{a}	0.429	0.850	0.396^{a}	0.403	0.799^{a}
Female	12	0.310	0.309^{b}	0.619	0.342^{b}	0.447	0.789	0.325^{b}	0.372	0.697^{b}
SE		0.014	0.014	0.000	0.023	0.047	0.059	0.019	0.027	0.030

HH and LL = Groups of animals on high and low protein ration during the entire period of experiment respectively.

HL and LH = Groups of animals on high or low protein ration for the first half but switched to low or high protein ration respectively during the second half of the experiment.

Values with different superscripts within the same column and subclass are significantly different (a,b,c, and d at 1%; e, f, g, h, at 5%) in Tables 6a to 16.

*There were 2 pens in each replicate and 3 animals in each pen.

TABLE 6b: MEANS OF DAILY DRY MATTER INTAKE (g) PER Kg METABOLIC WEIGHT

Treatment	No of replicates *	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Concentrate	Hay	Total	Concentrate	Hay	Total	Concentrate	Hay	Total
HH	6	52.70^{a}	16.35^{b}	69.05	45.12^{b}	17.93^{b}	63.05	48.29^{a}	17.01^{a}	65.30^{a}
HL	6	53.84^{a}	15.94^{b}	69.78	19.41^{b}	68.88^{a}	85.29	36.11^{b}	43.93^{b}	80.04^{b}
LH	6	16.99^{b}	60.26^{a}	77.25	50.42^{a}	15.98^{b}	66.41	31.31^{b}	34.44^{c}	65.75^{b}
LL	6	15.50^{b}	56.43^{a}	71.93	14.76^{b}	50.30^{a}	65.06	15.02^{c}	53.03^{b}	68.05^{a,b}
	SE	0.437	4.220	4.323	3.943	5.689	10.950	2.041	5.851	3.499
Male	12	36.28^{a}	40.01^{e}	75.99^{c}	32.35^{c}	35.33	65.68	31.46^{a}	36.87	71.26
Female	12	33.24^{b}	34.48^{f}	67.73^{d}	30.05^{d}	41.21	71.33	30.82^{b}	37.82	68.75
	SE	0.218	2.110	2.161	1.421	4.845	5.475	1.021	2.926	1.749

TABLE 7a: MEANS OF DAILY NUTRIENT INTAKE PER ANIMAL

Treatment	No of replicates *	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Drymatter (g)	Crude Protein (g)	Energy (kcal)	Drymatter (g)	Crude Protein (g)	Energy (kcal)	Drymatter (g)	Crude Protein (g)	Energy (kcal)
HH	6	706.3^{a}	88.00^{a}	2744.0^{a}	843.2^{c}	101.90^{a}	3263.4^{e}	769.4^{ab}	94.94^{a}	3[illegible]5.1^{a}
HL	6	696.1^{a}	87.16^{a}	2704.5^{a}	1,019.4^{a}	73.52^{e}	3779.9^{e}	844.3^{a}	80.94^{e}	3195.4^{a}
LH	5	704.2^{a}	51.50^{b}	2614.2^{c}	757.1^{a}	94.00^{ae}	2937.0^{ef}	727.1^{ab}	70.90^{be}	2761.5^{ab}
LL	5	645.4^{b}	47.06^{b}	2394.2^{b}	661.3^{b}	48.52^{b}	2454.8^{f}	652.4^{b}	47.73^{b}	2421.9^{b}
SE		4.323	2.098	56.16	10.793	10.793	441.4	6.499	5.706	228.4
Male	10	756.1^{a}	75.08^{a}	2874.0^{a}	850.2^{a}	84.26	3230.6	799.1^{a}	79.27^{a}	3036.8^{a}
Female	12	619.3^{b}	61.79^{b}	2354.4^{b}	789.1^{b}	74.71	2986.9	697.3^{b}	67.69^{b}	2643.2^{b}
SE		4.671	1.049	28.08	5.475	5.397	220.7	3.249	2.853	14.2

TABLE 7b: MEANS OF DAILY NUTRIENT INTAKE PER kg METABOLIC WEIGHT

Model	No. of Animals	0 to 100 Days			0 to 164 Days			0 to 164 Days		
		Drymatter (g)	Crude Protein (g)	Energy (kcal)	Drymatter (g)	Crude Protein (g)	Energy (kcal)	Drymatter (g)	Crude Protein (g)	Energy (kcal)
Hd	6	68.15^{b}	6.64^{b}	268.76^{b}	63.33^{b}	7.65^{a}	245.15^{d}	65.47^{b}	8.03^{a}	253.80^{c}
Ld	6	69.83^{b}	6.75^{b}	271.35^{bc}	84.28^{b}	6.08^{c}	312.62^{a}	79.59^{b}	7.63^{a}	301.31^{a}
Sd	6	77.35^{a}	6.65^{b}	287.24^{b}	66.61^{c}	8.81^{a}	259.59^{c}	66.22^{b}	6.46^{c}	251.65^{b}
Ld	6	74.28^{c}	5.42^{b}	275.70^{c}	65.86^{c}	4.83^{b}	244.58^{d}	69.73^{c}	5.10^{b}	259.00^{c}
Sh		0.582	0.171	2.96	0.641	0.702	22.68	0.479	0.358	14.678
male	12	74.61^{a}	7.43^{a}	284.39^{a}	67.41^{a}	6.68	256.19	70.62^{a}	7.01	268.41
female	12	67.62^{b}	6.70^{b}	257.20^{b}	71.00^{b}	6.74	268.78	67.51^{b}	6.59	257.15
SE		0.407	0.139	2.483	0.664	0.438	16.714	0.300	0.263	10.53

TAPLE 8: MEANS OF DIGESTIBILITY COEFFICIENTS OF FEED NUTRIENTS IN EXPERIMENT 1

Diet	No of Samples	Means of digestibility coefficients of feed nutrients (%)				
		DM Coefficient	NCoefficient	EE Coefficient	CF Coefficient	Energy Coefficient
High protein	48	79.0[a]	71.8[a]	87.6[a]	68.3[a]	78.3[a]
Low protein	40	72.3[b]	62.3[b]	68.4[b]	80.0[b]	70.8[b]
SE		1.4	1.7	1.7	2.2	1.5

TABLE 9: MEANS OF DIGESTIBILITY COEFFICIENTS OF FEED NUTRIENTS IN EXPERIMENT 2

Diet	No of Sample	Means of digestibility coefficients of feed nutrients (%)				
		DM Coefficient	NCoefficient	EE Coefficient	CF Coefficient	Energy Coefficient
High protein	42	73.9[a]	66.5[a]	79.6[a]	65.9	73.1[a]
Low protein	28	59.4[b]	44.5[b]	76.6[b]	68.2	60.0[b]
SE		1.9	2.7	2.3	1.8	2.6

TABLES 10: MEANS OF DIGESTIBILITY COEFFICIENTS OF FEED NUTRIENTS IN EXPERIMENT 2

Diet	No of Samples	Means of digestibility coefficients of feed nutrients (%)				
		DM Coefficient	NCoefficient	EE Coefficient	CF Coefficient	Energy Coefficient
High protein	35	71.2[e]	62.9	77.8[a]	65.7[a]	70.7[a]
Low proteir	35	76.2[f]	62.1	67.2[b]	83.4[b]	76.2[b]
SE		2.1	3.3	2.6	1.9	2.1

TABLE 11: MEANS OF DIGESTIBILITY COEFFICIENTS OF FEED NUTRIENTS IN EXPERIMENT 4

Diet	No of Sample	Means of digestibility coefficients of feed nutrients (%)				
		DM Coefficient	NCoefficient	EE Coefficient	CF Coefficient	Energy Coefficient
High protein	35	70.2[a]	58.2[a]	79.7[a]	57.8	71.3
Low protein	35	55.4[b]	40.2[b]	52.9[b]	59.6	58.2[b]
SE		3.5	4.9	3.4	3.7	3.2

TABLE 12a: MEANS OF DAILY INTAKE OF DIGESTIBLE NUTRIENTS PER ANIMAL

Treatment	No of replicates *	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Digestible			Digestible			Digestible		
		Organic matter (g)	Crude Protein (g)	Energy (kcal)	Organic matter (g)	Crude Protein (g)	Energy (kcal)	Organic matter (g)	Crude Protein (g)	Energy (kcal)
HH	6	539.74^{a}	60.85^{a}	2077.2^{a}	596.00^{b}	61.70^{a}	2317.0^{ef}	565.42^{b}	61.21^{a}	2186.7^{a}
HL	6	532.09^{e}	60.27^{a}	2047.3^{a}	670.50^{a}	37.61^{b}	2540.1^{e}	595.28^{a}	49.93^{c}	2272.3^{a}
LH	5	463.65^{b}	27.50^{b}	1709.7^{b}	535.20^{d}	56.91^{a}	2085.3^{ef}	496.32^{d}	40.93^{d}	1881.2^{e}
LL	5	424.73^{c}	25.13^{b}	1565.8^{c}	434.94^{c}	24.82^{b}	1649.6^{f}	422.50^{c}	24.89^{b}	1604.1^{b}
SE		3.097	1.301	39.9	7.497	6.074	305.8	5.106	3.430	161.3
Male	10	541.52^{a}	46.54^{a}	2041.1^{a}	582.00^{a}	47.42	2237.8	560.00^{a}	46.94	2130.9^{a}
Female	12	443.39^{b}	38.30^{b}	1672.1^{b}	540.23^{b}	42.04	2069.0	487.60^{b}	40.01	1853.3^{b}
SE		3.348	0.650	19.9	3.749	3.037	152.9	3.531	3.206	80.6

TABLE 17?: MEANS OF DAILY INTAKE OF DIGESTIBLE NUTRIENTS PER kg METABOLIC WEIGHT

Treatment	No of replicates *	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Digestible			Digestible			Digestible		
		Organic matter (g)	Crude Protein (g)	Energy (kcal)	Organic matter (g)	Crude Protein (g)	Energy (kcal)	Organic matter (g)	Crude Protein (g)	Energy (kcal)
HH	6	52.86^{c}	5.96^{a}	203.45^{a}	44.77^{d}	4.64^{ac}	174.05^{b}	48.14^{c}	5.21^{a}	186.17^{b}
HL	6	53.39^{a}	6.05^{a}	205.41^{a}	55.46^{a}	2.11^{c}	219.08^{a}	58.13^{a}	4.71^{d}	214.27^{a}
LH	5	50.95^{b}	3.02^{b}	187.86^{c}	47.30^{c}	5.03^{a}	184.31^{ab}	45.21^{b}	3.73^{c}	171.96^{b}
LL	5	48.91^{d}	2.94^{b}	180.31^{b}	43.33^{b}	2.47^{b}	164.35^{b}	45.18^{b}	2.67^{b}	171.54^{b}
SE		0.162	0.068	2.09	0.318	0.258	12.979	0.238	0.162	7.53
Male	10	53.18^{a}	4.61^{a}	201.97^{a}	46.15^{a}	3.76	177.46	49.50	4.15	188.84
Female	12	48.43^{b}	4.18^{b}	182.66^{b}	48.61^{b}	3.78	186.18	47.44^{b}	3.79	180.30
SE		0.340	0.068	2.08	0.318	0.258	13.97	0.320	0.296	7.433

TABLE 13: MEAN FEED CONVERSION EFFICIENCY OF ANIMALS **

Treatment	No of replicates **	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Live-weight at day 0 (kg)	Daily weight gain (g)	Feed conversion	Live-weight at day 100 (kg)	Daily weight gain (g)	Feed conversion	Live-weight at day 184 (kg)	Daily weight gain (g)	Feed conversion
HH	6	17.3	97.5	7.24^{e}	27.0	107.5^{ef}	7.84^{b}	36.1^{e}	102.1^{e}	7.53^{b}
HL	6	17.0	89.5	7.78^{e}	25.9	43.1^{f}	23.64^{a}	29.6^{ef}	68.3^{ef}	12.36^{be}
LH	5	18.0	27.2	25.88^{f}	20.0	127.9^{e}	5.92^{b}	30.8^{ef}	73.2^{ef}	9.93^{be}
LL	5	15.9	25.2	25.00^{f}	19.8	43.3^{f}	15.27^{ab}	23.5^{f}	33.3^{f}	19.46^{a}
SE		3.3	33.45	8.099	4.3	33.33	5.250	5.0	27.22	2.721
Male	10	17.9	78.9	9.58	25.8	84.4	10.07	32.9	81.4	9.82
Female	12	16.7	49.6	12.48	21.6	76.3	10.34	28.0	61.8	11.28
SE		1.6	16.724	4.050	2.2	16.67	2.625	2.5	13.61	1.360

** Feed conversion = $\frac{\text{Feed DM intake}}{\text{weight gain.}}$

TABLE 14: MEAN EFFICIENCY OF NUTRIENT UTILIZATION***

Treatment	No of replicates*	0 to 100 Days			101 to 184 Days			0 to 184 Days		
		Drymatter	Crude Protein	Energy	Drymatter	Crude Protein	Energy	Drymatter	Crude Protein	Crude Energy
HH	6	5.54[a]	0.624[a]	21.30[a]	5.54[c]	0.574	21.55[b]	5.538[a]	0.600	21.42[e]
HL	6	5.98[a]	0.673[a]	22.88[a]	15.567[a]	0.873	58.94[a]	8.716[d]	0.731	33.27[f]
LH	5	17.05[b]	1.011[b]	62.86[b]	4.195[b]	0.445	16.30[c]	6.780[c]	0.559	25.70[e]
LL	5	16.86[b]	0.997[b]	62.14[b]	10.05[d]	0.573	38.10[a]	12.612[b]	0.746	47.88[f]
SE		0.187	0.018	2.40	0.326	0.264	13.30	0.350	0.238	11.05
Male	10	6.86[a]	0.590[e]	25.87[a]	6.90	0.562	26.51	6.880	0.577	26.18
Female	12	8.94[b]	0.772[f]	33.71[b]	7.08	0.551	27.12	7.890	0.647	29.99
SE		0.403	0.078	2.40	0.326	0.264	13.30	0.484	0.439	11.04

*** Efficiency of nutrient utilization = $\frac{\text{Digestible nutrient}}{\text{weight gain.}}$

TABLE 15: ECONOMIC ANALYSIS OF PRODUCTION PER kg LIVEWEIGHT

Treatment	No of replicates*	0 to 100 Days				101 to 184 Days				0 to 184 Days			
		Concentrate (k)	Hay (k)	Total (k)	Cost/kg gain (N	Concentrate (k)	Hay (k)	Total (k)	Cost/kg gain (N)	Concentrate (k)	Hay (k)	Total (k)	Cost/kg gain (N)
HH	6	0.5	0.1	0.6	1.4	0.4	0.1	0.5	1.5	0.5	0.1	0.6	1.6
HL	6	0.5	0.1	0.6	1.4	0.2	0.3	0.5	3.2	0.4	0.2	0.6	2.1
LH	5	0.2	0.3	0.5	3.5	0.5	0.1	0.6	1.2	0.3	0.2	0.5	1.7
LL	5	0.2	0.3	0.5	3.5	0.2	0.3	0.5	2.5	0.2	0.3	0.5	2.9
Male	10	0.4	0.2	0.6	1.7	0.3	0.2	0.5	1.7	0.4	0.3	0.7	2.2
Female	12	0.4	0.2	0.6	2.3	0.3	0.2	0.5	1.6	0.4	0.3	0.7	2.5

TABLE 16: MEANS OF BODY MEASUREMENTS (cm)

Treatment	No of replicates *	Day 0				Day 100				Day 184			
		Length	Height	Girth	Loin	Length	Height	Girth	Loin	Length	Height	Girth	Loin
HH	6	70.6	60.0	64.2	76.2	74.0	65.2	76.0	81.2	84.5	70.5	81.7[c]	87.0
HL	6	69.4	61.0	63.3	74.9	77.5	68.2	77.0	82.0	83.2	70.5	79.5[ce]	80.8
LH	5	73.5	59.7	64.1	75.5	73.0	61.8	69.6	76.4	82.4	69.0	77.8[ec]	79.4
LL	5	72.3	60.3	66.2	73.7	73.8	63.4	69.8	77.6	76.8	66.2	70.4	80.4
SE		4.5	4.4	4.2	4.3	3.9	3.2	4.0	4.4	4.5	3.4	4.6	4.7
Male	10	71.8	61.6	64.9	76.5	75.8	66.9	74.2	78.2	82.5	70.3	80.0	82.4
Female	12	71.0	59.9	64.0	73.6	73.9	63.1	72.8	80.6	81.4	68.3	75.7	81.8
SE		2.3	2.2	2.1	2.2	2.0	1.6	2.0	2.2	2.3	1.7	2.3	2.4



PLATE 1: MALE ANIMALS OF HH TREATMENT



PLATE 2 : MALE ANIMALS OF HL TREATMENT.

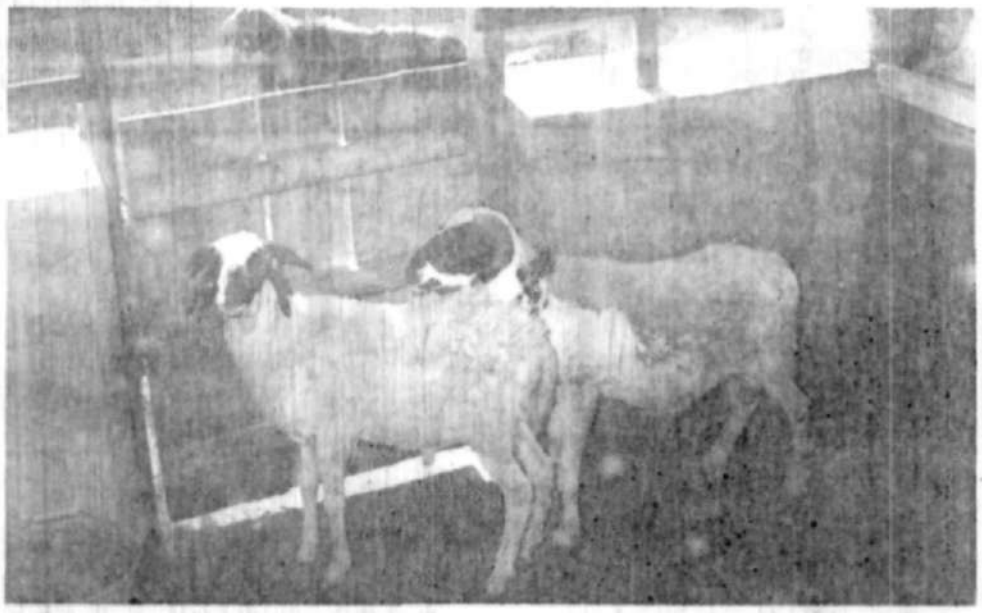


PLATE 3: MALE ANIMALS OF LH TREATMENT.



PLATE 4 : MALE ANIMALS OF LL TREATMENT.



PLATE 5 : FEMALE ANIMALS OF HH TREATMENT



PLATE 6 : FEMALE ANIMALS OF HL TREAMENT



PLATE 7 : FEMALE ANIMALS OF LH TREATMENT



PLATE 8: FEMALE ANIMALS OF LL TREATMENT



PLATE 9: ISOLATED ANIMAL IN HH TREATMENT



PLATE 10 : ISOLATE ANIMAL IN HL TREATMENT

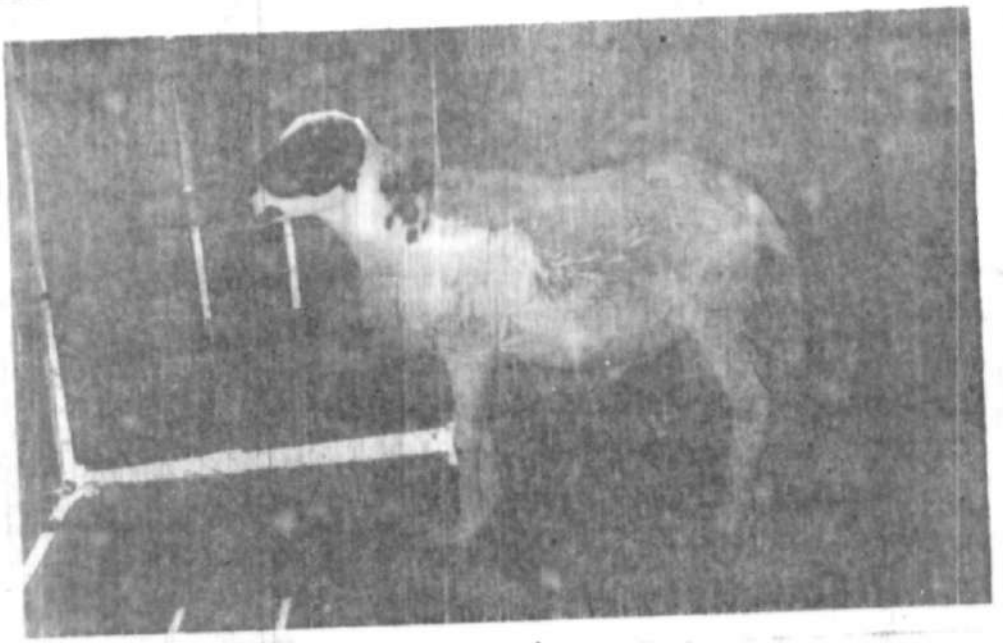


PLATE 11 ISOLATED ANIMAL IN LH TREATMENT

CHAPTER IV - CARCASS ANALYSIS

CHAPTER IV

CARCASS ANALYSIS

4.1 - Carcass Measurements:

Tables 17 and 18 show the means for treatments and sexes of various parameters measured. HH animals had the highest carcass length, heart girth, height at weithers and width of legs. The difference between treatments in height at withers and width of leg were significant ($P/0.05$). HH animals were 1.7 cm higher in height at withers than those on LH treatment while the HL group was 3.7 cm higher than LL animals. The width of legs in LL animals was 1.8 cm less than for HL animals while LH animals were 2.3 cm lower than the HH group. There was no significant difference between sexes in carcass length, heart girth, height at withers, length of leg and width of legs.

In table 18, the difference between treatments was significant ($P/0.05$) for liveweight, slaughter weight, dressing percentage, weights of cold carcass, mesenteric fat, blood and liver.

Dressing percentage, weights of hot carcass, mesenteric fat and lungs were also significantly ($P/0.01$) different among treatment groups. The differences between animals on HH and LH treatments in liveweight and slaughter weight were about the same and this was 3.2 kg higher in the HH group. HL animals were about 4.6 kg more than LL animals in liveweight and slaughter weight. The dressing percentage of HH animals was 4.5% higher than the LH group while that of animals on LL treatment was 3.8% lower than for the HL group. Shrinking loss was more (about 2.4%) in HH animals than in the LH group while animals on LL treatment had less shrinking loss than the HL group. The mesenteric fat depositions in HH and HL groups were 50.0% higher than those of LH and LL groups correspondingly.

The liveweight and slaughter weight of the male animals were significantly ($P/0.05$) higher than those of the females. The female animals had a higher shrinking loss, dressing percentage and mesenteric fat than the males. However, the head and skin of the males weighed more than in

the females. Kidney fat in the females weighed 2.7 times more than that of the males.

4.2. Carcass Dissection:

Table 19 shows the means for weight of cuts and tissues in the cuts. The weights of leg, loin, shoulder and flank cuts were significantly ($P/0.05$) different between treatments while rack and shank cuts were highly significantly ($P/0.01$) different between treatments. The muscle in leg, sirloin and loin cuts were significantly ($P/0.05$) different between treatments. There was a significant ($P/0.05$) difference in the amount of fat contained in leg, loin, rack, shoulder, breast and flank cuts of the treatments.

The leg weight and legmuscle of animals on HH treatment were about 12.3% higher than those on LH treatment while the legfat in HH animals was 26.7% higher. LL animals were 20.0% less in legweight and legmuscle and 15% less in legfat than animals on HL treatment. The muscle in the Sirloin of HH animals was 22.0% higher than in LH animals while that of LL was 15% lower than in HL animals.

The loinweight, loinmuscle and loinfat of LH animals were 21.0%, 16.4% and 33.6% less than those of animals on HH treatment respectively. HL animals were 30% higher in loinweight and muscle, and 44.3% more in loinfat than animals on LL treatment.

Animals on LH treatment were about 0.8 times those of HH animals in rackweight, shoulder weight and shankweight. The muscle in rack, shoulder and shank cuts of HH animals was 1.3, 1.1 and 1.4 times higher than in animals on LH treatment respectively. LH animals had 0.5 and 0.8 times fat in rack and shoulder cuts respectively as in HH animals. HL animals were about 1.4 times more than animals on LL treatment in rackweight, shoulder weight, shankweight and in their respective muscle weights while fat in rack and shoulder cuts were 2.4 and 1.4 times higher in HL group.

The flankweight in LL animals was 29.0% less than in animals on HL treatment while those on HH treatment were 15.3% higher than LH animals.

Animals of HL treatment had 19.3% more breast bone than LL animals while HH animals had 31.6% more bone than LH animals. The breast fat and flankfat in HH animals were 50.0% and 31.6% respectively higher than in animals on LH treatment while HL animals were correspondingly higher than LL animals by 63.0% and 49.4% respectively.

The males had significantly ($P/0.05$) higher shankweight, neckweight and flank-muscle while the females were higher in legfat, breastfat and flankfat. There were significantly ($P/0.01$) more shank muscle and neckmuscle in the males than in the females.

Table 20 shows the means for percentage of tissues in left half of carcass and their proportions. The left half carcass of animals on HH and HL treatments on one hand were 1.2 times those of LH and LL treatments correspondingly. The total muscle of HH and HL animals were 1.1 and 1.4 times higher than those of LH and LL animals respectively while there was 1.2 times

more total fat in HH and HL than in LH and LL groups correspondingly.

The proportion of fat to bone shows that HH animals were 22.2% higher than the LH group of animals while animals on LL treatment were 33.3% less than HL animals. The percentages of total bone and fat in carcass were significantly ($P/0.05$) different between treatments. The HH animals had the highest percentage of total fat in their carcass while the LL animals had the least. HH animals had a higher percentage of total fat than LH animals by.4.5% while HL animals had more than the LL group by 3.1%. The LH animals had 4.1% more muscle relative to their carcass than was the case for animals on HH treatment. The males significantly had more percentage of total muscle and total fat than the females. The effect of dietary protein level on carcass composition directly influenced the proportion of the soft tissues (muscle and fat) in the carcass.

D I S C U S S I O N

Animals on HH treatments were heaviest because of the cumulative effects of higher mean carcass length, heart girth, height at withers, width of legs, weights of blood, head, feet, skin, liver, kidney fat and mesenteric fat. LH animals ranked second in mean liveweight because the following mean parameters ranked highest or second highest - carcass length, heart girth, width of legs, weight of blood, head, feet, skin liver, lungs, kidney fat, full and empty gastro-intestinal track. Animals on treatment HH were able to assume such a leading position in these parameters due to their higher crude protein and digestible crude protein intakes than animals on the other treatments during the overall period of the experiment. Since none of the carcass measurements attained a level of significance for treatment and sex when liveweight was added as a covariate to the model, the significant differences observed between treatments and sexes were due to differences in liveweight which might

in part be due to differences in efficiency of feed utilization. Thus, treatment and sex had effect on the different carcass measurements through liveweight.

Animals on LH treatment came to assume a second position in the above parameters possibly as a result of the compensatory process exhibited in feeding, digestibility and daily growth rate during the second half of the experiment and which ultimately boosted the overall efficiency of production for the entire experimental period.

The males had a significantly higher skin weight than the females due to the fact that they had more fold of skin with hair as dewlap - like mane, this being a secondary male character of the breed. This result partially agreed with that of Jagusch *et al.* (1970) who observed that irrespective of the dietary protein status, skin and blood made the most inefficient use of available nitrogen.

Since mean feed dry matter intake and empty gastro-intestinal tract weight were not significantly different between sexes, the significant

difference between the male and female mean full gastro-intestinal tract weight could have been due to incomplete gut evacuation and differences in water intake during the overnight starvation imposed on them before slaughter. This was contrary to the report of McMeekan (1940) with pigs that the apparent increase in the rate of gain in realimented animals was due to increase in gastro-intestinal tract content.

It appears that the lungs utilized nitrogen more efficiently during compensatory growth than animals on continuous good nutrition.

That there was no significant difference between the mean dressing percentage of HH and LH animals showed that realimentation with high protein ration resulted in more increase in the carcass than the offals. The females had a significantly greater mean dressing percentage because the males had heavier head and skin than the females. The heavier head in the males might be due to their horns which were absent in the females. The males had more neckweight than the females because they had significantly more neckmuscle

to support the heavier head of the males.

The differences between treatments in legweight and loinweight were due primarily to corresponding muscle weights in the cuts. The nonsignificant differences between treatments in rackmuscle, rackbone and rackfat cumulated to bring about the significant difference in rack-weight. Even though there were no significant differences between treatments in shank-muscle, shankbone and shankfat, they all cumulated to effect a significant difference between treatments in total weight of cuts which was due primarily to the additive effect of the significant differences in total muscle and total fat.

LH animals which underwent compensatory growth due to realimentation with high protein ration had total muscle and total fat which were not significantly lower than for HH animals which were adequately nourished throughout the experiment. That the muscle to bone and muscle to fat ratios were higher while fat to bone ratio was lower in LH than HH treatment groups meant that LH animals

had proportionately more muscle and less fat than HH animals. This result agrees with those of Haecker (1920); Sheehy and Senior (1942); Steensbery (1947); and Reid *et al.* (1955) who suggested that realimented animals of the same liveweight as unrestricted controls proportionately had more muscle and less fat than the latter group. On the contrary, Wilson, 1960; Wilson and Osbourn, 1960 observed that realimented animals had more body fat than the unrestricted controls. It is probable that this disparity in result as to the relative tissue composition of the carcass of realimented animals compared to the unrestricted controls could have been due to differences in the stage of development of the animals used, the intake, digestibility and utilization of the feed used for realimentation.

With a smaller mean muscle to fat and fat to bone ratios, animals on HH treatment contained more percent total fat than those on LH treatment. Since fat shrinks more than muscle and bone, the carcass of HH animals shrank more than that of LH animals.

As the females had a lower percent muscle to fat and higher fat to bone than the males, the females shrank more than the males because the former contained more percentage of total fat. The higher percentage of muscle in males than in the female animals was probably as a result of male secondary sexual character due to the influence of testosterone while oestrogens made the females have more percentage of fat than the males (Hafez, 1969).

CONCLUSION

This study has shown that weaned Yankasa lambs realimented with a high protein diet demonstrated compensatory response in terms of higher feed consumption rate and liveweight gain than the unrestricted controls. The continuously well nourished animals however, attained a specified weight much faster than higher liveweight gain.

The cost of production of weaned Yankasa lambs was less for low protein treatments than for high protein treatments. However, the well - fed animals had the least overall cost of production per kg weight gain while those on continuously poor diet had the highest.

Good nutrition thus saves time, labour and money compared to realimented or poor feeding.

The results of carcass analysis show that the components and cuts of carcass are in a definite proportionate relationship with liveweight irrespective of the nutritional treatments the animal may have been subjected to.

The animals on high protein ration have a higher dressing percentage, percents total fat and total muscle but less percent total bone than those on low protein ration. This was due to the fact that muscle and fat development are more easily influenced than bone by dietary protein level. The realimented animals had relatively more total muscle and less fat than the unrestricted control animals.

TABLE 17: MEANS OF CARCASS MEASUREMENTS

Treatment	No of replicates	Means of carcass measurements				
		Carcass length (cm)	Heart girth (cm)	Height at withers (cm)	Length of leg (cm)	Width of legs (cm)
HH	6	77.333	69.750^{c}	47.400^{c}	39.750	26.333^{c}
HL	6	77.250	66.750^{cd}	46.750^{cd}	39.867	22.917^{cd}
LH	5	74.100	67.500^{cd}	45.700^{cd}	40.100	24.100^{cd}
LL	5	72.700	60.660^{d}	43.100^{d}	39.800	21.100^{d}
SE		4.985	3.572	2.121	2.500	2.045
Male	10	74.050	67.300	46.944	39.270	23.450
Female	12	76.750	65.567	44.917	40.375	23.917
SE		2.493	1.786	1.065	1.250	1.023

Values with different superscripts within the same column and subclass are significantly different (a,b at 1%; c,d,e,f) in Tables 17 to 20.

TABLE 18: MEANS OF LIVEWEIGHT, CARCASS WEIGHT AND WEIGHTS OF ORGANS

Treatment	No of replicates	Means of liveweight, Carcass weight and weights of organs										
		Liveweight (kg)	Slaughter weight (kg)	Dressing Percentage (kg)	Hot carcass (kg)	Cold carcass (kg)	Shrink loss (%)	Mesenteric fat (kg)	Blood (kg)	Head (kg)	Feet (kg)	Skin (kg)
HH	6	30.990	29.358^{c}	53.122^{a}	16.500^{a}	14.925^{c}	9.605	1.620^{ad}	1.317^{c}	2.100	0.750	2.600
HL	6	25.337^{cd}	24.158^{cd}	46.927^{cd}	11.892^{ab}	10.792^{cd}	9.433	0.608^{cb}	0.917^{cd}	1.800	0.700	1.917
LH	5	27.524^{cd}	26.190^{cd}	48.611^{ac}	13.300^{ab}	12.350^{cd}	7.243	0.750^{acb}	1.060^{cd}	1.880	0.720	2.400
LL	5	20.502^{d}	19.590^{d}	43.052^{bd}	8.820^{b}	8.050^{d}	8.933	0.300^{b}	0.780^{d}	1.500	0.560	1.780
SE		4.491	4.185	2.174	2.405	2.268	1.831	0.358	0.192	0.293	0.118	0.420
Male	10	28.941^{c}	27.510^{c}	46.727^{c}	13.720	12.695	7.587^{a}	0.833^{a}	1.120	2.230^{a}	0.730	2.510^{a}
Female	12	24.057^{d}	22.908^{d}	49.278^{d}	11.979	10.779	9.936^{b}	0.979^{b}	0.950	1.500^{b}	0.650	1.908^{b}
SE		2.245	2.092	1.181	1.202	1.134	0.915	0.179	0.096	0.146	0.059	0.210

Treatment	No of replicates	Gastro-intestinal tract (full) (kg)	Gastro-intestinal tract (empty) (kg)	Heart (kg)	Liver (kg)	Lungs (kg)	Spleen (kg)	Kidneys (kg)	Kidney-fat (kg)
HH	6	4.617	2.433	0.142	0.442^{c}	0.600^{ab}	0.100	0.108	0.792
HL	6	5.800	2.383	0.108	0.325^{d}	0.550^{ab}	0.075	0.092	0.417
LH	5	5.260	2.440	0.140	0.430^{c}	0.670^{a}	0.080	0.100	0.460
LL	5	5.420	1.820	0.120	0.300^{d}	0.410^{b}	0.060	0.090	0.240
SE		1.012	0.410	0.027	0.047	0.101	0.000	0.000	0.326
Male	10	5.970	2.490	0.135	0.405^{c}	0.580	0.090	0.105	0.255^{c}
Female	12	4.683^{d}	2.108	0.121	0.350^{d}	0.542	0.71	0.092	0.683^{d}
SE		8.506	0.205	0.014	0.023	0.051	0.000	0.000	0.163

TABLE 14: MEANS OF WEIGHTS AND WEIGHTS IN CUTS (kg)

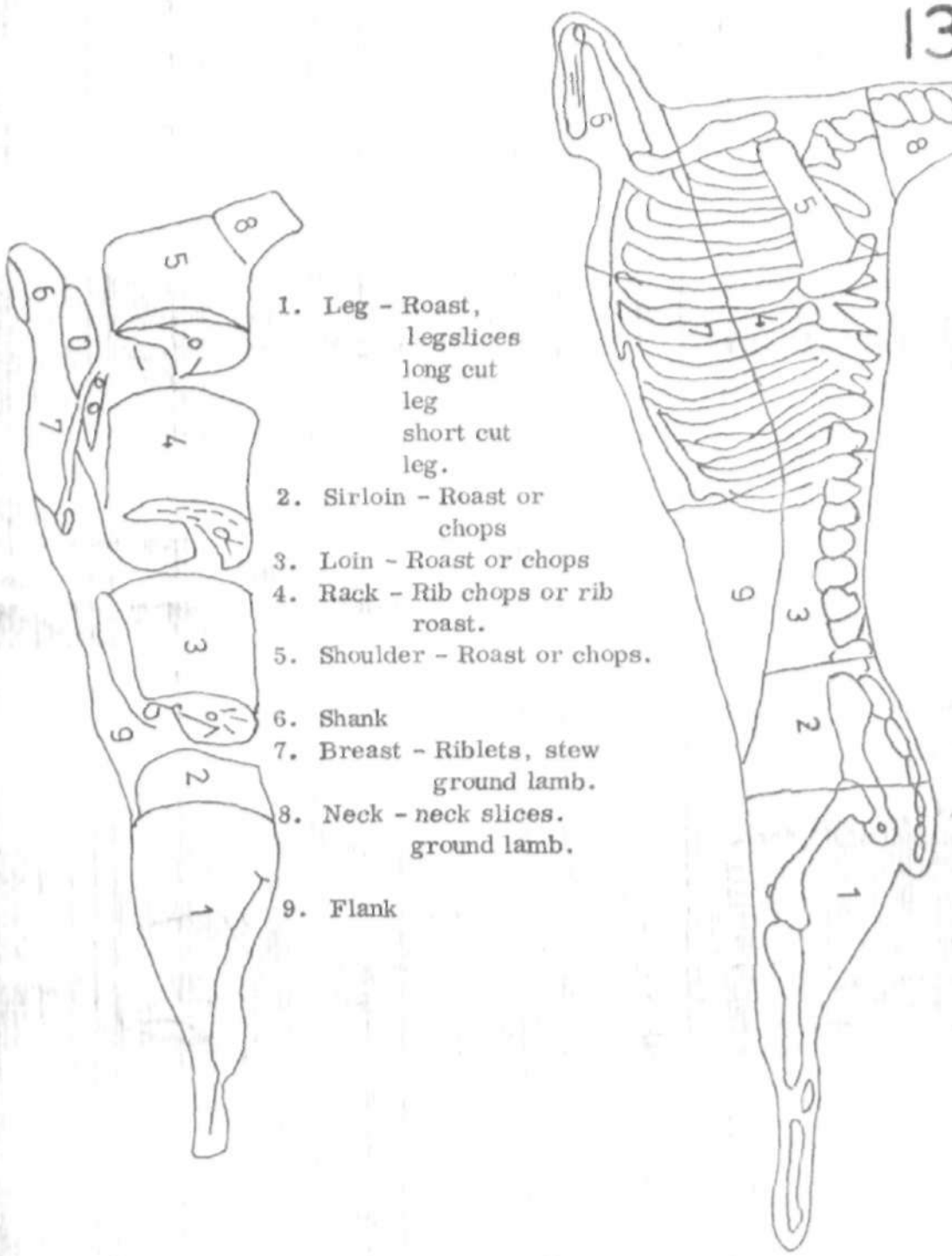
Treatment	No of replicates	Leg				Sirloin				Loin			
		Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat
HH	6	1.638^{c}	1.169^{c}	0.322	0.146^{a}	0.228	0.151^{c}	0.020	0.057	0.911^{c}	0.496^{c}	0.175	0.241^{a}
HL	6	1.104^{cd}	0.917^{cd}	0.285	0.082^{bc}	0.145	0.101^{cd}	0.015	0.028	0.617^{cd}	0.345^{cd}	0.162	0.115
LH	5	1.446^{cd}	1.014^{cd}	0.305	0.107^{ab}	0.176	0.118^{cd}	0.014	0.044	0.721^{cd}	0.414^{cd}	0.147	0.160^{abc}
LL	5	1.045^{d}	0.737^{d}	0.251	0.057^{b}	0.188	0.136^{d}	0.043	0.059	0.439^{d}	0.241^{d}	0.133	0.064
SE		0.213	0.165	0.038	0.027	0.066	0.027	0.027	0.038	0.148	0.072	0.038	0.052
Male	10	1.392	0.997	0.314	0.080^{c}	0.201	0.119	0.030	0.052	0.681	0.393	0.162	0.127
Female	12	1.345	0.951	0.278	0.116^{d}	0.171	0.112	0.016	0.042	0.682	0.366	0.151	0.166
SE		0.107	0.082	0.019	0.014	0.033	0.014	0.014	0.019	0.073	0.036	0.019	0.030

Treatment	No of replicates	Rack				Shoulder				Shank			
		Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat
HH	6	0.682^{ac}	0.358^{a}	0.171	0.154^{c}	1.417^{c}	0.880	0.318	0.220^{c}	0.861^{ac}	0.502^{a}	0.222	0.138
HL	6	0.449^{cd}	0.224^{b}	0.144	0.081^{cd}	1.041^{cd}	0.639	0.264	0.139^{cd}	0.645^{c}	0.362^{c}	0.180	0.103
LH	5	0.495^{cd}	0.284^{ab}	0.122	0.079^{cd}	1.238^{cd}	0.784	0.279	0.175^{cd}	0.665^{c}	0.368^{c}	0.200	0.098
LL	5	0.323^{bd}	0.174^{bc}	0.115	0.034^{d}	0.784^{d}	0.486	0.199	0.099^{d}	0.424^{bd}	0.240^{b}	0.142	0.042
SE		0.098	0.038	0.027	0.054	0.279	0.193	0.072	0.047	0.105	0.054	0.038	0.047
Male	10	0.505	0.283	0.156	0.066	1.265	0.803	0.301	0.161	0.725^{c}	0.429^{a}	0.202	0.094
Female	12	0.486	0.246	0.130	0.110	1.018	0.619	0.239	0.160	0.603^{d}	0.327^{b}	0.175	0.100
SE		0.049	0.019	0.014	0.027	0.139	0.097	0.036	0.023	0.052	0.027	0.019	0.023

Treatment	No of replicates	Breast				Neck				Flank			
		Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat
HH	6	0.607	0.316	0.158^{a}	0.111^{a}	0.600	0.355	0.140	0.104	0.339^{c}	0.180	0.001	0.158^{c}
HL	6	0.383	0.204	0.088^{c}	0.091^{abc}	0.447	0.267	0.134	0.045	0.237^{cd}	0.147	0.003	0.087^{cd}
LH	5	0.793	0.619	0.108^{abc}	0.066^{bc}	0.441	0.257	0.128	0.056	0.287^{cd}	0.176	0.003	0.108^{cd}
LL	5	0.268	0.164	0.071^{b}	0.031^{b}	0.401	0.183	0.097	0.021	0.168^{d}	0.104	0.000	0.044^{d}
SE		0.325	0.333	0.027	0.024	0.138	0.081	0.038	0.018	0.061	0.038	0.000	0.018
Male	10	0.463	0.293	0.121	0.071^{c}	0.542^{c}	0.351^{a}	0.127	0.064^{b}	0.354	0.182^{c}	0.001	0.072^{c}
Female	12	0.331	0.142	0.097	0.111^{d}	0.181^{d}	0.102^{b}	0.125	0.053	0.166	0.127^{d}	0.002	0.136^{d}
SE		0.142	0.166	0.014	0.021	0.070	0.041	0.019	0.019	0.061	0.019	0.000	0.019

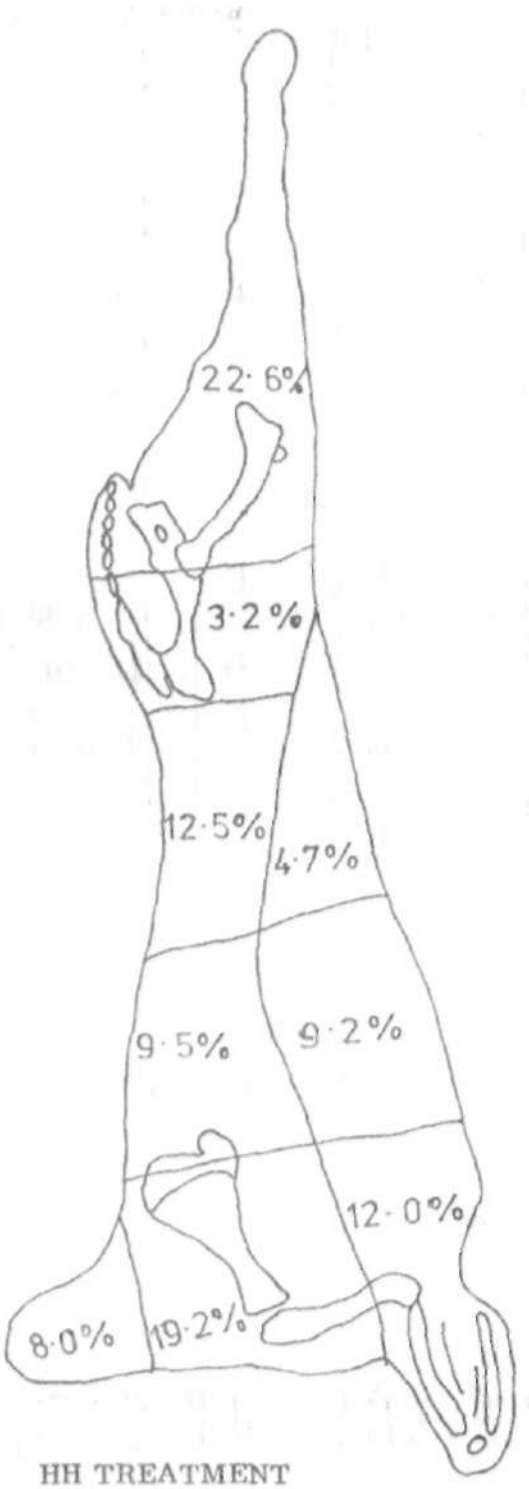
TABLE 20: MEANS OF PERCENTAGE OF TISSUES IN LEFT HALF CARCASS AND THEIR PROPORTION

Treatment	No of replicates	Weight				Percentage			Ratios		
		Half (kg)	Muscle (kg)	Bone (kg)	Fat (kg)	Muscle (%)	Bone (%)	Fat (%)	Muscle:Bone (%)	Muscle:fat (%)	Fat:Bone (%)
HH	6	7.283^{c}	4.406^{c}	1.527	1.351^{c}	60.390	20.921^{c}	18.689^{c}	2.910	3.579	0.922^{c}
HL	6	5.271^{cd}	3.315^{cd}	1.284	0.772^{cd}	60.884	24.618^{cd}	14.492^{cd}	2.491	4.779	0.593^{cd}
LH	5	6.152^{cd}	4.044^{c}	1.316	0.893^{cd}	64.465	21.385^{c}	14.150^{cd}	3.096	4.754	0.678^{cd}
LL	5	3.940^{d}	2.435^{d}	1.052	0.451^{d}	61.728	26.827^{d}	11.404^{d}	2.306	5.739	0.426^{d}
SE		1.070	0.721	0.218	0.254	3.168	1.918	2.803	0.365	1.193	0.167
Male	10	6.027	3.850	1.414	0.762	63.945^{c}	23.972	12.058^{a}	2.684	5.634^{c}	0.512^{a}
Female	12	5.502	3.302	1.213	0.986	59.929^{d}	22.881	17.190^{b}	2.714	3.856^{d}	0.790^{b}
SE		0.535	0.361	0.109	0.127	1.584	0.958	1.402	0.183	0.597	0.083

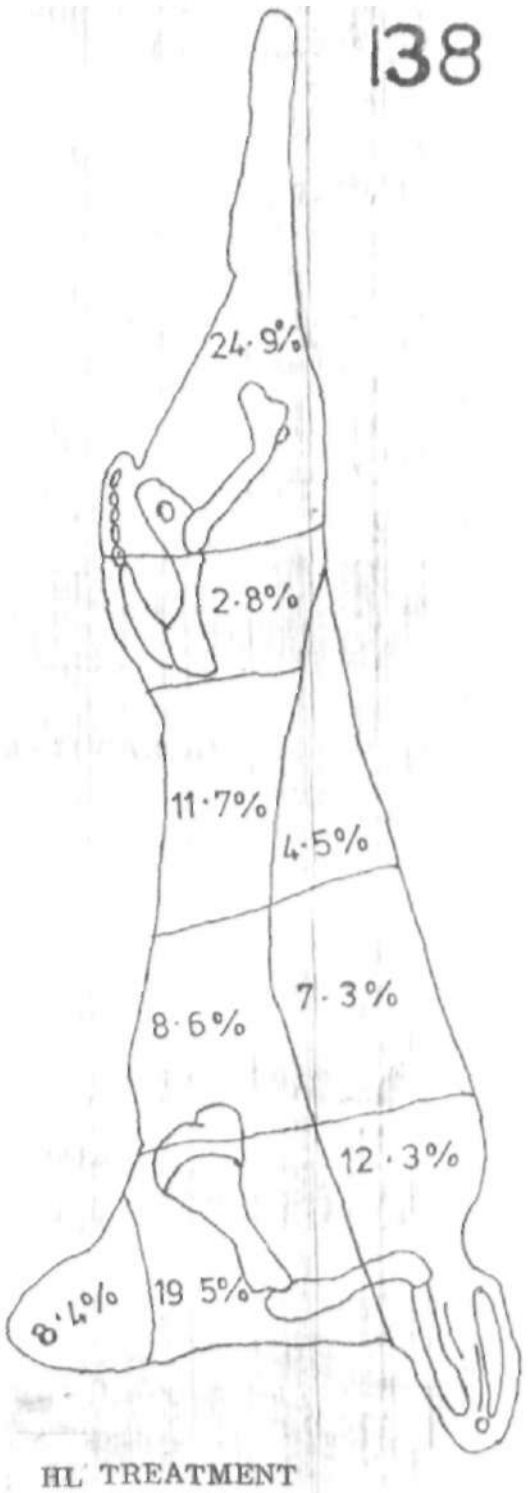


1. Leg - Roast, legslices long cut leg short cut leg.
2. Sirloin - Roast or chops
3. Loin - Roast or chops
4. Rack - Rib chops or rib roast.
5. Shoulder - Roast or chops.
6. Shank
7. Breast - Riblets, stew ground lamb.
8. Neck - neck slices. ground lamb.
9. Flank

FIGURE 1: LAMB CUTTING CHARTS

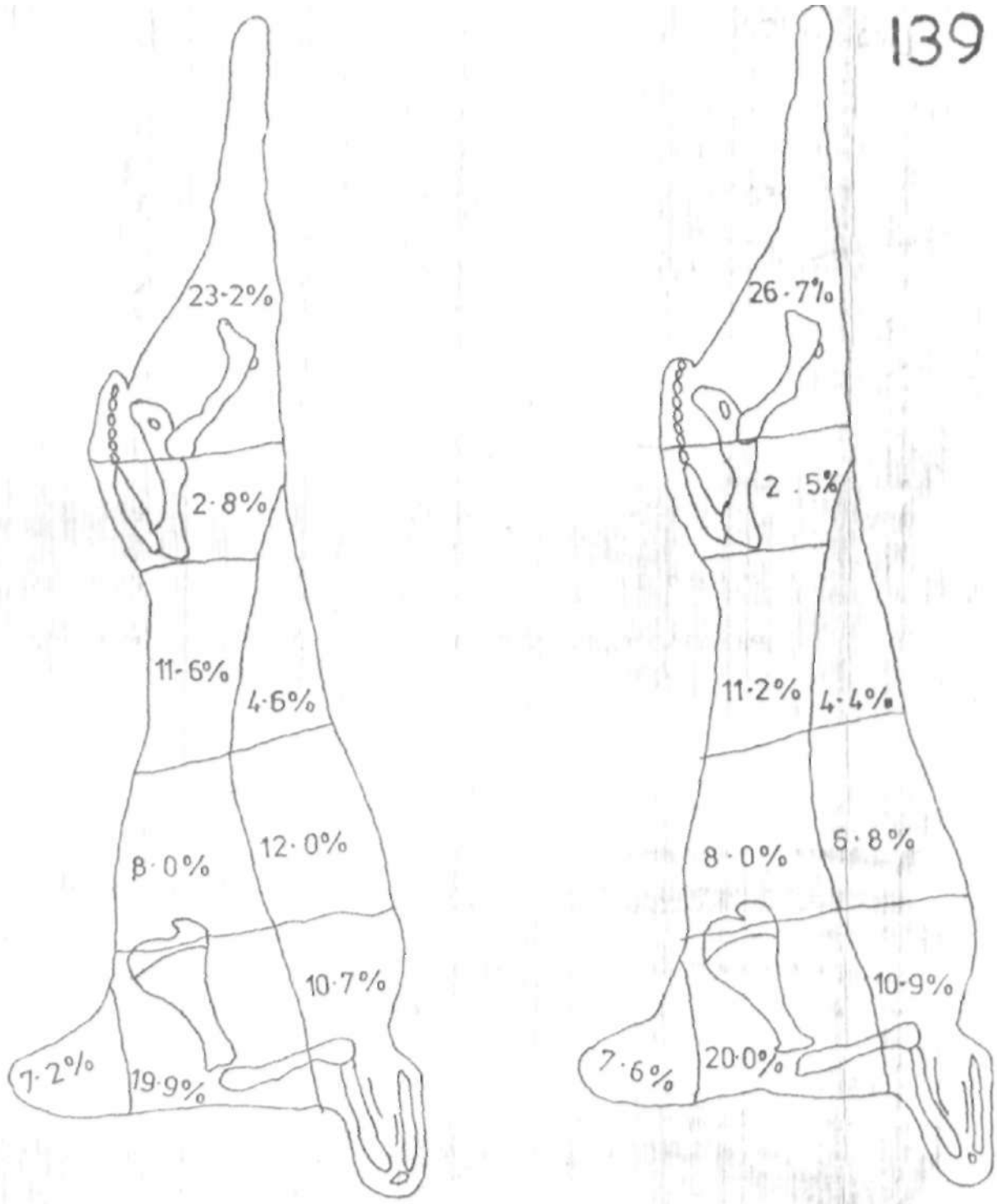


HH TREATMENT



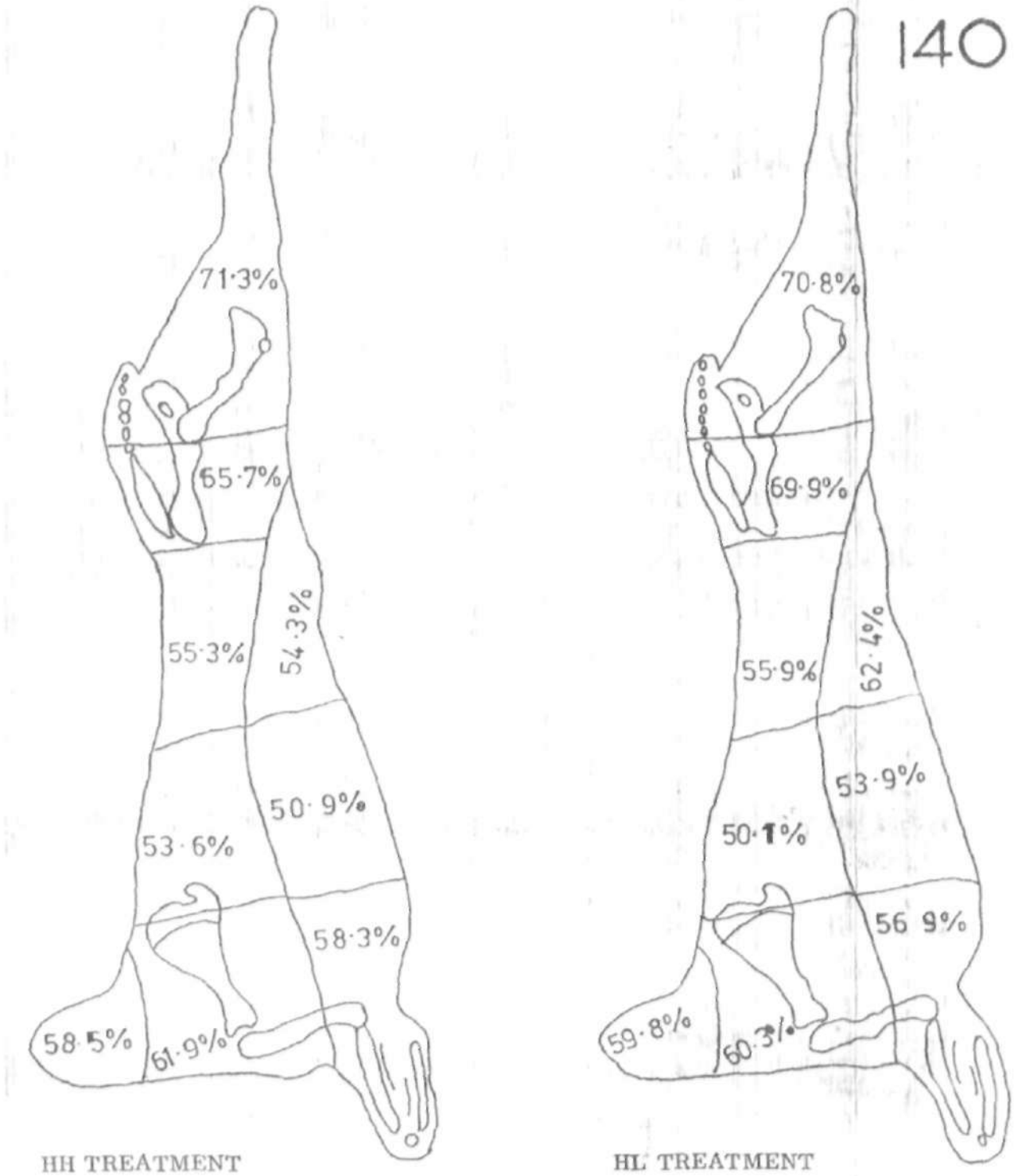
HL TREATMENT

FIGURE 2a: *PERCENTAGE CUTS OF TREATMENT CARCASS.*



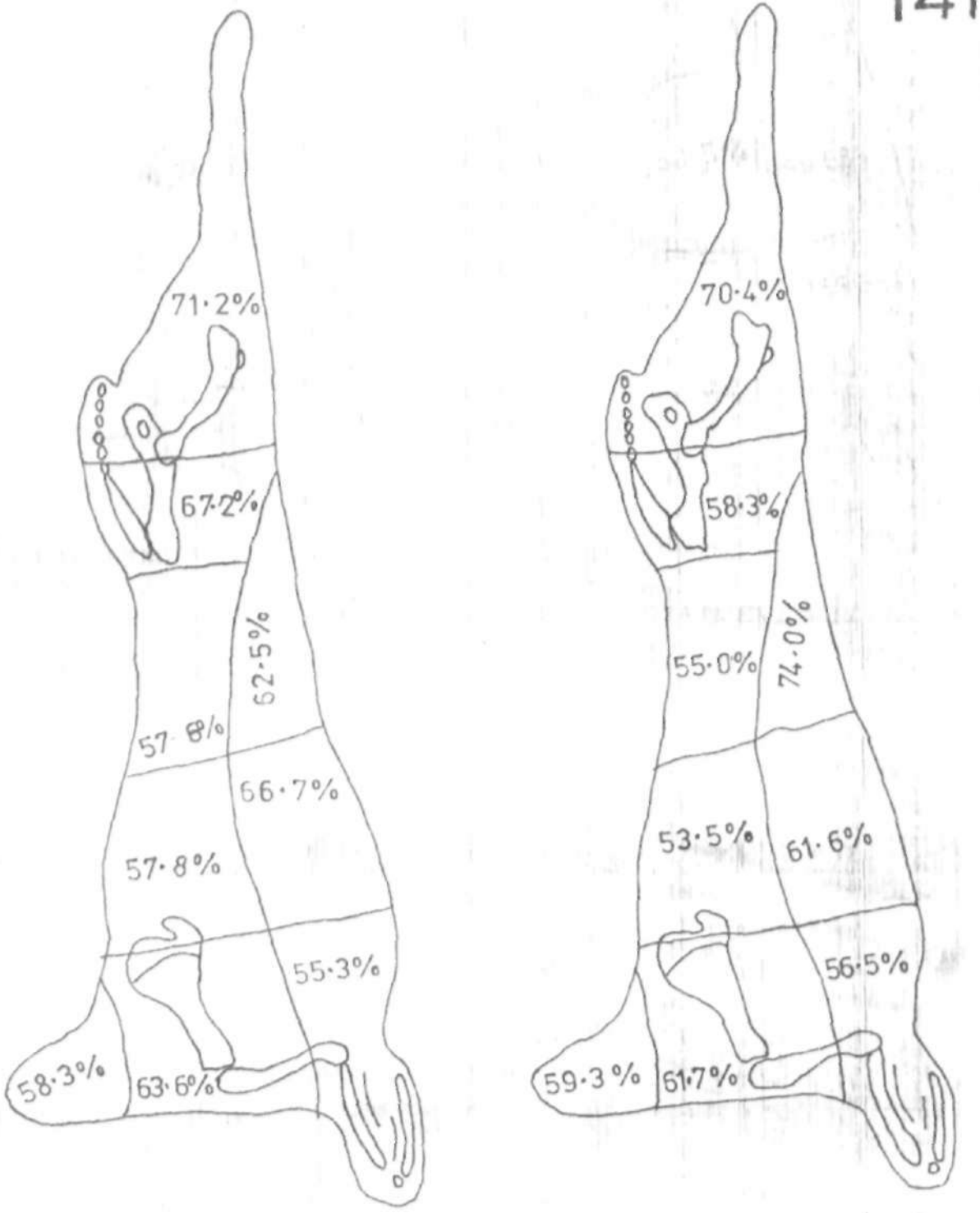
LH TREATMENT LL TREATMENT

FIGURE 2b: PERCENTAGE CUTS OF TREATMENT CARCASS.



HH TREATMENT HL TREATMENT

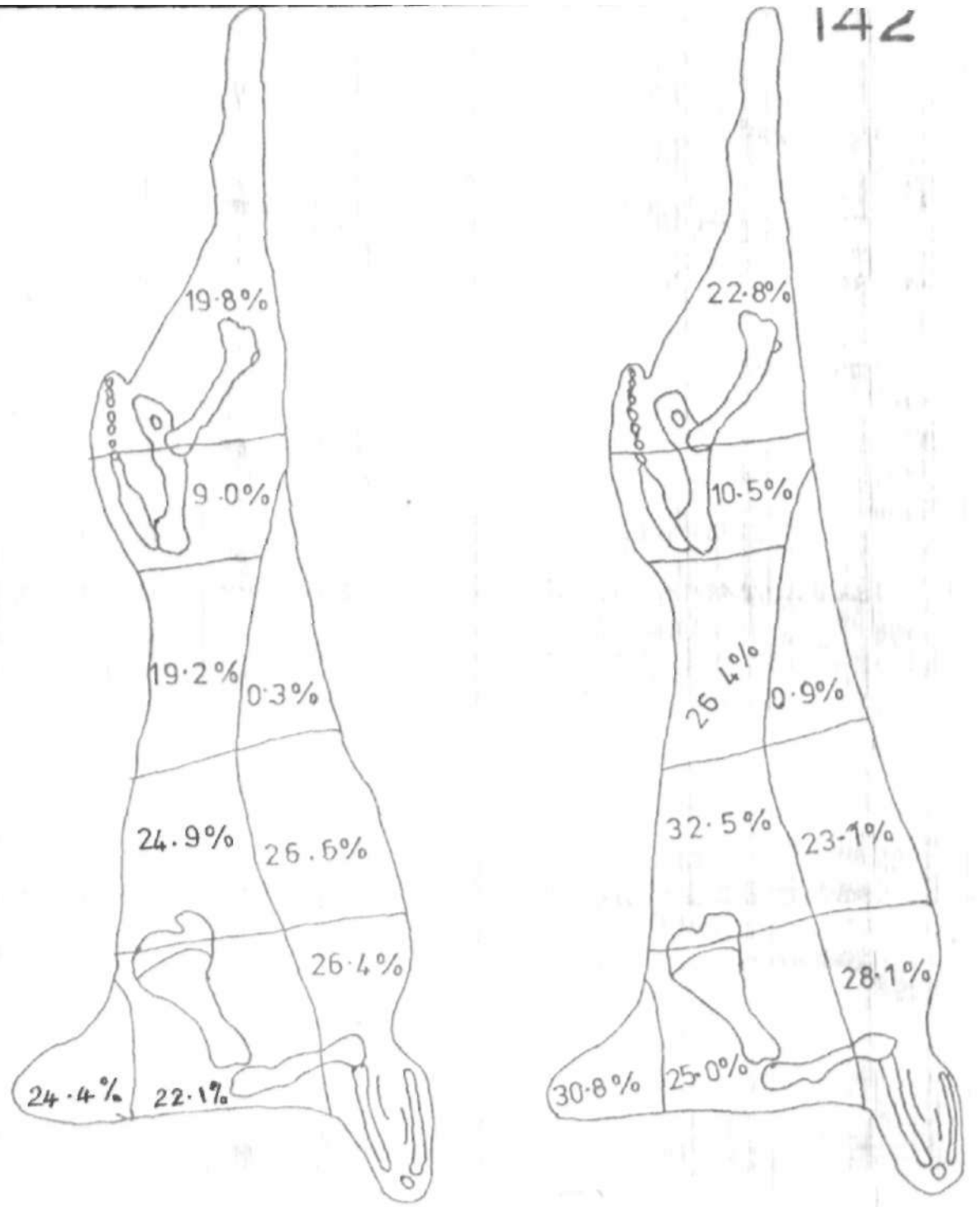
FIGURE 3a: PERCENTAGE MUSCLE IN CUTS OF TREATMENT CARCASS.



LH TREATMENT

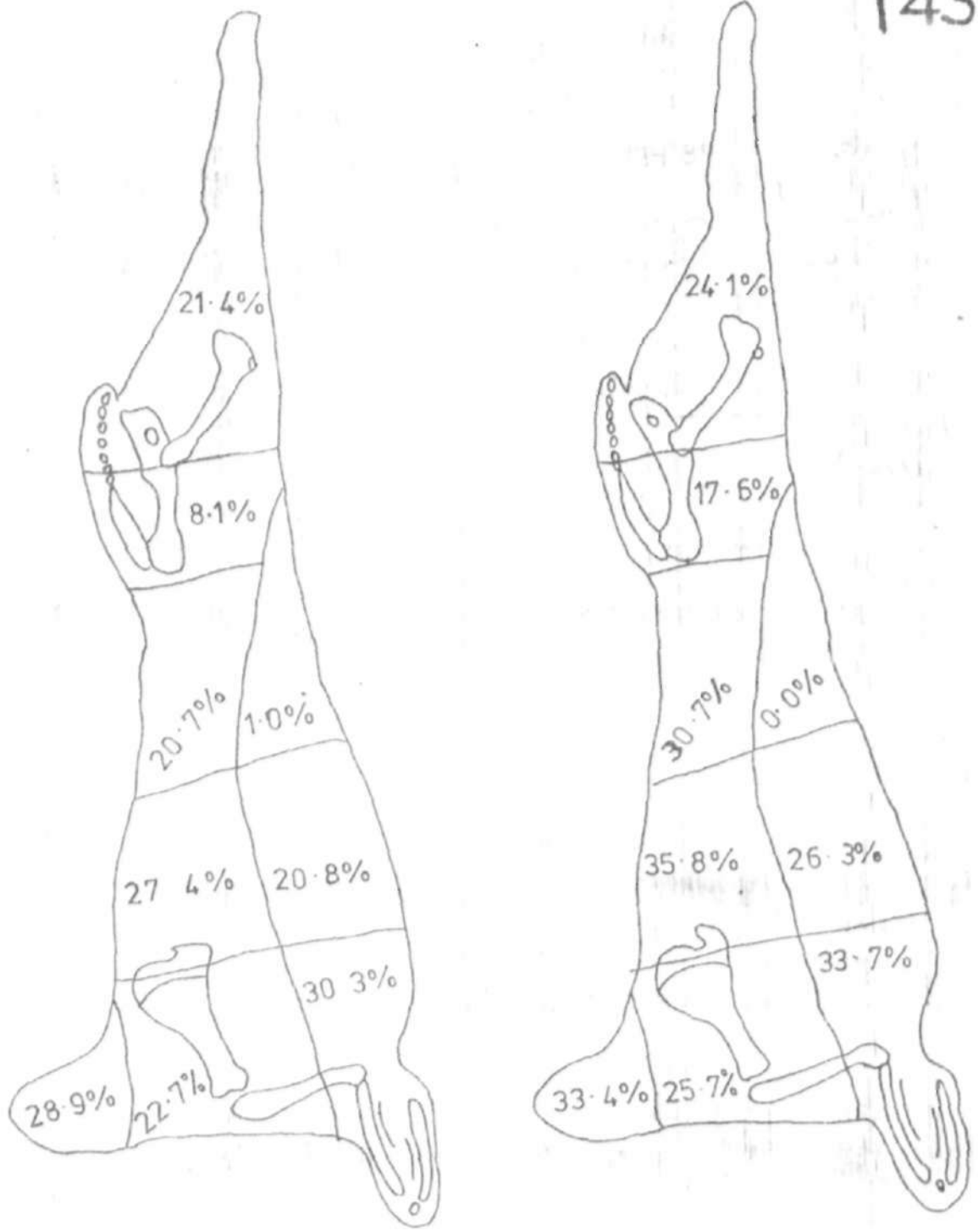
LL TREATMENT

FIGURE 3b: PERCENTAGE MUSCLE IN CUTS OF TREATMENT CARCASS.



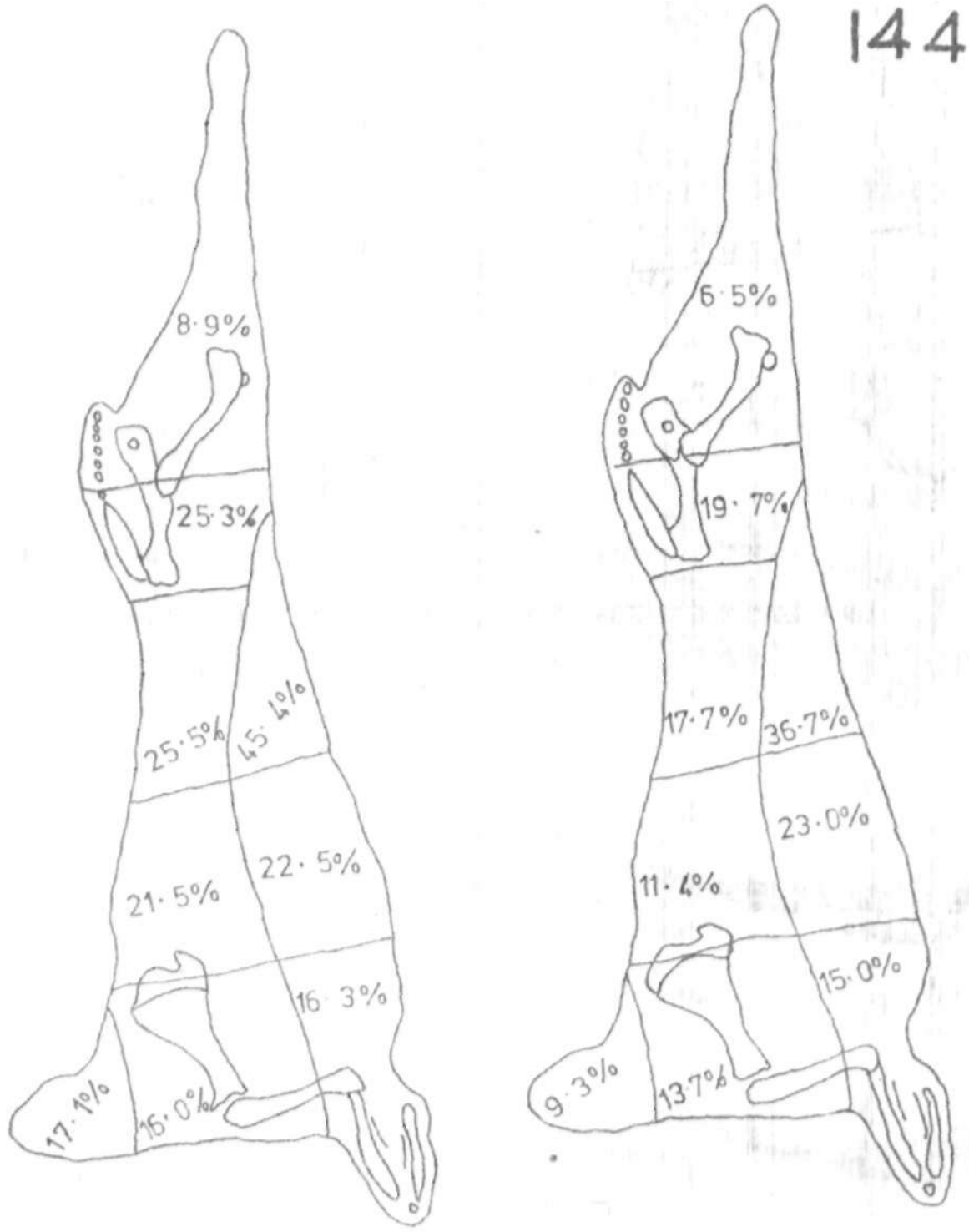
HH TREATMENT HL TREATMENT

FIGURE 4a: PERCENTAGE BONE IN CUTS OF TREATMENT CARCASS.



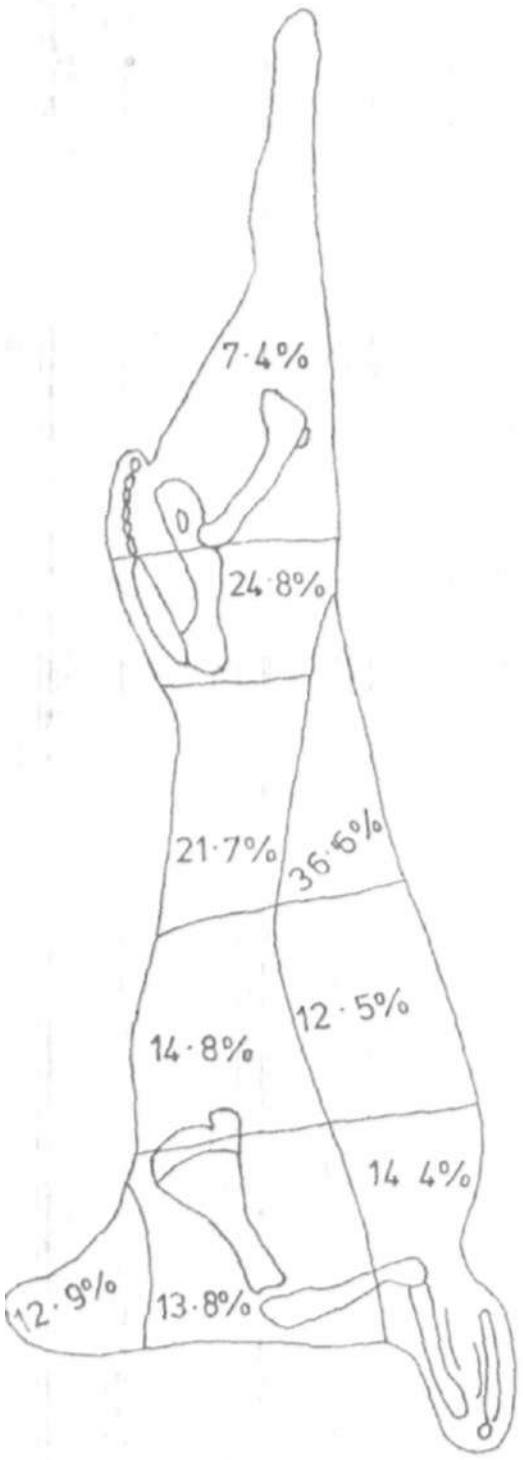
LH TREATMENT LL TREATMENT

FIGURE 4b: PERCENTAGE BONE IN CUTS OF TREATMENT CARCASS

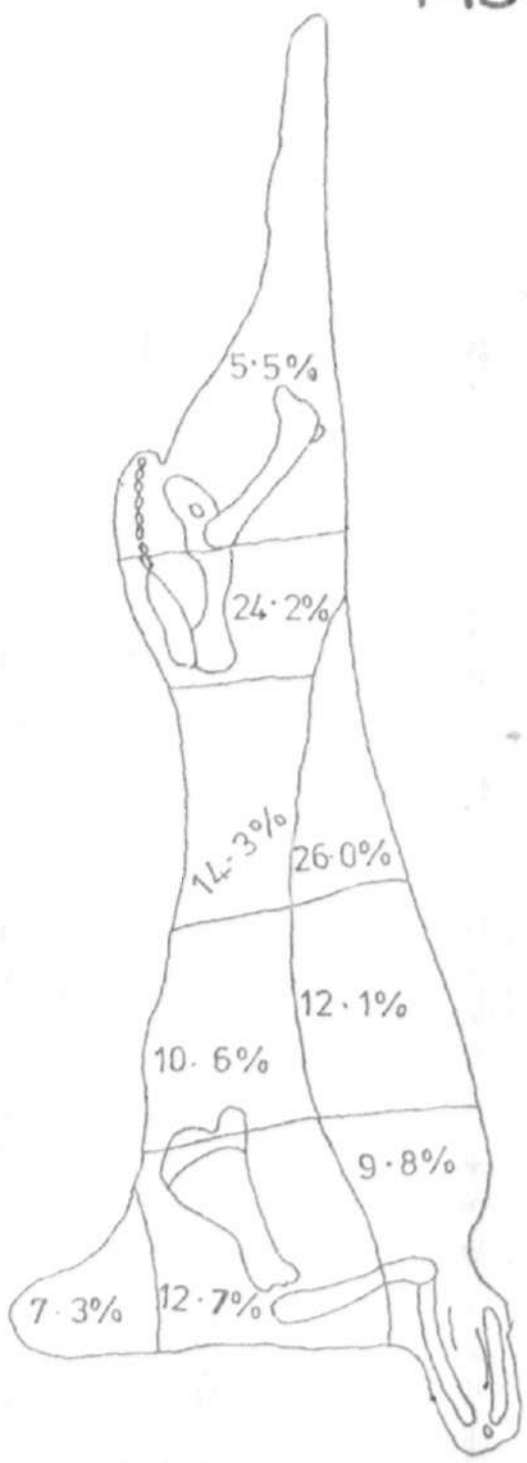


HH TREATMENT HL TREATMENT

FIGURE 5a: PERCENTAGE FAT IN CUTS OF TREATMENT CARCASS.



LH TREATMENT



LL TREATMENT

FIGURE 5b: PERCENTAGE FAT IN CUTS OF TREATEMNT CARCASS.

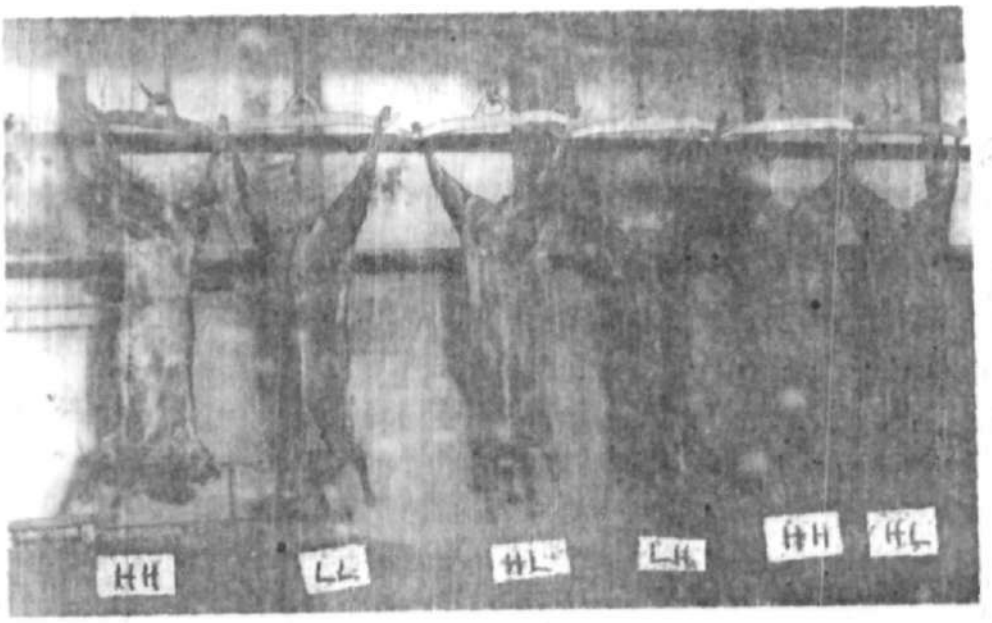


PLATE 12 : CARCASS FROM DIFFERENT TREATMENTS IN THE FIRST BATCH OF SLAUGHTER

HH AND LL = GROUPS OF ANIMALS ON HIGH AND LOW PROTEIN RATIONS RESPECTIVELY THROUGH OUT THE EXPERIMENT.

HL AND LH = GROUPS OF ANIMAL ON HIGH OR LOW PROTEIN RATIONS FOR THE FIRST 100 DAYS BUT WHICH WERE SWITCHED OVER TO LOW OR HIGH PROTEIN RATIONS RESPECTIVELY FOR THE SECOND HALF OF THE EXPERIMENT.



PLATE 13: CARCASS FROM DIFFERENT TREATMENTS IN THE SECOND BATCH OF SLAUGHTER.

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APPENDIX

TABLE 17b: ANALYSIS OF VARIANCE OF CARCASS MEASUREMENTS

Source	df	Mean squares of carcass measurements				
		Carcass length (cm^2)	Heart girth (cm^2)	Height at withers (cm^2)	Length of leg (cm^2)	Width of legs (cm^2)
Treatment	3	49.901	80.907*	17.529	0.090	27.056**
S e x	1	19.804	14.267	19.024	6.556	2.467
Error	17	33.892	17.408	6.191	8.521	5.704

TABLE 16b: ANALYSIS OF VARIANCE OF LIVEWEIGHT, CARCASS WEIGHT AND WEIGHTS OF ORGANS

Source	df	Mean square of liveweight carcass weight and weights of organs										
		Live-Weight (kg^2)	Slaughter weight kg^2)	Dressing percentage ($\%^2$	Hot carcass (kg^2)	Cold carcass (kg^2)	Shrink loss $(\%)^2$	Mesenteric fat (kg^2)	Blood (kg^2)	Head (kg^2)	Feet (kg^2)	Skin (kg^2)
Treat-ment	3	98.315*	86.631*	95.729**	54.072**	43.668**	7.505	1.585**	0.285**	0.275	0.035	0.809*
Sex	1	116.584	105.856*	41.953*	11.223	15.000	34.226**	0.719	0.125	2.731**	0.028	1.884**
Error	17	27.502	23.880	6.444	7.886	7.015	4.570	0.175	0.050	0.117	0.019	0.240

Source	df	Gastro-intestinal tract (full) (kg^2)	Gastro-intestinal tract (empty) (kg^2)	Heart (kg^2)	Liver (kg^2)	Lungs (kg^2)	Spleen (kg^2)	Kidneys (kg^2)	Kidney fat (kg^2)
Treat-ment	3	1.546	0.429	0.002	0.028**	0.061*	0.001*	0.000	0.343
Sex	1	9.309*	0.690	0.001	0.016*	0.007	0.002	0.001	1.134
Error	17	1.396	0.229	0.001	0.003	0.014	0.000	0.000	0.145

TABLE 19b: ANALYSIS OF VARIANCE OF WEIGHT CUTS AND TISSUES IN CUTS (kg^2)

Source	df	Mean squares of tissues in carcass cuts											
		Leg				Sirloin				Loin			
		Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat
Treatment	3	0.332**	0.176**	0.005	0.009**	0.007	0.004**	0.001	0.001	0.214**	0.062**	0.002	0.033**
Sex	1	0.003	0.005	0.006	0.008**	0.005	0.000	0.001	0.001	0.002	0.002	0.000	0.012
Error	17	0.062	0.037	0.002	0.001	0.006	0.001	0.001	0.002	0.029	0.007	0.002	0.005

Source	df	Rack				Shoulder				Shank			
		Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat
Treatment	3	0.123**	0.034**	0.003	0.015**	0.382*	0.153	0.012	0.015**	0.166**	0.055**	0.006*	0.009*
Sex	1	0.000	0.006	0.003	0.014	0.278	0.162	0.018	0.000	0.057*	0.044**	0.003	0.001
Error	17	0.013	0.002	0.001	0.004	0.106	0.051	0.007	0.003	0.015	0.004	0.002	0.003

Source	df	Breast				Neck				Flank			
		Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat	Weight	Muscle	Bone	Fat
Treatment	3	0.281	0.215	0.008**	0.011**	0.074	0.023	0.002	0.007*	0.009**	0.004	0.000	0.013**
Sex	1	0.040	0.007	0.001	0.027	0.118	0.107**	0.000	0.000	0.002	0.010*	0.000	0.019**
Error	17	0.104	0.051	0.001	0.003	0.026	0.009	0.001	0.001	0.005	0.002	0.000	0.002

TABLE 20b: ANALYSIS OF VARIANCE OF PERCENTAGE OF TISSUES IN LEFT SIDE OF CARCASS AND THEIR PROPORTIONS

Source	df	Mean squares of tissue in carcass cuts								
		Weights			Percentages			Ratios		
		Side	Muscle	Bone	Fat	%Muscle	%Bone	%Fat	Muscle:Bone	Muscle:Fat	Fat:Bone
Treatment	3	10.841**	4.065**	0.191	0.809**	21.518	42.182**	58.277**	0.695*	5.093	0.261**
Sex	1	0.914	1.324	0.177	0.382*	100.079	8.264	167.447**	0.005	19.576**	0.492
Error	17	1.560	0.709	0.065	0.088	13.689	5.006	10.716	0.182	1.942	0.038