EFFECT OF FEEDING POULTRY WASTE BASED DIETS ON MILK PRODUCTION FROM GALLA GOATS.

BY

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DECLARATION:

This thesis is my original work and has not been presented for a degree in any other University.

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LIST OF ABBREVIATIONS

ADF	=	Acid Detergent Fibre
ADG	=	Average Daily Gain
APW	=	Autoclaved Poultry Waste
CF	=	Crude Fibre
CHM	=	Caged Hen Manure
CLW	=	Caged Layer Waste
CP	=	Crude Protein
CPW	=	Cooked Poultry Waste
CSC	=	Cotton Seed Cake
CSM	=	Cotton Seed Meal
DM	=	Dry Matter
DMI	=	Dry Matter Intake
DPG	=	Dual Purpose Goat
DPW	=	Dried Poultry Waste
EE	=	Ether Extract
FCM	=	Fat Corrected Milk
N	=	Nitrogen
N.A.H.R.C.	=	National Animal Husbandry Research Centre
NDF	=	Neutral Detergent Fibre
NFE	=	Nitrogen Free Extract
NPN	=	Non Protein Nitrogen
OM	=	Organic Matter
PEL	=	Poultry Excreta Litter
PL	=	Poultry Litter
PW	=	Poultry Waste
RMO'S	=	Rumen Microorganisms
SBM	=	Soybean Mean
SNF	=	Solid Not fat
SR-CRSP	=	Small Ruminant Collaborative Support Programme
TDN	=	Total Digestible Nutrients

ABSTRACT

A study was conducted to examine the potential of poultry waste as a source of nitrogen in supplemental diets for lactating Galla goats. In Experiment I. eighty four goats (21 per treatment) maintained on *Chloris gayana* hay were supplemented for 12 weeks of lactation with 500g (as is) of concentrate containing 0, 15, 30 and 45% poultry waste for Treatment I, II, III and IV respectively. The poultry waste used, was obtained from the litter after disposal of layer pullets at the end of the laying period. The basic litter materials (wood shavings) were sieved off through a 1cm wire grid before feeding. The experiment lasted for 90 days.

With an increase in the level of poultry waste from 0 to 45% there was a corresponding increase in the mean percent proximate composition values of ASH: 5.9 to 8.4; CF: 12.1 to 15.7 and ADF: 13.4 to 17.8 in the four treatment diets. Values for the other proximate components viz:- DM, OM, EE, CP and NFE were similar.

All the concentrate diets were acceptable to the goats without any appreciable leftovers. Voluntary hay DM intake was 1020.7$\pm$31.3, 1026.0$\pm$31.6, 1050.6$\pm$30.5 and 1069.3$\pm$31.3 g/doe/day for Treatment I, II, III and IV respectively, showing no significant (P>0.05) difference among the treatments. The mean 12 week lactation yields were 680.7$\pm$62.6, 730.6$\pm$63.6, 600.7$\pm$61.2 and 673.1$\pm$63.9 mls/doe/day for Treatment I, II, III and IV respectively with no significant

(P>0.05) differences among treatments.

The mean percentage values for the milk composition in the four Treatments ranged from 13.3±0.25 and 13.9±0.26 for Total Solids; 4.2±0.14 and 4.6±0.14 for Gerber Fat; 9.1±0.22, and 9.6±0.22 for Solid Not Fat; 3.9±0.09, and 4.1±0.09 for Total protein and 0.7±0.17 and 0.8±0.17 for ASH. No statistically significant (P>0.05) differences among treatment means were observed. However, there was a trend towards increasing Gerber Fat and Ash contents as the poultry waste levels were raised in the treatment diets.

During the study period, all the does lost weight, in the order of 61.4±8.4, 63.9±8.9, 69.2±8.6 and 63.1±8.9 g/doe/day for Treatment I, II, III and IV respectively, but the differences were not statistically significant (P>0.05). The respective growth rates for the kids were 55.5±3.1, 50.6±3.4, 51.4±3.5 and 48.4±3.2 g/kid/day over the same period.

In Experiment. II twenty four goats (six per treatment diet) were used to determine the digestibilities of the various nutrients of the diets used in Experiment I. The digestibility coefficients in the four treatment diets showed a decreasing trend from 60.3±1.5 to 55.7±1.5 for DM; 64.5±1.5 to 60.0±1.5 for OM; 69.8±2.0 to 60.0±2.0 for EE; 67.7±3.0 to 60.7±3.0 for CP; 59.5±1.8 to 54.2±1.8 for CF and similarly 26.0±2.3 to 26.3±2.3 for ASH with increasing levels of poultry waste in the diets but these differences were not significant (P>0.05). Does on the different diets maintained similar ($P>0.05$) positive N balance of 8.1 ± 0.53, 7.6 ± 0.53, 7.6 ± 0.53 and 7.1 ± 0.53 g Nitrogen/doe/day, for Treatment I, II, III and IV, respectively.

The lack of significant differences among the treatment means for most of the variables studied in this work suggests that poultry waste could be used effectively as a source of nitrogen in the diets for lactating Galla goats, as opposed to the conventional type of concentrate without significantly reducing performance.

1. INTRODUCTION.

Since independence more than two decades ago, East African governments' policy statements have often emphasized the need to increase the production of milk and meat, so as to attain self sufficiency in animal proteins supply. Several livestock projects, including importation of high yielding exotic animals for direct use or cross breeding have been launched in order to improve meat and/or milk output at both small and large scale levels in our rural farmlands. Successful results have been realised especially in Kenya where there is remarkable milk production from dairy cattle. Similarly, irrespective of quality, East African countries particularly Kenya and Tanzania have managed to satisfy their internal markets for beef.

While dairy farming comprise mainly of dairy cattle, small ruminant stock do contribute but to a lesser extent in this respect. Currently small ruminants contribute to the total livestock production much more in terms of meat than milk, although the latter product is equally acceptable to most people in the region (Gachuiri, 1987; Skea, 1988). Emphasis on research to improve productivity of small ruminants is currently being shifted from the production of meat alone, to both milk and meat production in all agricultural zones of East Africa.

Alongside breeding, efforts to raise livestock productivity include improved feeding, as this has constantly been considered, among others, the most important strategy in achieving this goal. However, one of the major limitations to efficient implementation of this task has been the lack of excess agricultural products to supply raw materials for various ration formulations. The sharp rise in the prices of plant protein containing feedstuffs, which constitute a large proportion of the protein fraction in the ruminant rations, and a high rate of competition for the same concentrate ingredients from pig and poultry industries are additional factors that contribute to this shortfall. The combination of these factors therefore, dictate the need to exploit alternative non-conventional sources of proteins for ruminant feeding. Livestock wastes such as cow, pig and poultry excreta have attracted great interest as possible candidates and a lot of work has been done to assess their nutritional value and potential. Among all these, poultry excreta have in the recent decades received special attention in this regard.

Apart from its conventional use as garden manure, poultry excreta has been reported to be a potential source of protein and minerals (such as calcium and phosphorus) for ruminants (Smith *et al.*, 1975; Angus *et al.*, 1978; Hadjipanayiotou, 1984; Kayongo and Muinga, 1985). The economic value of the excreta products as feed components in balanced diets for various classes of ruminants has been demonstrated to be about 10 times greater than their value as farm manure.

Droppings from chickens under deep litter systems, caged layer batteries and slatted floors have been the principal sources of poultry waste for livestock feeding. The main constraints in the utilization of the poultry waste products from such sources have been the presence of pathogens, drug residues and toxicity caused by minerals like copper. But subjecting the raw poultry waste to treatments like dehydration in the oven, blown air drying, drying under the sun or room temperature, application of formaldehyde, ensilage as well as withdrawal of toxic mineral elements from poultry rations, appear to render the materials safe for ruminant feeding (Bhattacharya and Taylor, 1975; Kinzel *et al.*, 1983; Hadjipanayiotou, 1984; Kayongo and Muinga, 1985). However, poultry waste feeding trials have successfully been carried out, mainly with beef cattle and sheep of all categories. Research work with dairy animals has however, been less extensively undertaken especially in East Africa, hence the limited data.

Studies to ascertain the performance of animals and digestibility of their respective feeds are of practical significance in assessing the nutritional quality of animal feeds. Very few such studies have been done with poultry waste in Kenya (Kayongo and Irungu, 1986; Odhuba *et al.*, 1986). High digestibility and subsequent observed increase in the level of performance for instance, in terms of milk yield of lactating animals fed a particular feed, is an indication of an inherently high nutritive value of a feed.

In this work therefore, two experiments were conducted to evaluate the potential of utilizing poultry waste as an N source in the supplemental diets for lactating Galla goats under the East African conditions. The main objectives of this study, were to investigate the effects of inclusion of poultry waste at different levels in the concentrate rations on yield and quality of milk from lactating goats. Acceptability, intake, digestibility of the aforementioned diets fed to the goats and live body weight changes during lactation were additional areas of interest in the study.

2. LITERATURE REVIEW.

2.1. Introduction

Milk production from pastures alone is normally the cheapest. The rapid deterioration of the nutritional value of grass, due to the fast growth and early maturity of tropical pastures contribute greatly to the low productivity of lactating dairy animals, especially during the dry seasons. Supplementation of grazing milking animals with high quality protein feeds is an alternative method known to boost production. However, due to mainly economic reasons as stated earlier the future of conventional plant and/or animal protein sources in livestock feeding programmes does not appear to be bright. Utilization of proteins from non-conventional sources for this purpose is becoming an approach worth serious consideration, hence the intensification of research efforts to exploit the potential of these less competitive feed protein sources. In this regard, animal wastes particularly those from poultry have been given top research priority. The feeding of poultry waste to ruminants has the additional advantage of more closely integrating poultry and ruminant production sectors, which in most cases operate within the same animal farming system.

In this chapter, therefore, discussion on the quality status of East African pastures, animal wastes as livestock feeds in general and poultry litter in particular, and performance of ruminants fed poultry waste containing diets as supplements in terms of intake, digestibility, milk yield and composition and liveweight changes will be reviewed.

2.2. Quality status of East African pastures.

McDonald *et al.* (1981) demonstrated that for a large part of the year, the natural food of domestic herbivorous animals is mostly pasture herbage. This consists of mainly two groups, namely the natural and cultivated grasslands. Natural grasslands largely include several species of grass, legumes and herbs which mainly cover the rough and hill grazing lands. The cultivated grassland group consists of pure or mixtures of relatively small number of species in the form of temporary or permanent pastures. Within the tropical belt there are about 4000 million hectares of natural grasslands which maintain about half the domestic animals of the world (Soneji *et al.*, 1971). However, since the natural pastures are composed of unimproved species, their nutritive values do not even meet the maintenance requirements of the grazing animals, particularly the high yielding *Bos taurus*. The low digestibility and eventual low intakes of such pastures by grazing ruminants leads to low productivity of the high yielding animals (Dradu and Harrington, 1972). The nutritive value of pastures in the tropics has been observed to be affected by the climate among other environmental factors. The climatic conditions in the tropics encourage rapid growth of the herbage, resulting into an equally fast decline in the nutrient contents, associated with a relatively shorter effective utilization time (Gihad, 1976;, Fianu and Assoku, 1982; Sorrenson *et al.*, 1986). Generally, both quality and available quantity are functional determinants of the value of pasture (Sorrenson *et* *al.*, 1986). From the farmers' point of view, the value of any pasture, whether grazed or conserved, depends on its capacity to promote milk, meat and wool production. In line with this, Hamilton *et al.* (1970) and Stobbs (1971) stated that the value of any feed depends on the quantity eaten and its intrinsic ability to supply the animal with energy, protein, minerals and vitamins as well as presence of low or insignificant quantities of compounds which may depress performance. Thus, pastures with less than 7% CP have been reported to seriously limit animal production in East Africa (Sands *et al.*, 1970; Taerum, 1970; van Voorthuizen, 1970; Stobbs, 1971; Karue, 1974). According to Fianu and Assoku (1982) such nutrient deficiency has been found to cause as much as 15% liveweight losses in grazing animals of Ghana, during the dry season, hence delaying their maturity. To solve this problem Fianu and Assoku (1982) suggested the use of nitrogenous feedstuffs such as urea, poultry manure, groundnut cake and copra cake in ruminant supplemental diets.

2.3. Animal wastes as livestock feeds.

2.3.1. Nutritional potential of animal wastes in livestock feeds.

In the recent decades there has been a constant rise in prices as well as declining quantities of conventional feed sources for livestock feeding. This has necessitated the need to look for alternative cheaper non-conventional sources. The possibility of reclaiming nutrients contained in non-conventional feed sources has aroused the interest of several researchers (Noland *et al.*, 1955; Bhattacharya and Fontenot, 1965; Bhattacharya and Taylor, 1975; Angus *et al.*, 1978; Smith and Wheeler, 1979; Hadjipanayiotou, 1984; Kayongo and Irungu, 1986; Kayongo and Muinga, 1985; Odhuba *et al.*, 1986). Animal wastes considered were cow dung, pig and poultry excreta. Although the potentiality exists of utilizing them as ingredients in animal feeds, differences in the nutritional values places wastes from ruminants lowest in preference.

Differences in composition of wastes from ruminants and non-ruminants may be due to the differences of their digestive mechanisms. Thus Smith (1973); Couch (1974); and Muller (1982) stated that nitrogen in faeces from monogastric animals is invariably more usable, because the digesta undergoes gastric digestion followed by a proliferation of microorganisms in the lower gut that escape digestion. In addition, the deposition of the NPN component (Uric Acid) on the droppings of poultry increases its quality as an N source. In the ruminants, the digesta undergoes microbial fermentation in the rumen followed by gastric digestion while the NPN component (urea) is lost through urine. According to Smith *et al.* (1979); Smith and Wheeler (1979) and Hadjipanayiotou (1984) poultry waste is a more valuable feed component, in both nutritional and economical terms, than cattle and pig excreta (Table 1). Use of poultry wastes receives highest preference, because it has been found to be an excellent source of inexpensive protein and minerals such as Ca and P in the diets for ruminants (Hadjipanayiotou, 1984; Kayongo and Irungu, 1986; Odhuba, 1987).

Table 1: Nutritional values of animal wastes.

Source of waste	CP	CF	TDN	Total Ash	minerals	
					Ca	P
	%DM					
Broiler	31.3	16.8	59.8	15.0	2.4	1.8
caged layer	28.0	12.7	52.3	28.0	8.8	2.5
Steer	20.3	-	48.0	11.5	0.87	1.6
Cow	12.7	-	45.0	16.1	-	-
Swine	23.5	14.8	-	15.3	2.72	2.13

Source: Fontenot *et al.* (1983).

2.3.2. Economic use of animal waste.

Fontenot (1979) outlined various options for utilizing wastes, that included (1) sources of plant nutrient (2) feed ingredients for farm animals and (3) substrate for methane production by microorganisms. In East Africa little consideration has been given to utilization of the wastes from cattle, swine and poultry as ingredients in livestock diets (Fianu *et al.*, 1984). The world wide conventional use has been farm fertilization (Bhattacharya and Fontenot, 1966, Fontenot *et al.*, 1983, Hadjipanayiotou, 1984, Kayongo and Muinga, 1985; Odhuba, 1987). According to Fontenot *et al.*, (1983) N, P and K as well as other minor constituents of animal wastes, provide nutrients to support crop production. The organic matter (OM) from the waste, in addition, improves soil physical properties such as tilth, structure, water holding capacity, water infiltration rate, and soil microbial activity.

Due to the recent advances in improving poultry using very intensive production systems and the availability of more economically produced commercial fertilizers, particularly in the developed countries, the wastes have been regarded as pollutants of the environment, nuisances and a liability due to the high costs of their disposal (El-Sabban *et al.*, 1970; Bhattacharya and Taylor, 1975; Fontenot *et al.*, 1983). In the developing countries such as those in East Africa the problem of waste pollution may not presently be apparent, but shortages in actual quantities and the rising prices of conventional protein concentrate are possible incentives for using poultry wastes as a non conventional N ingredient in livestock feeds (Shah and Muller, 1983; Kayongo and Irungu, 1986).

Smith *et al.* (1975); Angus *et al.* (1978); Smith and Wheeler (1979); Martin *et al.* (1983); Hadjipanayiotou (1984) and Kayongo and Muinga (1985) reported that the economic value of the excreta products as feed components in balanced diets for all classes of ruminants is about 10 times greater than their value as plant nutrients. Muller (1982) in support of the above views, pointed out that the primary purpose of this aspect of recycling animal excreta products was (1) to minimize the extent to which animal husbandry competes with humans for the same resources, particularly cereals and pulses, and (2) to find a substitute for the common soil/plant /animal cycle. Since feed costs usually represent 60 -

90% of total production costs, replacing feed ingredients with wastes of little or no commercial value inevitably contributes towards reducing the cost of production of meat, milk and other animal products (Muller, 1982).

2.4. Poultry waste in livestock feeds.

2.4.1. Source of poultry waste.

Several criteria have been used to classify the sources of animal wastes. One among them has been the type of animal producing the waste, namely poultry, pigs and ruminants such as cattle (Bhattacharya and Taylor 1975). Waste from poultry can be classified even further, based on the systems involved in rearing the birds. For instance, Bhattacharya and Taylor (1975) and Smith and Wheeler (1979) used poultry manure from caged layer hens, and litter from broilers under deep litter systems in their studies. Kayongo and Muinga (1985) combined class of birds, age, and housing systems as criteria for classifying the various chicken manure sources (Table 2). Caged layers manure was named as chicken excreta by Jayal and Misra (1971) and poultry battery manure by Couch (1974). Manure from poultry houses where birds are maintained on litter was designated as poultry house litter, and when it was ensiled for a period of six weeks the litter was described as broiler litter silage (Couch, 1974). It can be observed from the prevailing literature that there is a general agreement to use these terminologies interchangeably, as they all refer to the same

Table 2. Class of birds and housing systems from which droppings were sampled.

Class of birds.	Age in weeks	Housing system
Pullet chicks	4	electric tier brooder
Young cocks	16	deep litter
Point of lay pullets	18	deep litter
Mature layers	30	deep litter
Mature Layers	30	slatted floors
Broilers	8	deep litter

Source: Kayongo and Muinga (1985).

product. To be more meaningful it may be necessary to identify the manure using a combination of criteria as described earlier. In agreement with this, the general trend by several workers has been the use of descriptive terms, for example, manure or waste or droppings followed by the corresponding system under which the birds were managed (Bhattacharya and Taylor, 1975; Holzer and Levy, 1976; Fianu *et al.*, 1984; Kayongo and Muinga, 1985; Okeudo, 1988). Taylor and Geyer (1979) defined dried poultry waste as a product composed of freshly collected faeces from commercial laying or broiler flocks not receiving medicants and which is thermally dehydrated to a moisture content of not more than 15%. It should not contain any substances at harmful levels and, in addition, should be free of extraneous materials such as wire, glass, nails, etc.

2.4.2. Quantity of waste produced.

Among poultry, droppings from chickens have been extensively used for ruminant feeding (Creger *et al.*, 1973; Gihad, 1976; Kagaard and van Niekerk, 1978; Cheshmedzhiev *et al.*, 1983; Shah and Muller, 1983; Hadjipanayiotou, 1984; Troeger *et al.*, 1984; Economides, 1986; Fiachowsky *et al.*, 1986; Kayongo and Irungu, 1986; Okeudo, 1988). The high technological progress so far achieved through breeding of highly productive early maturing breeds, hence large annual turnover of layers and broiler birds, has probably been the major reason for the availability of abundant quantities of chicken as well as turkey manure (Cross and Jenny, 1975; Holzer and Levy, 1976). The quantitative estimation reported by Bhattacharya and Taylor (1975) and Smith and Wheeler (1979) showed that in the U.S.A. the intensive poultry production systems produced 2 billion tons of poultry waste per annum, which contained nearly 2.2 million tons of nitrogen, 50% of which was noted to be collectable for recycling as a feed ingredient. In Kenya, Muinga and Kayongo (1985) reported that a bird voids out an average of 34g of droppings per day on a dry matter basis. Since the population of exotic layers and broilers reared under confinement in the country was estimated at 1.6 million and 2 million birds respectively in 1985, it implied that a total of 122.4 tons daily or 44,676 tons annually of waste is produced. This is quite an abundant resource available for ruminant feeding.

2.4.3. Nutritional potential of poultry waste.

The protein content in poultry waste ranges from about 14 to 33% (Table 3). Large variations observed in the composition of poultry litter have been noted to be dependent on such factors as species of birds housed, age of the birds, composition and levels of intake of original diet, ventilation in the poultry house, duration of storage, processing methods, type of housing, and bedding materials used (Smith, 1973; Bhattacharya and Taylor, 1975; Holzer and Levy, 1976; Fontenot *et al.*, 1983; Kayongo and Muinga, 1985; Odhuba *et al.*, 1986).

Various forms of poultry waste such as caged layer waste (CLW), layer litter and broiler litter, also show differences in composition. Bhattacharya and Taylor (1975) and Odhuba *et al.* (1986), reported that although all of these forms contained similar amounts of protein of the range 28% to 31% CP, CLW contained 52% TDN, a value lower than that of broiler litter which was 59% TDN (Table 1). Essi Evans *et al.* (1978) and Odhuba (1987) attributed this to high ash contents, especially Ca, which tends to reduce the energy value of the CLW. In support of this view, it was demonstrated that the high ash fraction is a critical constituent of the waste as it lowers the level of organic matter in the complete ration and adds to the total indigestibles (Shah and Muller, 1983; Aderibigbe and Church, 1987).

Differences in the type of management of the birds were found to considerably influence the variability in the nutrient composition of the poultry litter (Bhattacharya and Taylor, 1975). Laying house litter was lower in CP (20%) and higher in Ca and P content

Table 3: Summary of nutritive values of various types of poultry manure fed to different animals.

Type source of waste products	Nutrient composition						Animals used	Years, authors(s) and (place)
	DE	CP	CF[1] ADF[2]	Ca	P	Total Ash		
	kcal/kg	%DM						
Broiler litter	-	32.58	13.06[1]	2.77	2.86	-	wethers	1965 Bhattacharya & Fontenot, (USA)
Dried caged layer	1911	28.0	12.70[1]	8.80	2.5	-	lambs, steers]	
Broiler litter	2440	31.3	16.80[1]	2.37	1.8	-	sheep]	1975 Bhattacharya & Taylor (USA)
Turkey litter Raw	-	15.6	14.5[1]	-	-	32.0	Beef cattle	1976 Holzer & Levy (Israel)
Sterilised	-	17.5	13.8[1]	-	-	24.0		
DPW caged layer	-	32.0	13.8[1]	8.46	2.09	-	fattening steers	1978 Kargaard & van Niekerk (South Africa)
Dried Chicken manure (battery)	-	30.0	13.6[1]	-	-	-	Fattening bulls	1984 Troeger *et al* (W. Germany)
Laying house litter	-	14.38	16.22[1]	6.0	1.77	22.64	Hereford bulls	1964 Brugman *et al* (USA)
Poultry droppings (Raw)	-	26.9	19.9[1]	-	-	34.08	-	1980 Sharma *et al* (India)
Pullet chicks	-	21.0	17.6[1]	-	-	10.2	-]	
Young cocks	-	14.6	27.9[1]	-	-	11.2	-]	
Pullets	-	17.3	20.7[1]	-	-	11.9	-]	1985 Kayongo & Muinga (Kenya)
Layers-deepliter	-	17.8	18.6[1]	-	-	16.0	-]	
Layers-slatted floor	-	20.4	20.9[1]	-	-	19.1	-]	
Caged layers	-	17.1[1]	-	-	-	20.5	-]	
Broiler wastes	-	19.6	30.0	-	-	9.9	-]	
Broiler litter	-	17.9	38.0[2]	-	-	12.7	fattening steers	1986] Odhuba *et al*
Caged layer	-	25.2	19.0[2]	-	-		Growing beef heifers	1986] (Kenya)

1 = Crude Fibre

2 = Acid Detergent Fibre

(5.7 and 2.2% respectively) compared to broiler litter with 28% CP, 1.7% Ca and 1.5% P. In line with Kubena *et al.* (1973) and Couch (1974) poultry excreta contains the remainder of the undigestible gross energy, indigestible components of the diets, compounds of metabolic origin such as non-protein N, spilled poultry diets and drug residues. Bhattacharya and Taylor (1975) noted further that the use of citrus pulp, corn cob, straw, wood shavings and peanut hulls as bedding increased the crude fibre content of the waste in that order. Nutrient (especially Nitrogen) losses through volatilization were cited to be associated with problems of storing this waste for too long in aerobic conditions. These significantly affected the excreta nutrient composition (Kubena *et al.*, 1973; Caswell *et al.*, 1975; Odhuba, 1987).

The feeding value of poultry waste centres around its NPN as a source of dietary N, with uric acid being its principal NPN component. The presence of rumen microorganisms (RMO's), provides ruminants with the unique ability to utilize uric acid and other forms of NPN (Figure I) contained in the waste. The NPN is used by the microorganisms to make their body protein, which is subsequently digested in the lower gut for utilization by the host animal (Henderick, 1967; Kaufmann and Lupping, 1982; Odhuba, 1987). Thus, for optimal microbial protein synthesis, certain favourable conditions must prevail in the rumen for NPN feeding. These include the presence of an NPN product, such as uric acid, which releases NH_3 slowly to avoid wastage and risks of NH_3 toxicity, as well as a readily

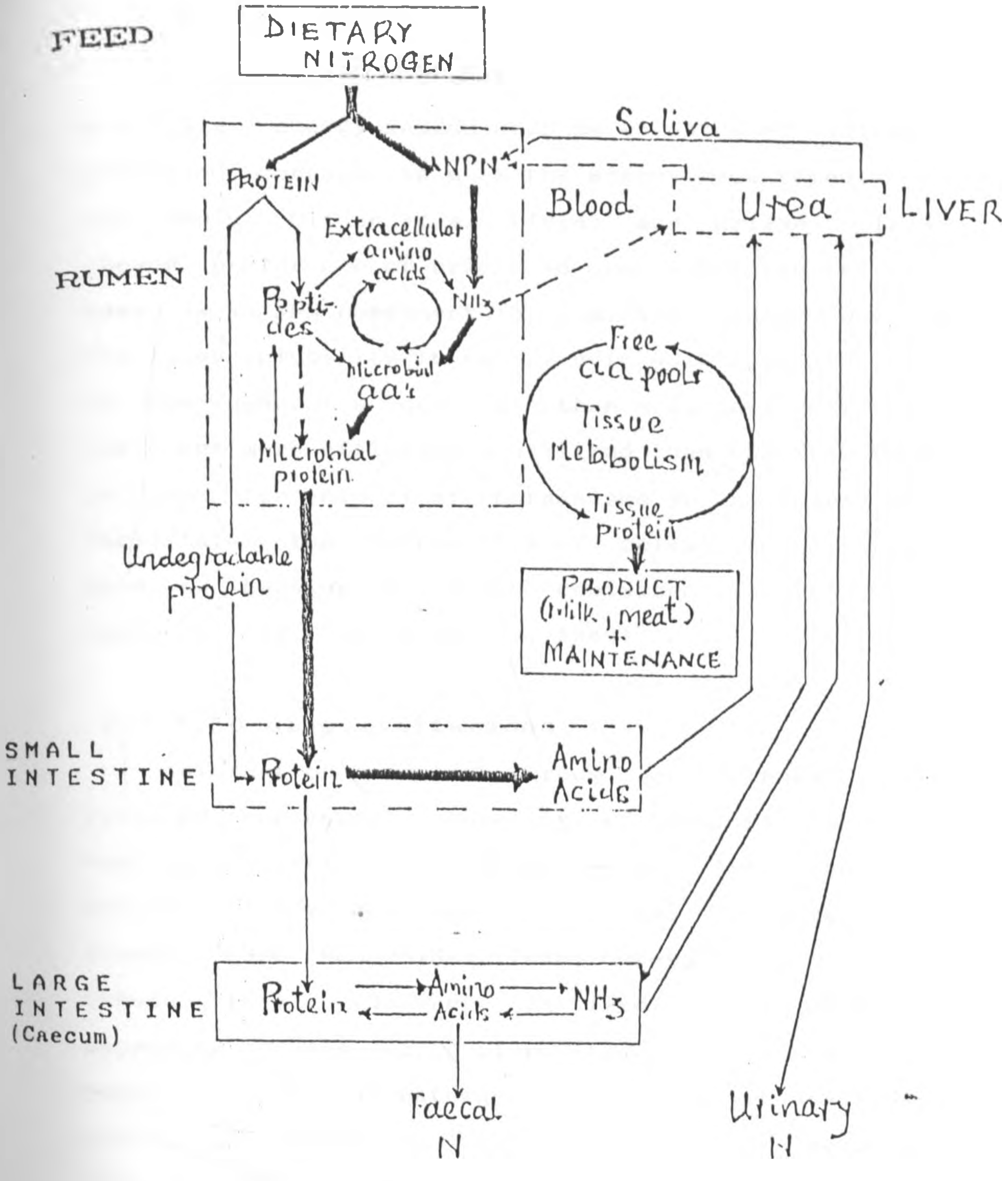


Figure 1: A schematic representation of the utilization of dietary nitrogen by ruminant animals modified after Mercer and Annison (1976).

available energy source such as molasses or suitably processed cereals, to meet the energy requirements of the RMO's. Oltjen *et al.* (1968) and Griesel (1979) showed preference of uric acid over other sources like urea, as an NPN component for ruminant feeding. Due to its lower solubility in water uric acid liberates NH_3 in the rumen at a lower rate than urea making it less toxic and more efficiently utilized than the NPN found in urea. Presence of microorganisms in the rumen also facilitates the degradation of cellulosic materials used as bedding which are contained in the waste (Muller, 1982; Odhuba *et al.*, 1986).

2.4.4.Feeding limitations.

Information from numerous researchers have revealed successful recycling of poultry waste to ruminants (Lovett, 1972; Thomas *et al.*, 1972; Shah and Muller, 1983; Hadjipanayiotou, 1984; Kayongo and Irungu, 1986; Economides, 1986; Odhuba, *et al.*, 1986; Okeudo, 1988). However, in feeding the material, depending on the source of poultry waste it may be a potential source of pathogenic organisms like bacteria, moulds and yeasts as well as residues of medicinal drugs and other medicants. These could pose a health hazard to the animals and humans (Alexander *et al.*, 1968; Smith *et al.*, 1975; Gihad, 1976; Angus *et al.*, 1978; MacCaskey and Anthony, 1979; Kinzel *et al.*, 1983; Hadjipanayiotou, 1984).

From several samples examined, pathogen isolates of the genus, *Chlostridium, Corynebacterium, Salmonella* and *Mycobacteria* were found present in the waste (Webb and Fontenot, 1975; McCaskey and Anthony, 1979).

Other pathogens identified include *Bacillus, Staphylococcus, Streptococcus*, Viruses and members of *Enterobacteriaceae*. In poultry waste, there could be pathogens that are communicable to humans like *Chlamydia or Psittacosis* which cause conjuctivitis and pneumonia respectively. *Mycobacterium avium*, which occasionally produces human tuberculosis or tuberculin sensitivity without disease in man, has also been reported (Bhattacharya and Taylor, 1975). *Clostridium botulinum* produces food poisoning while *Salmonella spp*. have been found to cause enteritis infection. Pathogens of animal health concern found in poultry waste are listed, as *Salmonella pullorum* which infect cattle and swine, *Listeria monocytogenes* is communicable from poultry to cattle and sheep whereas *M. avium* infects swine and in addition may sensitize cattle that react to mammalian tuberculin (Bhattacharya and Taylor, 1975).

The presence of medicinal drugs and other harmful compound residues in poultry waste has also been reported. Drug residue isolates found in the waste include, arsenicals, antibiotics, hormones, coccidiostats, pesticides, heavy metals such as copper, lead, cadmium and trace elements. These residues were mainly detected after examining blood, urine and various tissue samples from cattle (Webb and Fontenot, 1975; Angus *et al.*, 1978; Kinzel *et al.*, 1983; Troeger *et al.*, 1984) and sheep (Lowman and Knight, 1970; Hartmans, 1975; Suttle, 1977; Griesel, 1979; Suttle *et al.*, 1981) as well as in the poultry waste samples (Couch, 1974; Smith *et al.*, 1975; Webb and Fontenot, 1975). Potential problems associated with feeding poultry waste containing these residues include animal poisoning and/or their subsequent secretion into animal products like milk and meat. For example, Cheshmedzhiev *et al.* (1983) discouraged the use of dried poultry manure in dairy rations after detecting slightly higher cell counts and mineral contents (i.e. Mn = 0.082 vs. 0.059; Cu = 0.210 vs. 0.173 and Zn = 4.30 vs. 3.66 ppm) in milk from cows fed dried poultry manure than those fed a standard diet.

Residual antibiotics especially in milk are undesirable because they interfere with the processing properties of milk products like yoghurt and cheese. They inhibit the bacteria involved in the coagulation and fermentation activities of the milk (W. Schulthess, 1988, personal communication).

The problem of high proportions of drug and mineral residues in the waste could be corrected using various methods. Some methods attempting to solve this problem have been outlined by several authors (Suttle, 1977; McCaskey and Anthony, 1979; Hadjipanayiotou, 1984; Shah and Muller 1983 and Antongiovanni, 1986).

Odour is another constraint in the use of poultry waste as a feed component (Fianu *et al.*, 1984). The formation of ammonia, amines, H_2S, indole and skatole compounds by anaerobic bacteria are responsible for the odour in poultry waste. Under aerobic conditions odourless substances such as CO_2, NO_3 and SO_4 are usually produced instead (White *et al.*, 1971). Although no absolute odour control can be achieved, methods that permit aeration like open air drying (either in the sun or under the shade), and aerobic liquid treatment are effective in the control of odour in the waste. Oven heating and autoclaving were found to have no effect on odour control, probably because of lack of aeration to effect oxidation (Fianu *et al*., 1984).

2.4.5. Processing techniques.

Processing poultry waste as a means of controlling microorganisms cannot be overemphasized. Although animal wastes have been used successfully in feeding livestock for many years without serious animal health problems, there is general agreement that processing of waste formulated rations to reduce the potential risk of disease dissemination was necessary (McCaskey and Anthony, 1979; Odhuba, 1987; Okeudo, 1988). Apart from pathogen destruction, processing of animal waste is beneficial for increasing palatability and for odour control (Arndt *et al.*, 1979). Major processing methods whose merits and demerits have been discussed by several researchers include, air drying, autoclaving, chemical treatment, ensiling, aerobic liquid treatment and composting (El - Sabban *et al.*, 1970; Smith, 1973; Bhattacharya and Taylor, 1975; Arndt *et al.*, 1979; Smith and Wheeler, 1979; Adeleye and Kitts, 1983; Fianu *et al.*, 1984; Nambi, 1987).

It has been advocated, however, that no one single method was without limitations when treating poultry manure for use as a feedstuff (Fianu *et al.*, 1984; Troeger *et al.*, 1984). In choosing a particular method for processing the waste it is imperative to consider such inherent factors as the costs involved, losses of nutrients particularly nitrogen, the control of the odour of the waste, and more importantly, reduction of the harmful pathogens and medicants. In terms of costs, some methods such as those involving chemical treatment, heated air drying and autoclaving have been found to be prohibitively expensive (Cross *et al.*, 1974; Arndt *et al.*, 1979; Nambi, 1987).

High nutrient losses, particularly N, were observed with natural sun drying, air drying and oven heating methods, while autoclaving and ensiling had the lowest (Fianu *et al.*, 1984). The main reason for this is probably the rapid generation of ammonia from Uric acid, which constitutes 60-70% of the N in poultry manure (Bhattacharya and Taylor, 1975). Sundrying may result in as high as 12% N losses, while air drying may result in losses up to 4.8% per day. The difference may be due to rapid volatilization of ammonia by the heating effect of sunlight. In contrast autoclaving results in no change in the N content as NH_3 cannot easily escape from the autoclave chambers (Fianu *et al.*, 1984; Nambi, 1987).

Best results on pathogen control in the poultry waste have been obtained with autoclaving, followed by oven drying and open air drying. Dehydration is the mechanism reported to be responsible for killing the bacteria in the waste with these methods (Fianu *et al.*, 1984; Nambi, 1987). Organisms such as *Staphylococcus* and *E. coli*, which are most susceptible to dehydration were readily eliminated, even by shade drying (Fianu *et al.*, 1984). Thus, it can be concluded that, despite the high N-losses resulting from air drying methods, their low operation costs and effectiveness in controlling bacteria and odour, render these the most practical methods to most farmers.

Ensilage of poultry waste with fodder crops is another processing technique that has been widely reported (Harmon *et al.*, 1975a&b; Rao *et al.*, 1977; Smith and Wheeler 1979; Hadjipanayiotou, 1984; Kayongo, 1985; Odhuba, 1987). It is advantageous in that fodders low in CP and minerals, such as corn forage are nutritionally upgraded when ensiled together with poultry waste. For example, Harmon *et al.* (1975a), who ensiled broiler litter with corn forage at inclusion levels of 0, 15, 30 and 40%, observed a significant increase in DM of the silages with increasing levels of litter. Similarly, addition of litter significantly increased the CP content of the silage (from 7.8% for the control to 10.5, 12.3 and 16.9% for silages containing 15, 30 and 40% broiler litter respectively. Higher final pH and greater concentrations of lactic and acetic acids were reported to have lowered coliform populations in silage containing litter than that for the control, hence reducing the bacterial load in the litter based silages.

Further management of the waste prior to feeding it to livestock has been reported (Hadjipanayiotou, 1984; Kayongo, 1985; Odhuba, 1987). Thorough raking of the waste to remove any caked material, and subsequent milling to facilitate mixing with other ingredients, has been found useful. Passing the litter over magnets to remove pieces of metals and nails, then through a hammer mill has been additionally suggested (Brugman *et al.*, 1964). Odhuba (1987) however, indicated that layer waste from deep litter houses does not usually require any milling.

2.4.6. Feeding Methods and levels.

2.4.6.1. Feeding Methods.

One way of utilizing raw waste is by feeding the material to animals alone without mixing it with other feed ingredients. This is rare, probably due to the odour of the raw waste as well as fear of disease risks from harmful organisms that may be present in such waste. A common method has been to mix the waste with other ingredients after processing, to form balanced diets for supplementation to ruminants (Hadjipanayiotou, 1984; Odhuba, 1987). With this method the waste may be substituting, at various inclusion rates, another conventional protein source (Kargaard and van Niekerk, 1978 Muller, 1982). For instance, in the work of Kargaard and van Niekerk (1978) 4 levels (0, 4, 8, and 12% on a dry matter basis) of dried cage layer manure (DPW) were used with either urea or sunflower cake meal to investigate the possibility of including low levels of DPW in cattle fattening rations. Okeudo (1988) formulated poultry waste based diets in which groundnut cake was replaced by poultry manure at inclusion rates of 0, 13, 25, 35 and 45%. Under this method the composition of all the diets were comprised of both the non conventional and conventional protein sources. The diets would normally be isonitrogenous whereby the levels of the poultry manure increase as those of the conventional protein source decrease.

The third method involves formulating two or more independent diets in which the first one will constitute the conventional protein source alone and poultry manure in the other while the accompanying ingredients for the mix may remain the same (Noland *et al.*, 1955). In the feeding trial by Holzer and Levy (1976) three treatment diets were formulated on this basis. The first treatment diet was made up of wheat straw and ground sorghum grain alone; the second treatment diet consisted of the ingredients of the first treatment plus poultry litter, whereas in the third diet, soybean meal substituted the poultry litter used in the second treatment diet. A similar approach was demonstrated by Gihad (1976). This approach is significant where an unknown non conventional protein source, such as dried poultry manure in this case is being tested against the known conventional source (i.e. the soybean meal) meaning that the unknown protein source is completely replacing the known source.

2.4.6.2. Form of feeding.

The nature in which the poultry excreta is offered to the animal is also significant. Fundamentally, poultry waste may be obtained in 3 forms, wet, dry and ensiled. For reasons stated earlier on of avoiding disease transmission risks, the wet form is rarely used. Although in terms of acceptability Essi Evans *et al.* (1978) observed no problems when this was fed to sheep. The dried form, through the various dry processing techniques, has been most commonly used and reported on in several studies (Kargaard and van Niekerk, 1978; Suttle *et al.*, 1981; Fianu and Assoku, 1982; Pagan and Ray, 1983; Thakur *et al.*, 1983; Guseva and Batazova, 1984; Kayongo and Irungu, 1985; Odhuba *et al.*, 1986). It appears from the authors' point of view that, the dry form which has less offensive smell, is easier to handle when compounding the rations. Poultry waste has also been used in the ensiled form. Although the waste can be ensiled alone (Hadjipanayiotou, 1984; Jain *et al.*, 1984) the material is preferred mixed with either green fodders particularly those low in crude protein and mineral contents such as fodder maize (Harmon *et al.*, 1975b; Hadjipanayiotou, 1984; McClure and Fontenot, 1986; Odhuba *et al.*, 1986), or crop products such as straws, beet pulp, pineapple peels, cassava peels (Muller, 1982; Deswysen *et al.*, 1984; Hadjipanayiotou, 1984; Okeudo, 1988) or cardboard wastes (Razzaque *et al.*, 1986; Aderibigbe and Church, 1987). All poultry waste containing silages were observed to have preserved well with typical fermentation characteristics. The percent dry matter and crude protein, aroma and palatability of the silage products were found to have significantly increased. Significant reduction of the pathogenic microbial count in the ensiled waste together with the fodder was an added advantage observed by these authors.

2.4.6.3. Feeding levels.

Studies to determine the effects of various levels of inclusion of poultry waste in the supplemental diets for ruminants have been conducted (Bhattacharya and Fontenot, 1965; Kargaard and van Niekerk, 1978; Griesel, 1979; Malick *et al.*, 1980; Shah and Muller, 1983; Hadjipanayiotou, 1984; Kayongo and Irungu, 1986). It has been illustrated that poultry waste could be included in rations to replace another nitrogen source at levels from 0 to 100% without adverse effects on diet acceptability by the target ruminants. In the rations formulated by Bhattacharya and Fontenot (1965) poultry litter was incorporated at levels high enough to replace approximately 25, 50 and 100% of the soybean protein nitrogen. The data revealed that poultry litter nitrogen could be utilized efficiently by ruminants when the levels of litter nitrogen did not exceed 50% of the total nitrogen intake. Lower levels of 0, 4, 8, 12% and 0, 6, 18, 24, 30%, were successfully used by Kargaard and van Niekerk (1978) and Griesel (1979) respectively. Malick *et al.* (1980) used levels of 27 and 37% poultry litter diets for buffalo heifers, whereas Hadjipanayiotou (1984) fed diets containing poultry litter at levels of 0 and 30 % to growing heifers, 0, 15 and 30% to lactating goats, ewes and fattening kids, and 0, 20 and 30% to fattening calves. Results indicated no significant differences in growth and fattening performance of the kids and calves. The milk yield from the group that received a diet containing 30% poultry litter was low at 1.78 kg /doe/day but was not significantly different from the yield of 2.08 and 1.99 kg/doe/day) from goats that received 0 and 15% poultry waste respectively. Devyatkin *et al.* (1983) who added poultry manure at 25 and 35% of the feed mixture to a pulp based diet for finishing young cattle, were able to reduce the cost of the concentrates up to 35%, reduce the cost of body weight gain by 11.7%, increase body weight gain by 24.8% and improve feed intake. Okeudo (1988) obtained similar results in terms of digestibility and growth rate of sheep when concentrate diets containing 0, 13, 25, 35, and 45% poultry waste were used. Shah and

Muller (1983) concluded that it was possible to feed poultry waste to high yielding dairy animals with inclusion levels of up to 80% DM in the supplement ration and to beef cattle with an optimal inclusion level for broiler litter of up to 40% DM. However, due to its high content of inorganic matter, layer manure was recommended to be fed at an inclusion level of not more than 30% on a DM basis in a concentrate diet.

Findings related to feeding poultry waste at higher levels has been reported by several workers (Bhattacharya and Fontenot, 1965; Harmon *et al.*, 1975b; Angus *et al.*, 1978; Suttle *et al.*, 1981; Martin *et al.*, 1983; Hadjipanayiotou, 1984). However, rations containing more than 50% litter may give a markedly depressed performance (Bhattacharya and Fontenot, 1965). Fontenot (1979) associated the lowered performance of the cattle consuming higher litter containing rations with low feed intake. On the other hand, when feeding larger quantities (above 25% DM) of poultry waste the supply of ingredients containing soluble carbohydrates such as molasses, root crops, grain etc, is important for balancing the energy requirements for maximum utilization of the NPN fraction of the waste (Shah and Muller, 1983).

Angus *et al.* (1978) and Suttle *et al.* (1981) reported health problems, such as anorexia, ascites, nephrotoxic properties and clinical Cu toxicosis in sheep fed diets containing poultry excreta levels of between 45 and 60%. Thomas *et al.* (1972) found that when diets containing 25 or 50% poultry manure were fed to lambs for 12 weeks a drop in feed conversion efficiency resulted. The only advantage in using supplemental diets containing high levels of poultry waste may be a reduction in feed costs.

From the cited literature, it is clearly shown that, though the effects of feeding poultry waste at inclusion levels greater than 50%, are not very adverse (Martin *et al.*, 1983), it is undesirable due to its depressive effects on milk yield of lactating animals (Hadjipanayiotou, 1984).

2.5. Voluntary feed intake and digestibility.

2.5.1. Voluntary intake

Voluntary intake significantly influences productivity of livestock (McDonald *et al.*, 1981) and is affected by feed characteristics and animal factors (Bines, 1976; McDonald *et al.*, 1981; Campling and Lean, 1983; Leaver, 1983; Forbes, 1986). Amongst the feed characteristics, physical nature of feed and chemical (mainly dietary energy and protein concentrations) properties and concentrate to forage ratio of feed have important effects on intake (Leaver, 1983; Forbes, 1986; Badamana, 1987). Additionally, animal factors particularly physiological state (growth, body size, fattening, sex hormones reproduction status and stage of lactation) have been known to affect voluntary intake (Journet and Remond, 1976; Campling and Lean, 1983; Forbes, 1986). However, in the present study a brief mention will be made on how some of the feed characteristics of poultry waste affect voluntary intake of ruminants.

Among the feed characteristics, it has been reported that the concentration of available energy in a feed is a major component which determines its voluntary intake (Forbes, 1986). Generally, the intake of energy will increase with increasing concentration of digestible energy in the ration (Morand-Fehr, 1981; Campling and Lean, 1983; Forbes, 1986), but it becomes constant once the animal is able to meet its total energy requirements. Poultry waste is reported to be low in digestible energy (Bhattacharya and Taylor, 1975) and this may be a factor limiting intake of poultry waste containing diets. Shah and Muller (1983) and Odhuba (1987) suggested that when feeding large quantities of poultry waste (about 25% DM), ingredients containing soluble carbohydrates, such as molasses, root crops, grain etc., must be offered to obtain maximum utilization of the NPN fraction of the waste. Despite improvement of intake, Kargaard and van Niekerk (1978) observed poor performance by cattle offered dried poultry waste supplemented with molasses. They attributed this to a possible adverse mineral interaction, as both these products have a high ash content.

The protein fraction was considered as another biochemical property of feed that greatly affects voluntary feed intake, particularly if dietary protein content falls below a lower critical value than the normal range of 10-18% CP (Bines, 1976; Dulphy and Demarquilly, 1983; and Forbes, 1986). Feeds low in protein content are eaten by ruminants in small amounts and supplementary protein or NPN will often improve voluntary intake (Campling and Lean, 1983).

Nicholson (1984) and Forbes (1986) illustrated that deficiency of nitrogenous substances in the ruminant diets limits microbial digestion hence the rate of breakdown of cellulose. Addition of a source of nitrogen such as a high protein concentrate, NPN or limiting amino acid (i.e. methionine) to a protein deficient diet results in a faster rate of disappearance of fibrous material from the rumen leading to a higher level of intake (Miles *et al.*, 1969; Morand-Fehr, 1981; Forbes, 1986). Between 40-60% of the CP in poultry waste is NPN (Nambi, 1987) and hence its value as a nitrogen source that could improve intake when fibrous feeds are part of the diets (Bhattacharya and Taylor, 1975; Gihad, 1976).

Palatability of a feed may act as a positive factor in the combination of signals which control feed intake and may sometimes lead to a prolonged increase in intake (Forbes, 1986). The potential of utilizing molasses in improving palatability hence acceptability of poultry waste containing diets has been shown in several studies (Shah and Muller, 1983; Odhuba, 1987). Diets supplemented with poultry waste and especially when mixed with some molasses were consumed as readily as diets supplemented with conventional protein sources (Bhattacharya and Fontenot, 1965; El-Sabban *et al.*, 1972; Yu Yu *et al.*, 1972; Gihad, 1976; Deswysen *et al.*, 1984; Hadjipanayiotou, 1984; Okeudo, 1988).

Adaptation to the diet is another factor affecting voluntary intake. Therefore, it is important to provide a period of adjustment by ruminant animals to the poultry waste containing supplements prior to full-scale feeding. Gradual introduction of such diets would enable the rumen microorganisms, sufficient time for adjustment to the new feed, and eliminate possible risks of digestive upsets. An adjustment period of about 3-5 days has been advocated (Shah and Muller, 1983; Guseva and Batazova, 1984).

2.5.2. Digestibility.

Digestibility and voluntary intake have been widely reported as the two most significant parameters related to the quality of feeds (Mwakatundu, 1977; McDonald *et al.*, 1981). This is mainly due to their usefulness as effective tools in the management and feeding of pastures to livestock (Said, 1974, Mwakatundu, 1977).

Digestibility of a feed has been noted to be dependent upon the chemical and physical qualities of the feed consumed (Van Soest, 1965; McDonald *et al*, 1981). It has been demonstrated that complete digestion of a feed does not occur owing to lignin encrustation which protects the cell wall contents (i.e. the cellulose and hemicellulose), from digestion by rumen micro-organisms of the host animal. Based on these effects, the digestibility of a feed would decline with an increase in its lignin and crude fibre (CF) contents (Whiteman, 1980). Fibrous (high cellulose) feeds would normally be broken down more slowly than less fibrous materials. Fibrous feeds are associated with slow physical (i.e. chewing) and enzymatic breakdown, which leads to an increase in retention time of feed in the rumen, hence limiting consumption of more feed. The point at which fibre mass appears to become limiting seems to be when the cell wall content lies between 50 and 60% of the forage dry matter (van Soest, 1965). Supplementation with a diet high in digestible energy and protein constituents to a poor quality roughage will increase digestibility of the latter, through increased rumen microbial growth hence microbial digestion activities in the rumen (Leaver, 1983; Forbes, 1986).

Trials to determine the effects of feeding poultry waste to improve digestibility and hence nutritional value of low quality forages and pastures have been reported (El-Sabban,1970; Oliphant, 1974; Gihad, 1976; Holzer and Levy, 1976; Caneque and Galvez, 1983; Toro and Mudgal, 1984; Kayongo and Irungu, 1986; Odhuba *et al.*, 1986; Okeudo, 1988). Gihad (1976) compared poultry manure with urea as protein supplements for sheep fed low quality hay. The digestion coefficients of dry matter and CP for diet constituting hay alone, were lower than those of the dried poultry manure and urea containing rations. Differences of CP digestibility among the supplemented rations were not significant. Nitrogen balance was positive for all supplemented rations and negative for the control hay diet. Similar results have been observed by Holzer and Levy (1976) who compared the feeding of poultry litter (PL) with soybean meal (SBM) supplemented to a wheat straw diet, offered to lactating beef cows, and Odhuba *et al.* (1986) who compared broiler waste with sunflower cake as constituents of supplements to fattening steers. El-Sabban *et al.* (1970) conducted a sheep metabolism trial in which wethers were fed semi-purified rations in which nitrogen was supplied by autoclaved poultry waste (APW), cooked poultry waste (CPW) or (SBM).

Digestibility coefficients for dry matter (72.1, 76.2 and 75.3% respectively) and energy (73.5, 76.3 and 74.7% respectively) were not significantly different among rations, but that of protein (65.5, 69.4 and 74.3% respectively for APW, CPW and SBM) were significantly higher for the ration containing SBM (control) than of rations containing APW. This discrepancy was explained to have been due to (1) the nitrogen content of the poultry waste product being more variable than soybean meal and (2) inadequate sampling and /or mixing of the rations.

Waste from cardboards manufactured for building purposes provides possible source of non-conventional fibre feeds for livestock (Razzaque *et al.*, 1986; Aderibigbe and Church, 1987). In a study by Aderibigbe and Church (1987) cardboard waste was supplemented with poultry waste and fed to ruminants. Four treatments were formulated. The Control diet I which constituted ground corn, chopped rye-grass straw, cane molasses and cotton seed meal (CSM), was compared with diets in which 15 or 30% cardboard replaced the same amounts of straw and a fourth diet (30% cardboard) in which caged hen manure (CHM) replaced 25% of the N supplied by the CSM. Results showed that the digestibility of fibre fraction increased with addition of cardboard to the diets, and was further increased with the addition of CHM to the 30% cardboard diet. This further indicated that addition of CHM improved digestibility of fibre in cardboard.

In a growth study with sheep, cassava péels were supplemented with dried poultry waste (DPW) at 0, 13, 25, 35 and 45% inclusion levels for Treatments I, II, III, IV and V respectively (Okeudo, 1988). Treatment I (control) contained groundnut cake as the protein source. No significant differences were observed in DM digestibility among the different treatment diets. This confirmed the positive contribution of the DPW in improving the digestibility of cassava based diets in sheep. Table 4 summarises several trials which were conducted to assess the digestibility of poultry waste based diets fed to ruminants on poor quality forages. Generally, the digestion coefficients obtained by most workers for all fractions compare favourably with those of diets based on protein of plant origin. The DM digestibility of test diets ranged between 50.0% and 77.0%. Most digestibility coefficients reported for CP ranged from 50% to about 83% (Brugman *et al.*, 1964; Jayal and Misra, 1971; Gihad, 1976; Holzer and Levy, 1976; Hadjipanayiotou, 1984; Fiachowsky *et al.*, 1986). Values showing CP digestibility less than 50% are very few (Jayal and Misra, 1971; Holzer and Levy, 1976;). Crude Fibre digestibility coefficients in the poultry waste containing diets ranged between 34% and 91%. Probably, differences in the management of the birds from which the manure were collected, as well as of the waste itself during storage before it was used might have caused the variations of the results (Kayongo and Muinga, 1985; Kayongo and Irungu, 1986).

le 4: Summary for per cent digestion coefficients by authors, year, type of litter and animal used.

hor	Year	Feed or Type of waste used	Group	% Digestion coefficients								Animal used
				DM	OM	CP	EE	CF	ASH	NFE	Energy	
gman *et al.*,	1964	Laying house litter	-	-	-	77.82	44.36	91.04	-	-	59.15	Beef cattle
al & Misra	1971	Battery cage litter	1 control	-	-	50.20	45.36	60.60	-	50.20	-	
.	.	.	2	-	-	45.10	46.30	59.00	-	48.90	-	Cattle
.	.	.	3	-	-	40.20	33.20	61.00	-	47.80	-	
ad	1976	Hay + Dried poultry manure	-	57.86	-	66.86	69.34	60.58	-	-	62.64	Sheep
zer & Levy	1976	Wheatstraw + Turkey litter	-	50.00	54.60	47.40	43.70	54.80	-	48.40	-	Beef cattle
.	.	Turkey litter alone	-	-	54.30	55.00	53.10	52.50	-	54.90	-	
éque & Galvez	1983	Layer hen excreta	-	-	-	54.50	50.20	60.20	-	50.40	-	Sheep
jipanayiotou	1984	Broiler litter	A	77.00	-	78.00	75.00	42.00	54.00	85.00	-	
.	.	.	B	74.00	-	78.00	73.00	37.00	53.00	83.00	-	Damascus goats & Chios ewes
.	.	.	C	72.00	-	78.00	69.00	34.00	49.00	82.00	-	
chowsky al.,	1986	Poultry litter	-	-	69.80	82.80	-	-	-	-	-	Sheep
thasarathy & dhan	1986	Poultry litter	-	53.20	-	54.90	-	-	-	-	-	Crossbred cattle calves

2.6. Performance of ruminants fed poultry waste containing diets.

2.6.1. Effect on milk yield and composition.

2.6.1.1. Milk yield.

Scanty documented information is available on the feeding potential of poultry waste as a protein source in dairy cattle rations (Thomas *et al.*, 1972; Cheshmedzhiev *et al.*, 1983; Hadjipanayiotou, 1984; Parthasarathy and Pradhan, 1986; Kayongo and Irungu, 1986; Odhuba, 1987) and even less for lactating goats (Hadjipanayiotou, 1984). Evidence dates back to nearly two decades ago indicating that inclusion of chicken waste in dairy rations has not produced any adverse effects on milk production even when dried poultry waste constituted up to 30% of the dairy concentrates (Bull and Reid, 1971; Thomas and Zindel, 1971; Thomas *et al.*, 1972). Many farms in Israel utilize poultry litter in supplementary diets for cattle during the dry season when the cows are pregnant or in early lactation. Holzer and Levy (1976) compared turkey broiler litter (PL) with soybean oil meal (SBM) as a supplement to a wheat straw basal ration for lactating beef cows. The results indicated that the effect of adding PL was similar to that of adding SBM. Since the straw was fed ad libitum, the authors did not expect much differences in DM intake between the two diets and, as a result, they attributed the improvement in milk output to the protein supplied by either PL or SBM. From the findings it was concluded that since the price of PL was much lower than that of any protein of plant origin, the material could be used as an economical source of protein for supplementation of fibrous roughages. However, feeding PL as a sole supplement for lactating cows can not supply sufficient energy, inspite of the possible increase in DM intake (Holzer and Levy, 1976). Neither can it supply enough undegradable protein (UDP) which is very much needed by high yielders.

Cheshmedzhiev *et al.* (1983) tested the effects of dried poultry manure (DPM) on milk production by feeding two groups of Black-pied dairy cows receiving maize silage and grass hay-lage, with pellets containing 30% lucerne meal or poultry manure. The daily 4% FCM yields at 17.8 and 17.3 kg, were similar for cows given lucerne or DPM respectively. However, due to high cell counts and mineral contents detected in milk from cows given DPM, the use of DPM for feeding dairy cattle was discouraged. In the work of Kayongo and Irungu (1986), dried broiler waste (DBW) substituted cotton seed cake (CSC) at 0, 10, 20 and 30% on "as is" weight basis. The level of broiler waste in the diets did not affect the 4% FCM yield, although heifers fed the control diet produced slightly more milk. Shah and Muller (1983) who supplemented lactating cows and buffaloes with diets based on 14% cotton seed cake or 40.6% broiler waste, containing 23.7 and 19.1% CP respectively observed higher milk yield per day in animals fed the broiler waste based diet than for those on the control diet. However, the differences among treatments were not statistically significant. These results were similar to those reported by Odhuba (1987) who compared broiler waste based diets with commercial protein diet formulations using either pure or crossbred Friesian and Ayrshire cows. The ration in which broiler waste completely replaced the conventional protein sources was able to support 10.2 kg of milk/day compared to 11.6 kg of milk/day from cows fed diets compounded from commercial protein sources. Although this difference was significant, it was concluded that the cost of feeding commercial protein supplements would tip the balance in favour of the poultry waste based diets.

In another study Hadjipanayiotou (1984) supplemented one group of lactating cows with conventional dairy concentrate and another group with 6 kg of ensiled poultry manure. There was no significant differences between the milk yield of cows that received conventional dairy concentrate with those that received 6 kg of silage containing poultry waste per head per day. The corresponding daily milk yield values were 16.7 and 17.0 kg. At the same time the silage was consumed completely by the cows. Subsequently, Hadjipanayiotou (1984) did not encounter any ill-effects with the cows nor was the quality of milk affected by the poultry litter fed. When the same author offered poultry litter containing diets to lactating Chios ewes and Damascus does, at three inclusion levels of 0, 15 and 30% in the supplement diets, to determine its effect on milk production; findings similar to those observed on cattle were recorded. The milk yield of ewes and goats receiving conventional dairy concentrate or 15% poultry litter were similar. The milk yield of ewes and goats receiving 30% poultry litter was significantly lower than that of animals on the other two treatments.

However, the reduction in milk yield was associated with lower feed intake and not with any direct adverse effects of poultry litter itself on milk yield.

2.6.1.2. Milk composition.

Milk composition is affected by many factors including breed (Akinsoyinu *et al.*, 1977; Sutton, 1979; Anifantakis and Kandarakis, 1980; Oldham and Sutton, 1980), stages of lactation (Schmidt and van Vleck, 1974, Akinsoyinu *et al.*,1977, Oldham and Sutton, 1980), concentrate to forage ratio (Jorgensen *et al.*, 1965; Thomas *et al.*, 1972; Schmidt and van Vleck, 1974; Sutton, 1979) and sources of protein (Hadjipanayiotou, 1984; Kayongo and Irungu, 1986). Studies to determine the effect of feeding poultry waste based diets on milk composition of various stock have been made. Hadjipanayiotou (1984) using Damascus goats and Chios ewes, offered 3 concentrates containing poultry waste at 0, 15 and 30% replacing soybean meal whose content in the diet subsequently decreased from 14 to 7 to 0% for Treatment I, II and III respectively. Differences among diets were not observed particularly with fat and protein content of the milk from either goats or ewes. In another study by Kayongo and Irungu (1986), broiler litter based diets at 0, 10, 15 and 30% replacing cotton seed cake whose inclusion rate decreased from 25 to 15 to 5 to 0% for treatment A, B, C and D respectively, were offered to lactating Friesian heifers. Increasing the level of broiler waste from 0 to 30% in the concentrates did not affect the composition of milk between the treatments. Values for TS (12.05, 11.91, 11.37 and 11.34), BF (3.95, 3.31, 3.55 and 3.68), CP (2.66, 2.53, 2.60 and 2.62) and Ash (0.66, 0.69, 0.70 and 0.72) for Treatments A, B, C and D respectively were similar. However, in the poultry waste containing diets a trend of increasing BF, CP and Ash with increasing broiler waste was observed. From the study, it was concluded that broiler waste could be included up to 30% replacing all the cotton seed cake as a protein source in the supplement diets for lactating heifers without any adverse effects on the quality of milk. Based on these findings, there is a strong indication on the potential use of poultry wastes for milk production in most types of dairy animals.

2.6.2. Influence on liveweight gain.

Poultry waste has been successfully fed to growing and fattening sheep and goats (Bhattacharya and Fontenot, 1965; El-Sabbañ *et al.*, 1972; Yu yu *et al.*, 1972; Gihad, 1976; Smith and Calvert 1976; Rao *et al.*, 1977; Angus *et al.*, 1978; Suttle *et al.*, 1981; Thakur *et al.*, 1983; Hadjipanayiotou, 1984; Deswysen, 1986; Fiachowsky *et al.*, 1986; Razzaque *et al.*, 1986; Aderibigbe and Church, 1987; Okeudo, 1988). Yuyu *et al.* (1972) offered dehydrated poultry manure containing diets to growing sheep at levels of 20 to 80% of a mixed ration. All sheep remained in positive nitrogen balance. The retention of digested nitrogen varied from 18 to 72% for poultry manure diets, which compared favourably with those of 16 to 65% for soybean meal rations. Because most of the parameters studied were in favour of poultry waste, the authors concluded that the material could be used in rations for fattening, growing or breeding sheep. While Gihad (1976) and Smith and Calvert (1976) concurred with the above findings, Thomas *et al.* (1972) and Tinnimit *et al.* (1972) reported lower weight gains for lambs fed diets supplemented with a ration containing 20-50% dried poultry waste than for control lambs on diets with soy bean meal. Hadjipanayiotou (1984) fed weaner Damascus goat kids with diets containing poultry litter at inclusion rates of 0, 150 and 300g of poultry litter in the supplements for Treatment A, B and C respectively for 114 days. Liveweight gain, feed efficiency, carcass quality and dressing percentage of kids fed poultry litter diets did not differ significantly from those fed on the control diet.

Fianu and Assoku (1982) compared urea and poultry manure as protein supplements for sheep on poor quality dry season pastures. They demonstrated that properly formulated diets based on chicken manure or urea could eliminate the animals' nitrogen deficits in the dry season diet and help reduce the slaughter age of these animals. This was in agreement with the results reported by Fiachowsky *et al.* 1986 working with Ogaden sheep in Ethiopia. In another study Fat tailed yearling Arabian sheep were used to test five poultry waste containing complete rations in a growth performance study (Razzaque *et al.*, 1986). The treatment diets included I(Ricestraw + Soybean meal as control); II(13.1% Cardboard + Soybean meal); III(25.9% Cardboard + Soybean meal); IV(24.2% cardboard + 9.6% CHM) and V(24% Cardboard + 10% broiler litter). Results confirmed no significant differences in liveweight gains of lambs fed control, cardboard and cardboard plus poultry manure diets. However, the intake of animals receiving diets with cardboard plus poultry manure was significantly higher than those fed the control diet. This was an indication that ground corrugated cardboard and dried poultry manure (CHM or broiler litter) can partly substitute for the conventional roughage and concentrates respectively, for sheep. Similar findings with the same products were reported by Aderibigbe and Church (1987). A growth experiment was conducted in which 5 levels of poultry waste containing diets were fed to sheep (Okeudo, 1988). Results showed growth rates of between 84.5 and 100.6 g/head/day. The differences in growth rates observed between ewes receiving groundnut cake and wheat offals, and those fed poultry manure as the sole protein supplement, were not statistically significant suggesting that poultry waste could effectively support weight gains of small ruminant animals.

Trials to determine the influence of poultry waste feeding on performance of other ruminants such as beef cattle have been carried out (Noland *et al.*, 1955; Drake *et al.*, 1965; Jayal and Misra, 1971; Oliphant, 1974; Holzer and Levy, 1976; Kargaard and van Niekerk, 1978; Davrieux *et al.*, 1986; McClure and Fontenot, 1986; Sorrenson *et al.*, 1986; Odhuba, 1987). Among the important parameters for beef production, saving in terms of feeding costs, average daily gain, and final body weight were reported. In a feeding trial, Jayal and Misra (1971) replaced groundnut cake with chicken waste as a protein source in a concentrate mixture at

0, 50 and 100% levels of replacement and offered these diets to 12 bullocks. The average daily dry matter intake of 1710, 1676 and 1755 g for groups 1, 2 and 3 respectively was statistically non significant.

Many reports of successful substitution of other protein sources such as soybean meals (Thomas *et al.*, 1972; Tinnimit *et al.*, 1972; Yu Yu *et al.*, 1972; Oliphant, 1974) and sunflower cakes (Kargaard and van Niekerk, 1978; Nikolic, 1983; Odhuba, 1987) with poultry waste in rations for beef animals have been made. In the work by Oliphant (1974) dried poultry waste replaced soybean and fish meal in an intensive beef ration in an attempt to reduce the cost of production. The treatment diets were isonitrogenous with the control at 14.5% CP. Significant reduction in liveweight gain was observed in animals receiving the dried poultry manure diet which was attributed to low DM intake and poor conversion ratios. Low mineral (especially sodium) content was noted in poultry wastes and this was said to have resulted in the low intakes and not due to the poultry manure itself. Provision of salt licks was reported to be effective in restoring the feed intake and growth rate. Despite this, the objective was achieved in that there was a considerable saving in the feed cost. This led to a conclusion that use of dried poultry manure could increase the profitability of intensively produced beef. The results of this study therefore, give an indication that poultry wastes can be satisfactory alternative sources of N in beef cattle feeding, which was in agreement with other studies (Nunez *et al.*, 1983; Guseva and Batazova, 1983; Hadjipanayiotou, 1984; Sorrenson, *et* *al.*, 1986).

Sunflower cake has been used in various studies as a source of N in beef rations despite its high fibre content (Odhuba, 1987). Nikolic (1983) compared diets of similar nutritive value containing either poultry litter or sunflower cake, as supplements for fattening young cattle on poor quality roughage. Partial replacement of sunflower seed meal, wheat bran and dried lucerne meal with poultry litter gave performances similar to that obtained with cattle given the standard concentrates. This was in agreement with the work of Hadjipanayiotou (1984), McClure and Fontenot (1986) and Sorrenson *et al.* (1986). However, Sorrenson *et al.* (1986) concluded that this system was only economic for farmers who had their own supply of chicken manure and not for those who have to buy and transport it from elsewhere.

Supportive findings were reported by Odhuba (1987), who included increasing amounts of broiler waste to replace sunflower seed cake in a finishing ration for steers on pasture. This researcher illustrated that sunflower seed cake could be completely replaced by broiler litter to constitute 30% of the ration as long as the animals were supplied with some molasses.

3. MATERIALS AND METHODS.

3.1. Introduction

Study Area:

This research project was conducted at Ol-Magogo Estate, Naivasha. On this station major work for the Small Ruminant Collaborative Support Programme (SR-CRSP), of breeding a Dual Purpose Goat (DPG), that can survive well and produce both milk and meat under the Kenyan and East African conditions as a whole is being carried out. The project involves crossbreeding the small East African and Galla female does to Toggenburg, Anglo-Nubian and Alpine bucks.

The Ol-Magogo Farm is situated at the foothills of the Aberdare Mountain Ranges and about 12 km away to the East of Gilgil Town, which is 114 km away to the West of Nairobi City (Figure 2). This farm is part of the main National Animal Husbandry Research Centre (N.A.H.R.C.) of Naivasha, which among others, deals with research and development of sheep and goats at Ol-Magogo. The DPG breeding project at this station is jointly run by N.A.H.R.C. and SR-CRSP. The day-to-day management and breeding activities on the farm are however, performed by staff from the Ministry of Livestock Development seconded to SR-CRSP and Senior Scientists in Dairy Goat breeding from SR-CRSP. It was possible to conduct this research project through the close cooperation between the N.A.H.R.C., SR-CRSP and the Department of Animal Production of the University of Nairobi.

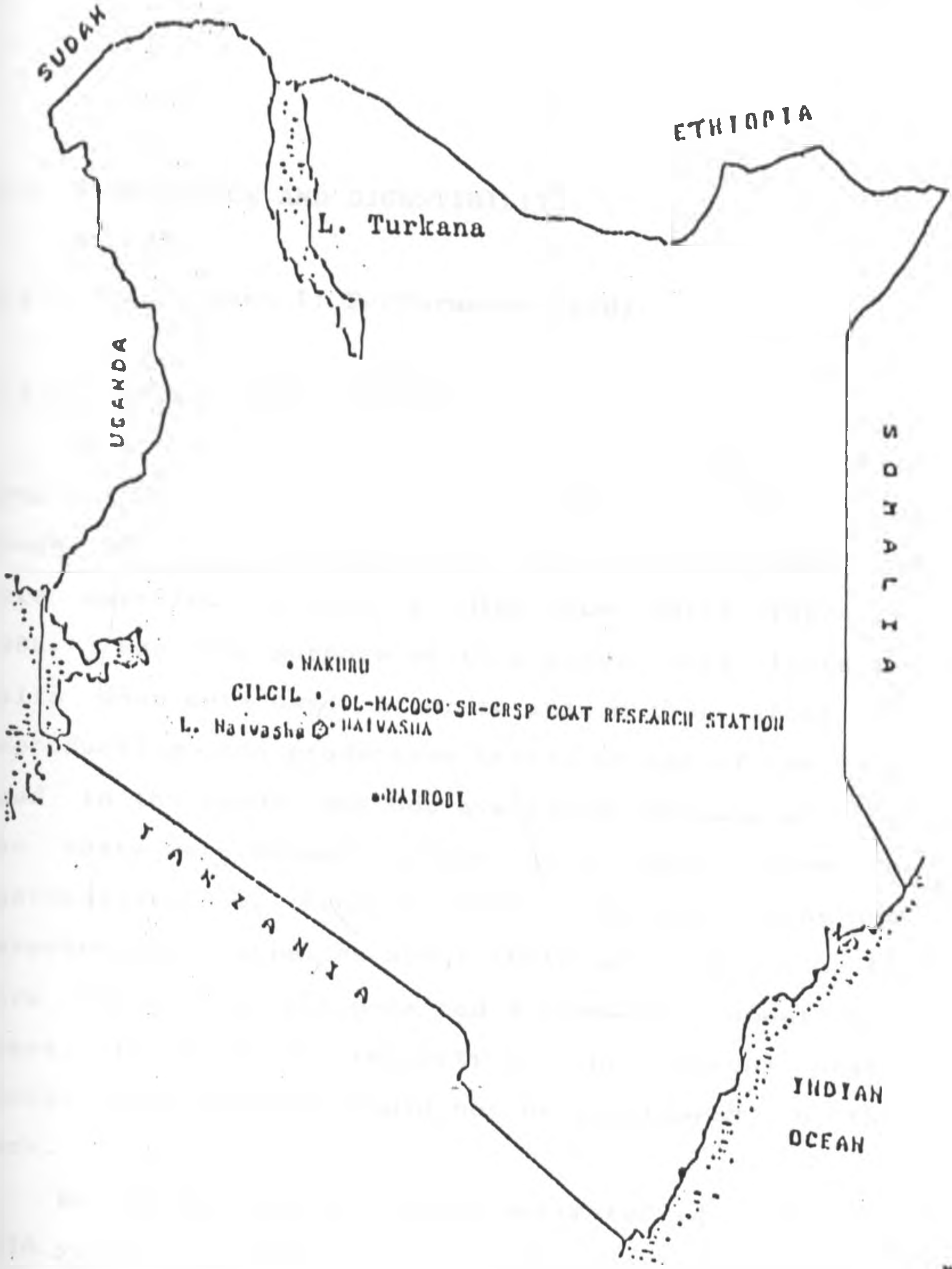


Figure 2: Geographical location of the SR-CRSP Goat Research station at Ol-Magogo.

3.2. PERFORMANCE AND DIGESTIBILITY STUDIES.

3.2.1. Experiment I: Performance Study.

3.2.1.1.Experimental Animals.

At the start of this project there were 317 Galla does out of the total herd of 4 goats on the farm. Of these, 120 does had been confirmed to be pregnant, and were expected to start kidding from early February, 1988. For the purpose of this study only lactating Galla does were used. Accurate information about the reproductive and production traits or age of the does used in the study, was not available because most of the goats were animals bought in, as adults from the pastoralists of Kenya's North Eastern Province. Nevertheless, estimates about their age compiled on the farm showed that the does had a range of about 5-10 years. It is in the totality of the reasons stated above, that blocking could not be considered in this work.

84 Galla females with an estimated age of about 5-10 years were randomly picked for use in this study, from the day each of them kidded. The lactating does, together with their kids were collected into one common pen and received the same management for the first week of lactation. This ensured free access to the does for the kids to suckle colostrum.

3.2.1.2. Feeds

Hay

Rhodes grass *(Chloris gayana)* hay was bought from a neighbouring Farm to be used as basal ration in this study.

Test diets.

Four Treatment diets (I, II, III and IV) based mainly on the inclusion of poultry waste in the supplement (at 0, 15, 30 and 45 percent respectively, on as fed basis), were formulated as shown in Table 5. Diet I, which contained conventional protein sources only (including Cotton Seed Cake) was used as a control. Maize germ, wheat bran, and molasses were included to balance the energy requirements of the test diets. The molasses added at 5% level was also expected to improve palatability and reduce dustiness.

The poultry waste was collected from the deep litter layer poultry houses at N.A.H.R.C., Naivasha. The material was floury and it was not necessary to grind it. However, it was sieved using a 1 cm wire grid to remove caked pieces and then was directly mixed with other ingredients in large plastic containers by hand.

3.2.1.3. Milking methods used in the study.

The goats were milked on two consecutive days of the week. Two milking procedures described below were used.

Table 5: The composition of formulated rations used in Expt. I and II.

Ingredients	Treatment diets			
	I	II	III	IV
	----------- percent -----------			
Maize germ	46	61	61	48
Wheat bran	46	17	3	2
Poultry waste	0	15	30	45
Cotton seed cake	3	2	1	0
Molasses	5	5	5	5
Total	100	100	100	100

MILKING METHOD I:

This process involved hand milking first, and then the kid is immediately left to suckle any residual milk in the udder. This procedure was carried out both in the morning and evening of Day 1. The milk intake by the kids was determined by the Weigh - Suckle - Weigh method. Milk yield recorded under this method, therefore, was as illustrated below:

Total daily milk yield I (Method I)
= morning hand milked yield plus kid intakes
+ evening hand milked yield plus kid intakes.

MILKING METHOD II:

This procedure involved having the kid suckling the dam to its satisfaction first and followed immediately by hand stripping of the does to obtain any milk leftover by the kids. Again the kid's milk intake was determined by weigh-suckle-weigh method. This procedure was carried out both in the morning and evening. Data for milk yield obtained under this method were as defined below:

Total daily milk yield II (Method II)
= morning kids milk intakes plus hand stripped milk + evening kids milk intakes plus hand stripped milk.

3.2.1.4. Experimental procedure

Animal Management

Lactating does

Immediately after a doe kids, and for the whole of the first week post-kidding, each doe, as the general feeding policy of the farm, received lucerne hay ad-libitum (1.5kg as is) and 250 g of a Commercial Dairy meal concentrate per day. On the 6th and 7th day of lactation, when the animals were being prepared to join the experiment, each doe was milked both in the morning and evening using milking method I and II respectively. On the eighth day of lactation, the goats were randomly allocated to the treatment pens and received a basal ration of Rhodes grass hay ad-libitum consisting of a known quantity of 1.8kg as is/doe/day. This amount of hay offered was decided upon in order to make sure that hay refusals from each pen should be equal to or above 15% of the amount offered (Schneider and Flat, 1975) throughout the experimental period of 12 weeks. Every morning at 09.00 hours, before fresh supplies of hay were provided refusals were collected, weighed and discarded (Plate 1). Due to lack of facilities for individual feeding, hay intake was determined for a group of 6-7 goats in each pen based on the differences between hay offered and its refusals. The hay refusals, appeared to have been soaked by urine at the time of collection. This could result in over-estimation of the weight of the refused material. To eliminate this limitation, representative samples of the wet hay refusals were taken at least thrice every two weeks for moisture determination and the DM values used for the calculation of DM refused.

The test diets were offered individually in two meals at a rate of 500g per doe per day. The quantity offered in the morning was about 75% of the total daily allowance. Test diets were introduced gradually over three days to facilitate adaptation. On the first day of experiment, a concentrate mixture of 50:50% (test diet as a proportion of dairy meal) was used, then it was increased to 75:25% on the second day, and 100% on the third day. Since most goats cleared the whole amount of the test diets allotted to them, the full amount (500g) was offered from the third day. Fresh water was offered ad-libitum daily. Commercial

Plate 1: Weighing and sampling for DM determination of hay refusals in the goat pen (Expt.I)

Maclick mineral blocks were offered, one in each pen of 7 does and were replaced every 3 weeks .

Suckling kids

The doe's and kid's liveweights were recorded within one hour of birth. Thereafter the procedure was repeated for the does once every week and at the same time in the morning before feeding. Kids were subsequently weighed, throughout the experiment, twice in each week, using milking methods I and II.

During the first month of life the kids were allowed only fresh water in addition to suckling. On milking days, kids were removed from their dams on the preceding night and confined in separate pens. They were rejoined with their dams during the time of milking only, while on the non milking days, kids remained with their dams all the time. After a month, kids were offered a solid ration of lucerne hay on the milking days in the hay racks. At two months of age, the kids were separated from their dams and confined in two large common pens during the day where they continued to receive lucerne hay, but were allowed access to their dams from 18.00 hours to 08.00 hours the following day, except on the nights preceding the two milking experimental days. This was to facilitate more accurate estimates of forage intake and milk outputs from the does. Weaning was done according to the following procedure. Goats which had terminated their 90 day period under Experiment I and which produced equal to or less than 50 mls of milk qualified for joining Experiment II or completely removed from Experiment I and their kids weaned. Goats which had completed Experiment I and were still in milk, were carried forward together with their kids to another experiment which is not reported in this study.

Feeds and milk sampling

Sampling of concentrate feeds was mainly carried out thrice every two weeks and bulked, while hay samples were collected from each new batch of hay supplied. Subsequently, all these samples were taken for dry matter determination. The dried concentrate and forage hay samples were then milled in a Wiley hammer mill to pass through a 1 mm sieve. Thereafter, representative samples of both materials were bulked and stored into 100 g sample glass bottles, for proximate (AOAC, 1984) and ADF, NDF (van Soest, 1963) analyses.

Sampling of milk was done weekly throughout the experimental period (week 1-13), in the morning of the day when milking method I was followed. A representative milk sample of 100mls was collected from each goat soon after milking. Seven drops of concentrated formalin equivalent to 0.25ml were then added to the milk samples for preservation and thereafter stored at -10^{o}C. This preservative method was chosen because formalin does not interfere with the Total Solids (TS) contents of the milk during chemical composition determination (W. Schulthess, 1988 - Personal communication). Subsequent to this, the milk samples for every alternative week starting from the first week of lactation were analysed for concentration of the Total solids, Gerber Fat, Milk nitrogen and Ash. Solids Not Fat was calculated by difference between the TS and Gerber Fat.

3.2.1.5. Statistical analysis

Data obtained from this study were subjected to statistical analysis on a Multitech Plus 700 Computer. The raw data for the various variables of interest were entered in the computer using PANACEA Program. Determination of the combined Least Squares means and Analysis of Variance was conducted using the Mixed Models Least Squares and Maximum Likelihood Computer Program of Harvey (1987). The differences between treatment means were detected by either fitting linear contrasts in the program or using t-Test (Steel and Torrie, 1981). The model of analysis, however, had one set of non-interacting random nested effects as outlined below:-

$$Y_{ijkl} = u + A_i + b_{ij} + F_k + e_{ijkl}$$

where:

u = overall mean.

Y_{ijkl} = are observations ie. milk yields, feed intake.

A_i = is a set of fixed effects i.e. Treatments, Birth type,

b_{ij} = are random nested effects i.e. weeks.

F_k = refers to all other fixed sets of effects.

e_{ijkl} = refers to residual effects.

3.2.2. Experiment II: Digestibility Study

This experiment was conducted mainly to determine the digestibility of the poultry waste containing diets fed to the goats in Experiment 1.

3.2.2.1. Animals

At the end of Experiment I, twenty four of the experimental goats were randomly selected to be used in Experiment II so that 6 animals in each treatment were used to assess digestibility of the diets. Because of limited number of crates, two runs of this trial, each having 12 animals, were done.

3.2.2.2. Experimental procedure

Animal management.

A completely randomised designed experiment bearing the same 4 treatments and feeds as those used in Trial I was carried out. There was no adaptation period since the goats were allocated to the same treatment diets they were on in Experiment I and were used to the tested diets. Instead the animals used this time to adjust to the digestibility crates (Plate 3). The adjustment period therefore only stretched for 7 days followed by a collection period of 8 days. Since the metabolism crates were designed for use by male animals, some modification (Plate 4) had to be done on the collection facilities (i.e. the urinal and faecal containers). This was to enable effective separation of the urine from the faeces that would normally be dropped together through the same outlet of the crate by the doe. The does were loosely tied around

Plate 2: Digestibility cage used in Expt. II.

Plate 3: Urine and faecal collection containers used in Expt. II.

their necks with a sisal twine which only enabled them to sit and stand comfortably. During the experiment the goats were offered concentrates in two unequal meals as described in Experiment I (sec. 3.2.1.4). However, the morning feeding was done at 9.00 a.m. following the collection of refusals of the hay forage, urine and faeces. In addition, the small size of the feed hoppers on the crates necessitated feeding the hay in chaffed form but still on ad-libitum basis. Furthermore, representative samples of the fresh hay, refusals and concentrate feeds (about 10% of the total offered amount) were collected during each collection day and from each experimental goat, then bulked for DM, OM, ADF and N determination.

Faeces collection

Total faecal output from each goat was collected in plastic basins placed under the crates (Plate 4). These were weighed daily and representative samples (composed of 10%) of each days output was bulked in plastic bags for each doe and stored at -10°C for proximate components and ADF determinations.

Urine collection

Urine was collected in the plastic containers placed in the basins (Plate 4). In both containers 15ml of 1M H_2SO_4 was put in to preserve and arrest the urine-N losses through volatilization. Daily urine output for each goat was then estimated as the contents of the two containers from each crate. A sample constituting 15% (W/W) of the daily urine content, was taken and bulked for each animal over the 8 day collection period. The bulked samples were thereafter stored in a deep freezer at -10^{o}C. In the laboratory, the bulked urine samples were thawed slowly and mixed well for N determination using Macro Kjeldahl Method of nitrogen analysis.

3.2.2.3. Statistical analysis.

Data obtained from this work were computed using the Models of analysis given in Section 3.2.1.4. of this chapter.

3.2.3. Chemical analysis

Data for the nutritive values of the various feed materials used in this work were gathered by conducting the chemical analyses of the respective representative samples collected earlier on. The methods however, used for determination of chemical composition of all the samples collected in both trials namely, hay on offer, hay refusals, concentrate diets, faeces and urine followed the standard procedures for proximate components (AOAC, 1984) while for ADF and NDF van Soest (1963) and van Soest (1967) procedures were used. The procedure used in analysing for Total Solids in milk samples was as described by the British Standard Method 1741 (1963), while the milk butterfat was determined using the Gerber Fat Test as described by Ling (1957). Milk protein and Ash were determined using Macro-Kjeldahl method and ignition of the total solid residues (from TS determinations) in the muffle furnace respectively according to AOAC (1984).

3.2.4. Calculations.

Hay Dry Matter Intake (DMI).

This was calculated using the following procedure.

Hay DMI = Offered Hay DM - Refused Hay DM.

Digestibility.

A total faecal collection technique (Schneider and Flatt, 1975) was followed. Thus the coefficients of digestibility were determined as illustrated by the following formula for Dry matter digestibility:-

$$\%DM\ Digestibility = \frac{Consumed\ DM - Faecal\ DM}{Consumed\ DM} \times 100$$

Digestible energy.

NRC (1981) and Church and Pond (1982) figures for the digestible energy (DE) of the various diet constituents were used to estimate the DE of the treatment diets used in both experiments. Due to lack of information from local sources, DE values for the poultry waste constituent were obtained from Bhattacharya and Taylor (1975).

Concentrate to forage ratio.

This is a proportionate contribution in the total feed DM offered to an animal by the concentrate and hay

DM fractions. This was derived as follows:

$$\text{Concentrate to forage ratio} = \frac{\text{Concentrate DM} \times 100}{\text{Hay DM}}$$

Liveweight change.

This was determined based on four period intervals as follows:-

Entire 12 Week Period:

Changes in the liveweight of the goats for this period were determined as the difference between the mean liveweights of the last 3 weeks and the first 3 weeks of experimental period.

Week 1 - 4 Interval:

This was determined based on the difference between the mean liveweight of weeks 1 and 2 and weeks 3 and 4.

Week 5 - 8 Interval:

This was calculated as the difference between the mean liveweights of week 5 and 6 and that of week 7 and 8.

Week 9 - 12 Interval:

This was obtained as the differences between the mean liveweights of week 9 and 10 and that of week 11 and 12

4. RESULTS AND DISCUSSION.

The data used for analysis in Experiment I were based on 82 lactating does and not on the 84 does initially allocated. The data for two does were screened out. The first of these does was from Treatment II which dried shortly after the first experimental week of lactation. The second doe was from Treatment III, which died of an unspecified disease in the fourth experimental week. The doe was however, observed to lose condition from the time of kidding and continuously emaciated until it died.

4.1. EXPT.I: PERFORMANCE STUDY.

4.1.1. Chemical composition of experimental feeds.

The mean proximate chemical composition (AOAC, 1984) of the ingredients used to formulate the four rations used in this study is summarized in Table 6. The poultry waste had 89.34, 18.59, 20.56 and 15.4 percent for DM, CP, CF and ASH contents respectively which were within the range reported by several other workers (Table 7). The cotton seed cake contained 91.9% DM, 38.4% CP, 11.4% EE, 6.4% ASH and 25.5% NFE values which are similar to those reported by Kayongo and Irungu (1986). While the poultry waste showed a higher value for the NDF (65.05%) than that of the cotton seed cake (29.69%), the values for the other fibre fractions, namely CF and ADF for the two protein products were similar (Table 6). The high CF fraction

Table 6: Mean values for the chemical constituents of the feeds used in Expt.I.

Item	% Composition									DE
	DM	OM	ASH	EE	CP	CF	NFE	NDF	ADF	Mcal/kgDM
<u>Ingredients</u>										
Maize germ	96.56	86.12	4.44	10.70	12.52	10.44	61.91	55.99	11.43	3.70
Wheat bran	91.39	84.76	6.63	7.88	16.42	14.95	53.27	59.09	15.58	3.09
Cotton Seed Cake	91.86	85.49	6.37	11.41	38.38	18.32	25.52	29.69	20.49	3.44
Poultry waste	89.34	73.94	15.40	2.52	18.59	20.56	32.27	65.05	27.21	2.00
Molasses	65.75	47.76	17.99	3.76	7.52	0.64	36.04	-	-	4.01
<u>Treatment diets</u>										
I (0% P/w)	92.96	87.05	5.91	8.05	15.56	12.11	58.35	55.89	13.35	3.16
II (15% P/w)	93.71	87.19	6.52	9.29	14.54	12.51	57.06	57.34	14.31	3.12
III (30% P/w)	93.32	85.92	7.40	9.01	15.05	14.18	54.36	61.11	15.49	2.96
IV (45% P/w)	92.48	84.00	8.48	8.61	15.47	15.66	51.78	61.05	17.79	2.71
Chloris gayana hay	94.05	83.56	10.49	6.75	5.87	44.81	32.09	82.79	50.82	2.25

Table 7: Mean values for the chemical composition of poultry waste used by different authors.

Item	% composition					Year and Authors	
	DM	CP	EE	CF	ASH		
Layers deeplitter waste	81.0	25.7	1.6	17.6	21.5	1984	Hadjipanayiotou.
Layers deeplitter waste	92.5	17.8	1.4	18.6	16.0	1985	Kayongo & Muinga.
Broiler litter	86.5	19.5	1.7	14.4	13.1	1986	Kayongo & Irungu.
Sundried poultry waste	92.4	17.6	3.9	15.3	28.9	1987	Nambi.
Dehydrated poultry manure	_	20.7	0.9	10.7	29.9	1988	Okeudo.
Deep litter poultry waste	89.3	18.6	2.5	20.6	15.4	-	The present study

in the poultry waste could be due to the wood shavings that were used as litter (Bhattacharya and Taylor, 1975; and Kayongo and Muinga, 1985).

There was little variation between the test rations with respect to the nutrients analysed (Table 6), except for the ASH, CF and ADF. These constituents tended to increase with the level of poultry waste which is consistent with the findings of Kargaard and van Niekerk (1978) and Kayongo and Irungu (1986). The mean crude protein content of the concentrate diets varied around 15%. The estimated DE values for the diets used in this study ranged from 2.7 to 3.2 Mcal/kgDM. These were a bit below the value of 3.3 Mcal/kgDM recommended for maintenance and milk production for lactating goats (NRC, 1981). A trend for decreasing energy values was also shown with increasing levels of poultry waste in the treatment diets (Table 6). The average crude protein value of the basal hay (*Chloris gayana*) used in this trial was 5.9% CP which was slightly higher than the 4.6% reported by Odhuba *et al.* (1986). However, the CP content of the hay was below the minimum level of 7% which indicated that the hay was of low nutritive value and would therefore not support animals even at the maintenance level (Sands *et al.*, 1970, van Voorthuizen, 1970 and Stobbs, 1971).

4.1.2. Feed Intake.

The average daily DM intake by the lactating goats which was calculated as shown in Section 3.2.1.4 and 3.2.4, during the 12 week experimental period is presented in Table 8. No significant differences

Table 8: Least Squares Mean values with SE for the hay and total feed DM consumed by lactating Galla goats.

Variable	Treatment				Significance
	I	II	III	IV	
Hay DM intake g/doe/day	1020.7 ± 31.3	1026.0 ± 31.8	1050.6 ± 30.5	1069.3 ± 31.3	ns
Hay DM intake g/kgW$^{0.75}$/day	73.8 ± 3.1	76.0 ± 3.1	77.3 ± 3.0	78.6 ± 3.1	ns
Concentrate DM intake g/doe/day	464.8	468.6	466.6	462.4	-
Total feed DM intake g/doe/day	1485.5 ± 31.3	1494.6 ± 31.8	1517.3 ± 30.5	1531.7 ± 30.3	ns
Total DE intake Mcal/doe/day	3.77	3.76	3.74	3.66	-
Total feed DM intake g/kgW$^{0.75}$/day	100.9 ± 3.3	103.9 ± 3.3	104.9 ± 3.2	105.8 ± 3.3	ns

ns = Not significantly different ($P>0.05$)

(P>0.05) among treatment means were detected in the daily hay DM intake, even when this was expressed on the basis of metabolic body weight. There was however, a tendency for increasing DM intake of hay with increasing levels of poultry waste in the diets. Thus animals in Treatment IV consumed 4.8% more hay DM followed by those of Treatment III (2.9%) than animals of Treatment I (Control).

The changes in average daily hay DM intake over the experimental period are shown in Figure 3. All goats in the four treatments showed a trend of increasing hay DM intake to a peak irrespective of the poultry waste level included in the diets. This suggested that hay DM intake was equally affected by both conventional and non-conventional sources of nitrogen which confirmed the work of other studies (Gihad, 1976, Holzer and Levy, 1976, Odhuba *et al.*, 1986).

The peak for all the poultry litter based treatments (II, III and IV) was reached during the 8^{th} week of lactation, while that for the control group was reached a week earlier in the 7^{th} week (Figure 3). However, despite this the results for all the four treatments were comparable to the peak intake period range of between 6 and 10 weeks reported by Morand-Fehr (1981) for lactating goats. This was confirmed further by Badamana (1987) who reported a peak DM intake by goats at between 6 and 11 weeks of lactation.

The average DM intake of concentrate diets for all the treatments was the same (Table 8). This was because does on all treatments were allocated the same amount of concentrate all of which they consumed with no

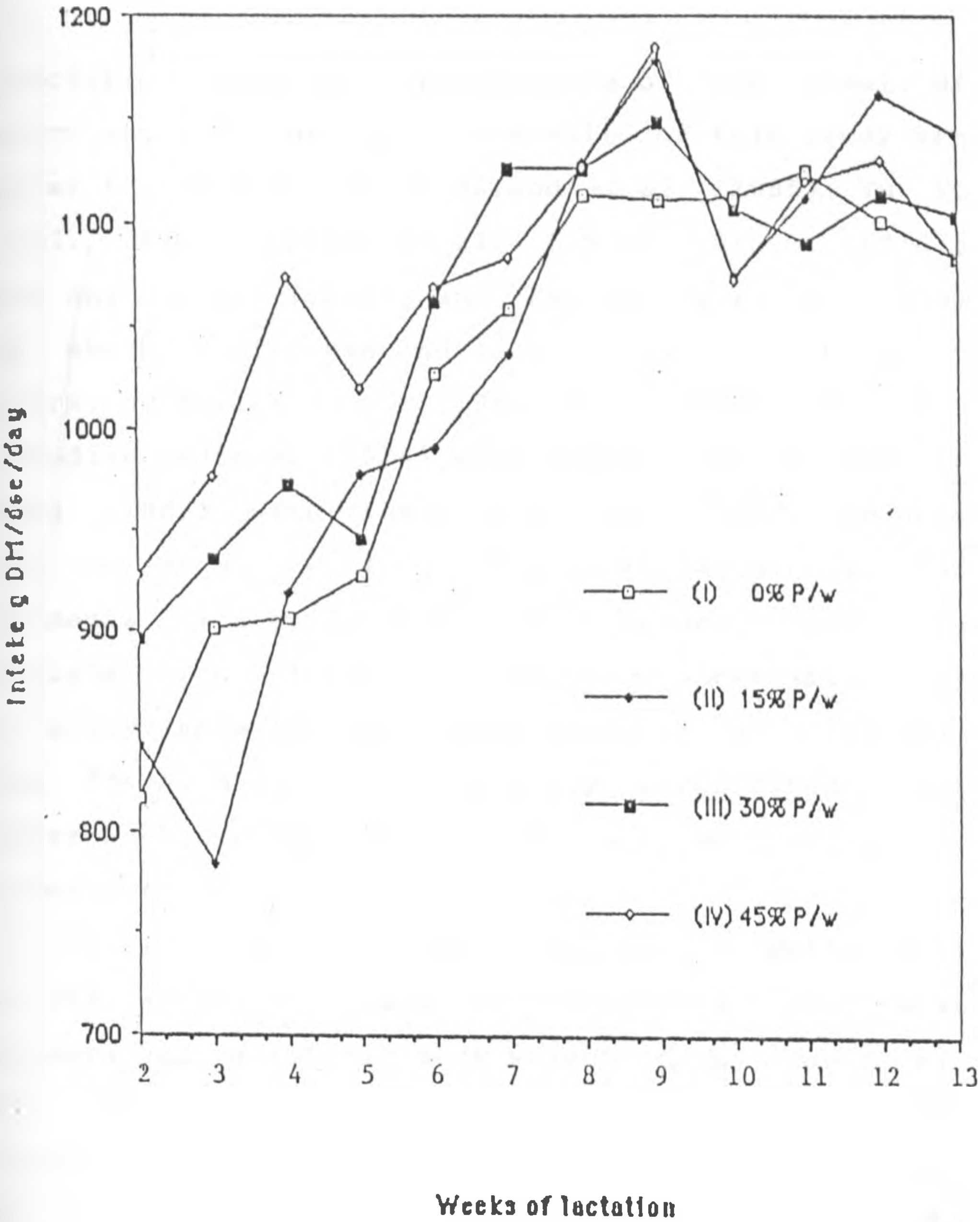


Figure 3: Daily hay DM intake of lactating Galla goats (Expt.I)

appreciable refusals, irrespective of the level of poultry waste inclusions. The results of this study are similar to the findings of Noland *et al.* (1955); Yu Yu *et al.* (1972); Creger *et al.* (1973); Gihad (1976); Smith and Calvert (1976); and Essi-Evans *et al.*(1978) with sheep, of Cross and Jenny (1975) with dairy heifers, of Malick *et al.* (1980) with buffalo heifers, of Hadjipanayiotou (1984) with Damascus goats and of Odhuba (1987) with finishing steers. These authors found no excessive feed refusals in either of the treatments with or without poultry manure, confirming the diets' high palatability and hence acceptability by the study animals used. Essi Evans *et al.* (1978), using fresh manure, conclusively illustrated that poultry wastes even when presented wet, were acceptable to ruminants.

Total feed DM intake was not significantly (P>0.05) affected among the treatments even when expressed on metabolic body weight basis (Table 8). There was however, a trend of increasing total feed DM intake for goats on Treatment I through to Treatment IV. This may probably have been due to the fact that goats were trying to compensate for the slightly low total amounts of DE consumed, which appeared to decrease as the level of poultry waste was raised in the treatment diets (Table 8). This confirms the findings by Holzer and Levy (1976) using lactating cows, who illustrated that feeding PL as a sole supplement in the diets cannot supply sufficient energy irrespective of the possible increase in DM intake. The peak DM intakes of hay and that of total feed DM (Figure 4) was observed in the 9th week of lactation

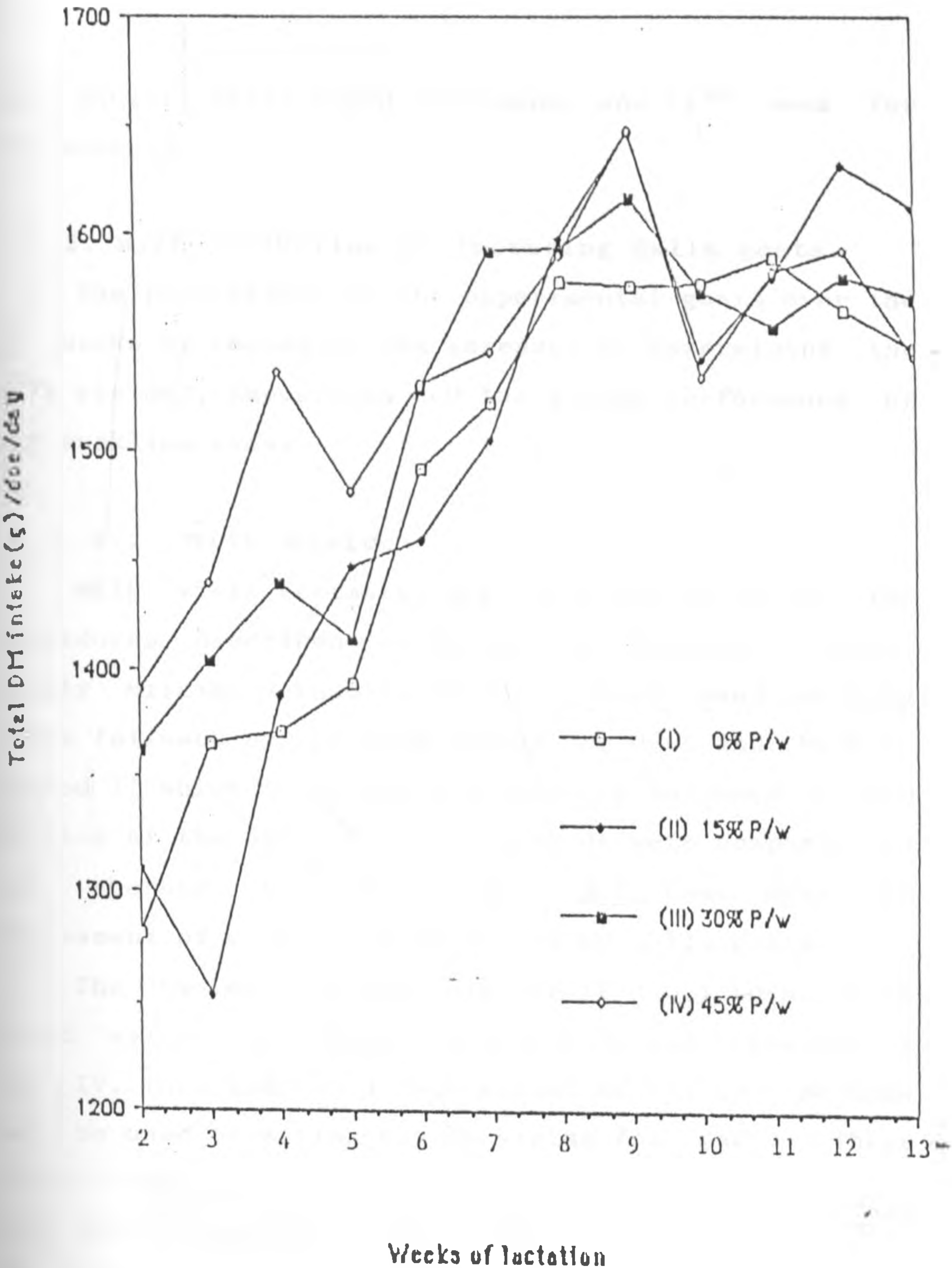


Figure 4: Total feed DM intake of lactating Galla goats (Expt. I).

for poultry waste based treatments and 11th week for the control.

4.1.3. Milk production of lactating Galla goats.

The performance of the experimental goats over the 12 weeks of lactation was assessed by determining the milk yields, composition and the growth performance of the suckling kids.

4.1.3.1. Milk yield.

Milk yield estimates were obtained using the two procedures described in detail in Section 3.2.1.3, namely Milking Method I, which involved hand milking first followed by kid suckling of the does and Milking Method II which involved kid suckling followed by hand milking of the does. The two methods were compared to see whether they would give different data for assessment of milk yield potential of Galla goats.

The two methods gave similar (P>0.05) total milk yield values as shown in Figure 5, and Appendix I and IV. This indicated that either of the two methods may be used to estimate milk yields for goats. These results agree with those of Ruvuna *et al.* (1988) using East African and Galla goats. Thus they suggested that in order to make estimates of total milk yield potential of the goats it was appropriate to combine both hand milked and sucked milk measurements simultaneously.

Results for the total milk yield estimates using methods I and II collected over the entire 12 weeks of experimentation are presented in Table 9 and 10 and illustrated by Figures 6 and 7 respectively. With

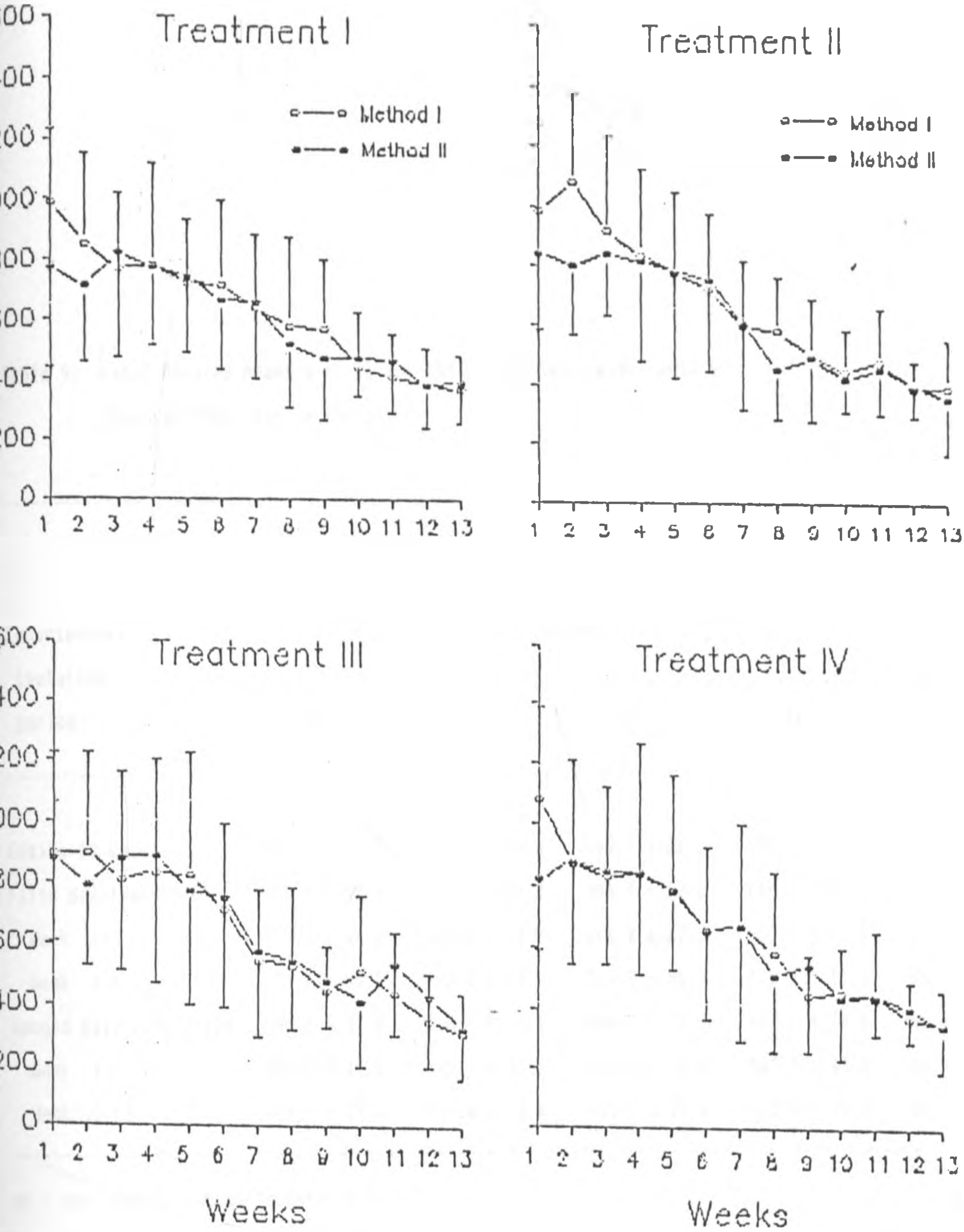


Figure 5: Comparison between the Total daily milk yield estimates with milking methods I and II.

Table 9: Least Squares Means with SE for the Total daily milk yield I (hand milking plus suckling).

Experimental lactation period	Daily total milk yield in (mls)				Significance
	Treatment				
	I	II	III	IV	
Entire 12 weeks	680.7 ± 62.6	730.6 ± 63.6	699.7 ± 61.2	673.1 ± 63.9	ns
First Half(Week 1-6)	854.4 ± 53.7	942.3 ± 54.8	900.9 ± 52.6	866.3 ± 54.8	ns
Week 1-3	928.9 ± 42.8	1085.9 ± 44.2	1008.2 ± 42.5	953.9 ± 43.7	ns
Week 4-6	779.9 ± 59.5	798.8 ± 60.9	792.2 ± 58.5	778.7 ± 58.5	ns
Second Half(Week 7-12)	506.8 ± 37.4	518.5 ± 38.1	498.2 ± 36.7	479.6 ± 38.2	ns
Week 7-9	593.1 ± 42.6	579.1 ± 43.6	580.2 ± 41.8	545.2 ± 43.5	ns
Week 10-12	420.1 ± 29.9	457.6 ± 30.6	415.2 ± 29.6	413.8 ± 30.5	ns

ns = non significant difference (P>0.05)

Table 10: Overall least Squares Mean values with SE for the Total daily milk yield II (suckling plus hand milking).

Experimental lactation period	Mean milk yield (mls) Treatment I	II	III	IV	significance
Entire 12 weeks	687.3 ± 56.9	700.7 ± 58.9	687.7 ± 56.8	708.5 ± 57.4	ns
First Half(week 1-6)	860.5 ± 40.2	904.8 ± 41.9	871.1 ± 40.4	907.2 ± 40.5	ns
Week 1-3	888.9 ± 35.6	938.2 ± 37.8	932.3 ± 36.4	970.1 ± 35.9	ns
Week 4-6	832.2 ± 51.9	871.4 ± 54.2	809.8 ± 52.2	844.3 ± 52.4	ns
Second Half(week 7-12)	514.1 ± 28.4	496.7 ± 29.5	504.4 ± 28.5	509.8 ± 28.6	ns
Week 7-9	567.9 ± 29.5	541.5 ± 30.9	544.4 ± 29.8	575.3 ± 29.7	ns
Week 10-12	460.3 ± 41.3	452.1 ± 43.0	464.6 ± 41.4	444.4 ± 41.7	ns

ns : not statistically significant difference (P>0.05).

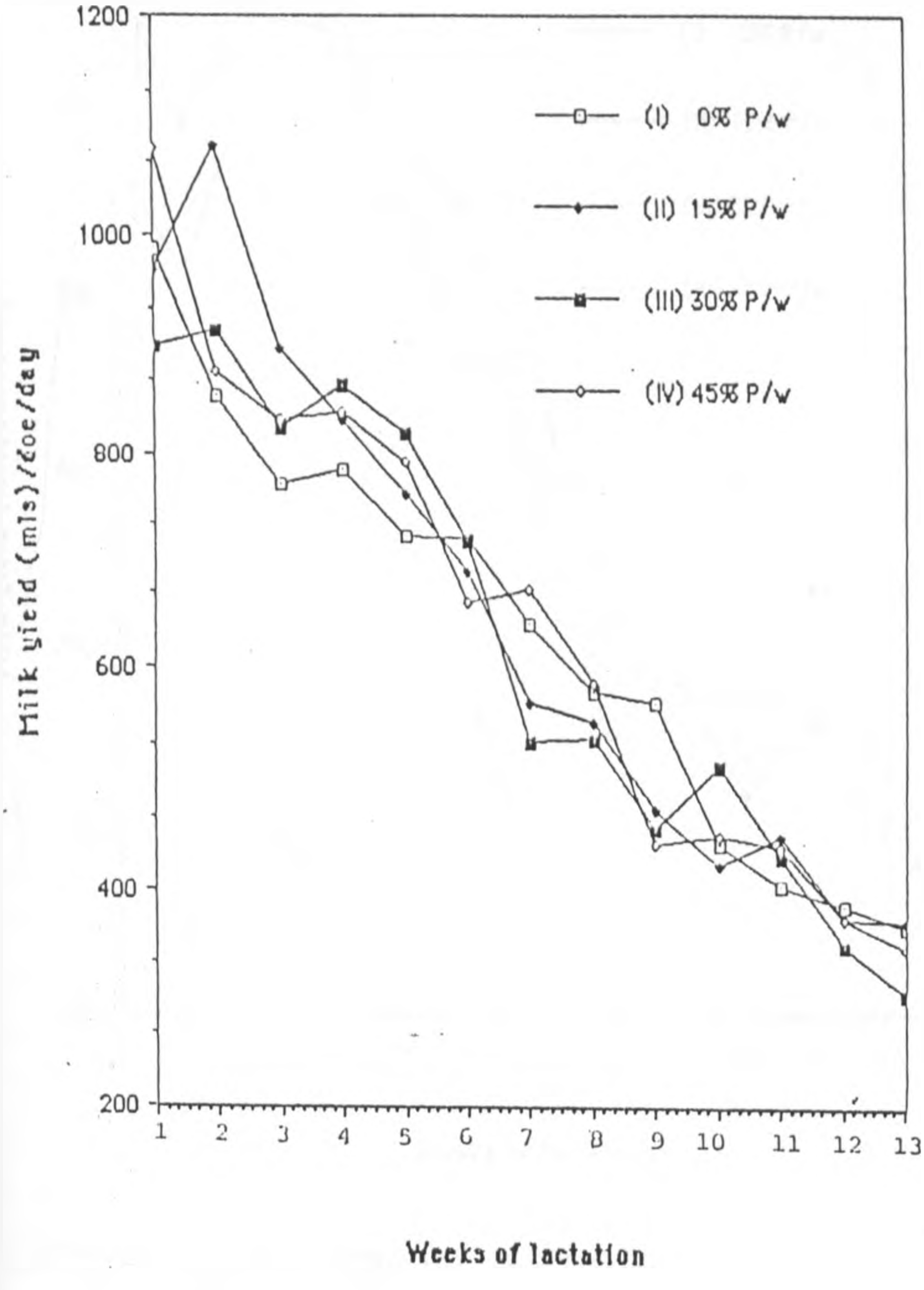


Figure 6: Mean total daily milk yield I (hand milking plus suckling).

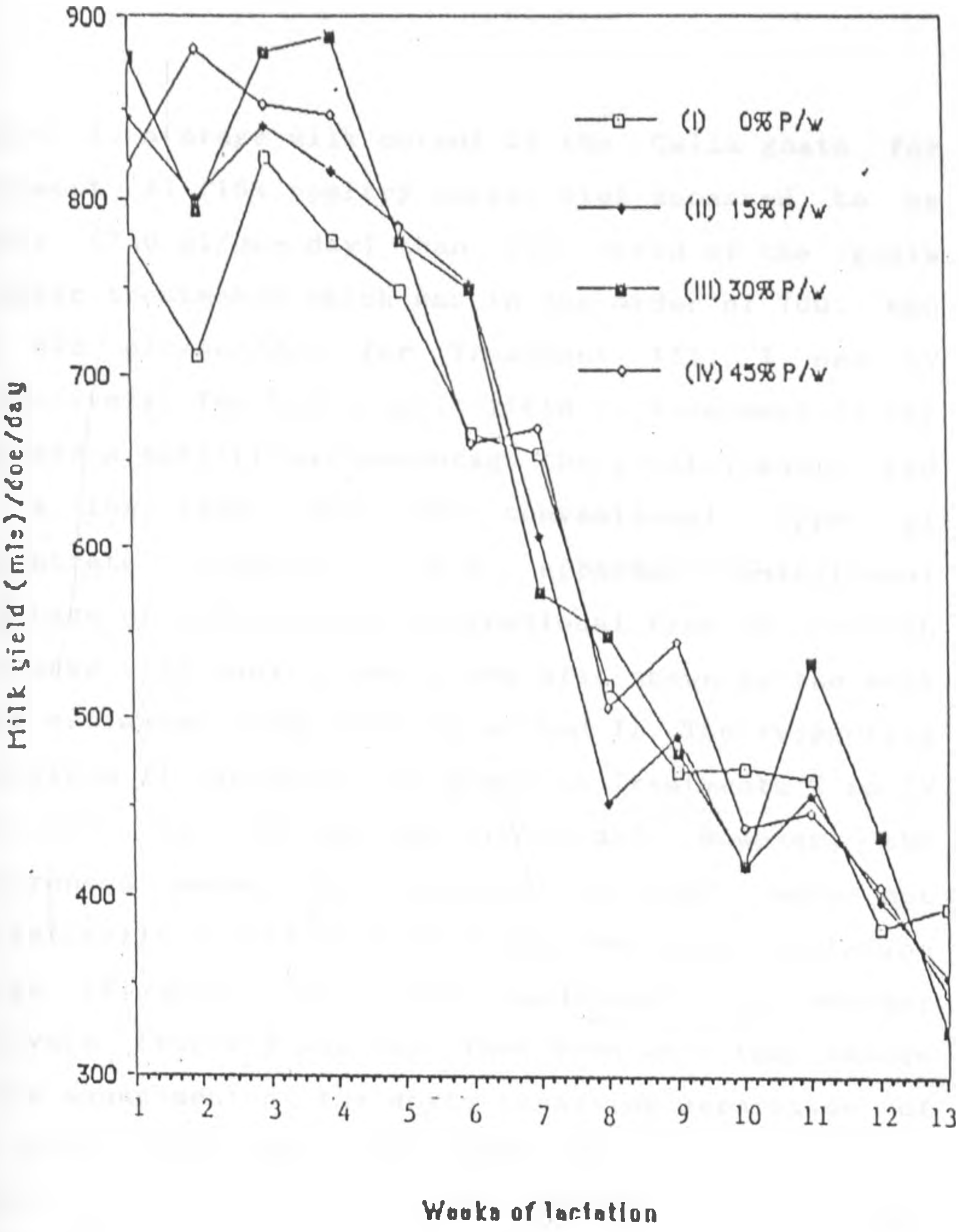


Figure 7: Mean total daily milk yield II (suckling plus hand milking).

method I, average milk output of the Galla goats for Treatment II (15% poultry waste) diet appeared to be higher (730 ml/doe/day) than the yield of the goats in other treatments which was in the order of 700, 680 and 673 mls/doe/day for Treatment III, I and IV respectively. The higher milk yield in Treatment II may indicate a nutritional advantage the poultry waste had at a 15% level over the conventional type of concentrate (control). This apparent nutritional advantage of substituting conventional type of protein seed cake with poultry waste was also shown by the milk yield estimates using milking method II. The respective milk yield II estimates for goats on Treatments I to IV were 687, 701, 688 and 708 ml/doe/day. However, the differences among the treatment methods were not statistically significant (P>0.05) even when lactation curves (Figures 6 and 7) were subdivided into shorter intervals (Table 9 and 10). Thus even when the change in the management of the goats involving separation of the kids from their dams during the day from the second month post kidding was instituted, neither the management change nor the treatment diets had any significant effect on milk yield I and II. These findings agree with those of Hadjipanayiotou (1984), who fed chios ewes and Damascus goats with diets containing 15 and 30% poultry litter. Milk yield of the ewes and goats fed a 0 or 15% poultry waste diet were similar (P>0.05), while a depression in the yield was observed with the groups which received a 30% poultry litter containing diet. He associated this reduction with lower feed intake and not any direct adverse effects of poultry litter.

The average yield recorded during the early weeks (1-6) of lactation (Table 9 and 10) for Treatment I, II, III and IV are comparable with the values outlined by Skea (1988). This implies that the Galla goats used in this study expressed their potential to produce high milk yield during early lactation, but this was followed by a marked decline with advancement of lactation. The lack of significant differences in milk yield among treatments, as well as the fact that the animals remained in good health throughout the study period, reflected a similarity in the nutritive values of the diets made up of conventional type of concentrate and those of poultry litter. This suggests that, where necessary, poultry waste could be a feasible partial or total source of dietary nitrogen replacing plant crude protein in the supplemental diets of ruminants, and confirms the views of Shah and Muller (1983); Hadjipanayiotou (1984); Kayongo and Irungu (1986) and Odhuba (1987).

The peak of the lactation curves using both Method I and II for goats on the 4 treatment diets are shown in Figure 6 and 7 respectively. All peaks for milk yield I were observed to be within the first week while in milk yield II were extended to the 3rd week of lactation and consistently followed by a decline in milk yield with advancement of lactation. The characteristic rise in the milk yield to a peak followed by a gradual decrease to the time of drying off was not apparent in the present work. This is consistent with the findings of Wahome *et al.*' (1987) with East African goats grazed on the semi-arid thorn-bush Savannah. However, Akinsoyinu *et al.* (1977)

working with West African dwarf goats illustrated a peak yield between 4 and 6 weeks. This was supported by Morand-Fehr (1981) and Badamana (1987) with Alpine and Saanen does respectively, who reported a peak yield at 6 weeks. The lack of a more apparent rise to a peak milk yield of the Galla goats used in this study, suggests a need for further research on this aspect.

In the present study goats responded poorly to hand milking, especially in the absence of their kids. Using paired students t-Test, the mean daily milk yield (hand milked) and the kids milk intakes obtained under the same method were compared (Table 11). Kid's milk intakes after hand milking were significantly ($P<0.05$) higher than the yield through hand milking. The fact that the goats released slightly more milk to the kids to suckle after apparent complete milking of milk from the udder by hand (Appendix II and III), is an indication of inadequate stimulation of milk letdown by the milker. When the kids suckled first followed by hand milking (milking Method II), the kids' daily milk intakes were significantly ($P<0.001$) far higher (97%) than the amounts obtained by hand milking (Appendix V and VI). Poor milk letdown response to hand milking in addition to genetic factors were cited by Akinsoyinu *et al.* (1977) to explain the low milk yields they recorded for West African dwarf goats. Ruvuna *et al.* (1988) also reported lower milk yields (343 g/doe/day) from Galla goats milked in the absence of the kids, but an increased yield (457 g/doe/day) from does with the kid present at milking. According to Wahome *et al.* (1987) and Ruvuna *et al.* (1988) this increase in milk yield was attributed mainly to the stimulation of milk

Table 11: Comparison between the daily milk yield I (hand milked) with milk suckled by kids from Galla goats.

Treatments	df	Daily milk yield I (hand milked)	Milk yield sucked by kids	Calculated paired t-value	Significance
		---mls---			
I	11	200.5^{a}	338.3^{b}	-10.477	***
II	11	234.5^{a}	332.7^{b}	-15.140	***
III	11	166.3^{a}	360.6^{b}	-10.585	***
IV	11	186.7^{a}	340.9^{b}	- 8.260	***

*** : Means followed by different superscripts on the same row differ significantly (P<0.001).

letdown by the presence of kids.

4.1.3.2. Milk Composition.

Table 12 summarizes the mean composition of the milk obtained from the goats used in the present study. The mean values for the milk components reported in this work were in various aspects comparable to the values of other workers (Table 13), and fall within the expected normal range. The combined least squares analysis of variance for the Total Solid (TS), Solid Not Fat (SNF), Gerber Fat, Total CP and Total Ash fractions did not show any significant (P>0.05) differences among the treatments (Table 12). This implies that the dietary treatments did not have any effect on the quality of milk of the Galla goats, confirming the results reported by Hadjipanayiotou (1984) for ewes and goats.

The variation of the TS, Gerber Fat, SNF and CP constituents of the milk harvested during the study period is shown in Figures 8, 9, 10 and 11 respectively. The curves in these figures, illustrated higher values of the respective constituents at the beginning of lactation followed by a rapid decrease in the first two to four weeks and then an increase towards the end of lactation. These findings are comparable with those reported by Anifantakis and Kandarakis (1980) and Zygoyiannis and Katsaounis (1986) for local goats of Greece. The minimum content of TS, SNF, Gerber Fat and Milk protein is known to occur at the time when milk yield is maximum (Akinsoyinu *et al.*, 1977; Oldham and Sutton, 1980). The curves for the Ash fraction (Figure 12) showed a less distinct

Table 12: Summary of the least squares mean values with SE for TS, Gerber Fat, SNF, Total N and Ash of milk from lactating Galla goats (EXPT.I).

Variable	Treatment values (Percent)				Significance
	I	II	III	IV	
TS	13.3 ± 0.3	13.4 ± 0.3	13.9 ± 0.3	13.8 ± 0.3	ns
Gerber Fat	4.2 ± 0.1	4.6 ± 0.1	4.3 ± 0.1	4.5 ± 0.1	ns
SNF	9.1 ± 0.2	8.7 ± 0.2	9.6 ± 0.2	9.3 ± 0.2	ns
Crude Protein	3.9 ± 0.1	3.9 ± 0.1	4.1 ± 0.1	4.0 ± 0.1	ns
Ash	0.7 ± 0.2	0.8 ± 0.2	0.8 ± 0.2	0.8 ± 0.2	ns

ns : not significant different ($P>0.05$)

Table 13: Comparison for the milk composition between the results of the present study and other researchers.

Source of milk	% Composition					Author(s) and year
	TS	BF	SNF	CP	Ash	
Boer Goats (South Africa)	15.1	5.6	10.1	3.1	0.89	Devendra (1980)
Jamnapari Goats (India)	14.2	4.6	9.6	4.0	0.84	Devendra (1980)
Red Sokoto (Nigeria)	15.8	5.3	10.5	4.7	0.78	Devendra (1980)
Cows	12.5	3.8	8.7	3.3	0.80	Castle & Watkins, (1984)
West African Dwarf goats	18.7	6.9	11.8	3.9	0.80	Akinsoyinu *et al.*, (1977)
Indigenous Greek Goats	14.8	5.6	9.2	3.8	0.73	Anifantakis & Kandarakis(1980)
Mean for Galla goats in:-						
Treatment I	13.3	4.2	9.1	3.9	0.70	The present study
Treatment II	13.4	4.6	8.7	3.9	0.80	The present study
Treatment III	13.9	4.3	9.6	4.3	0.80	The present study
Treatment IV	13.8	4.5	9.3	4.5	0.80	The present study

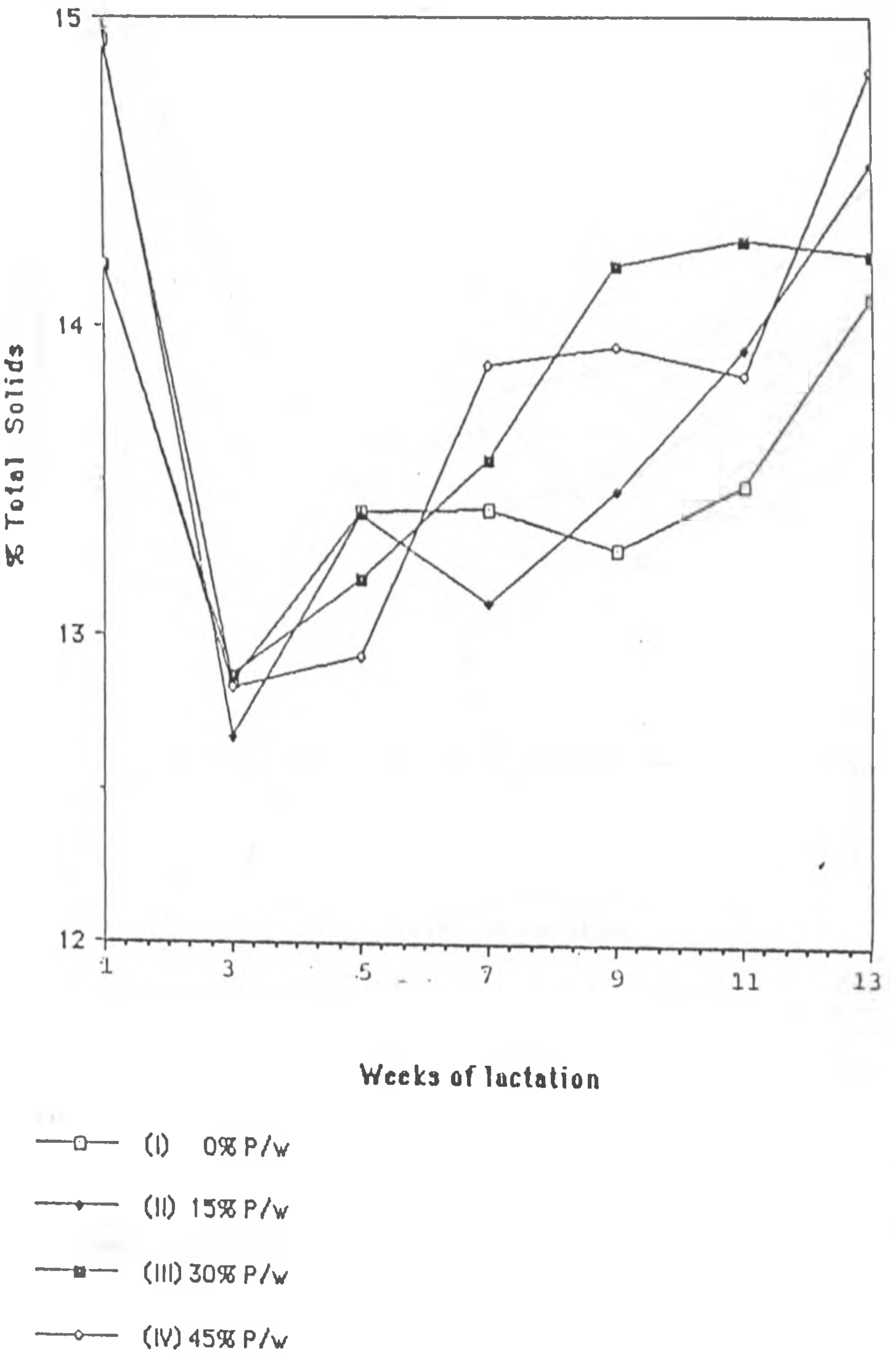


Figure 8: %TS of Galla goat milk.

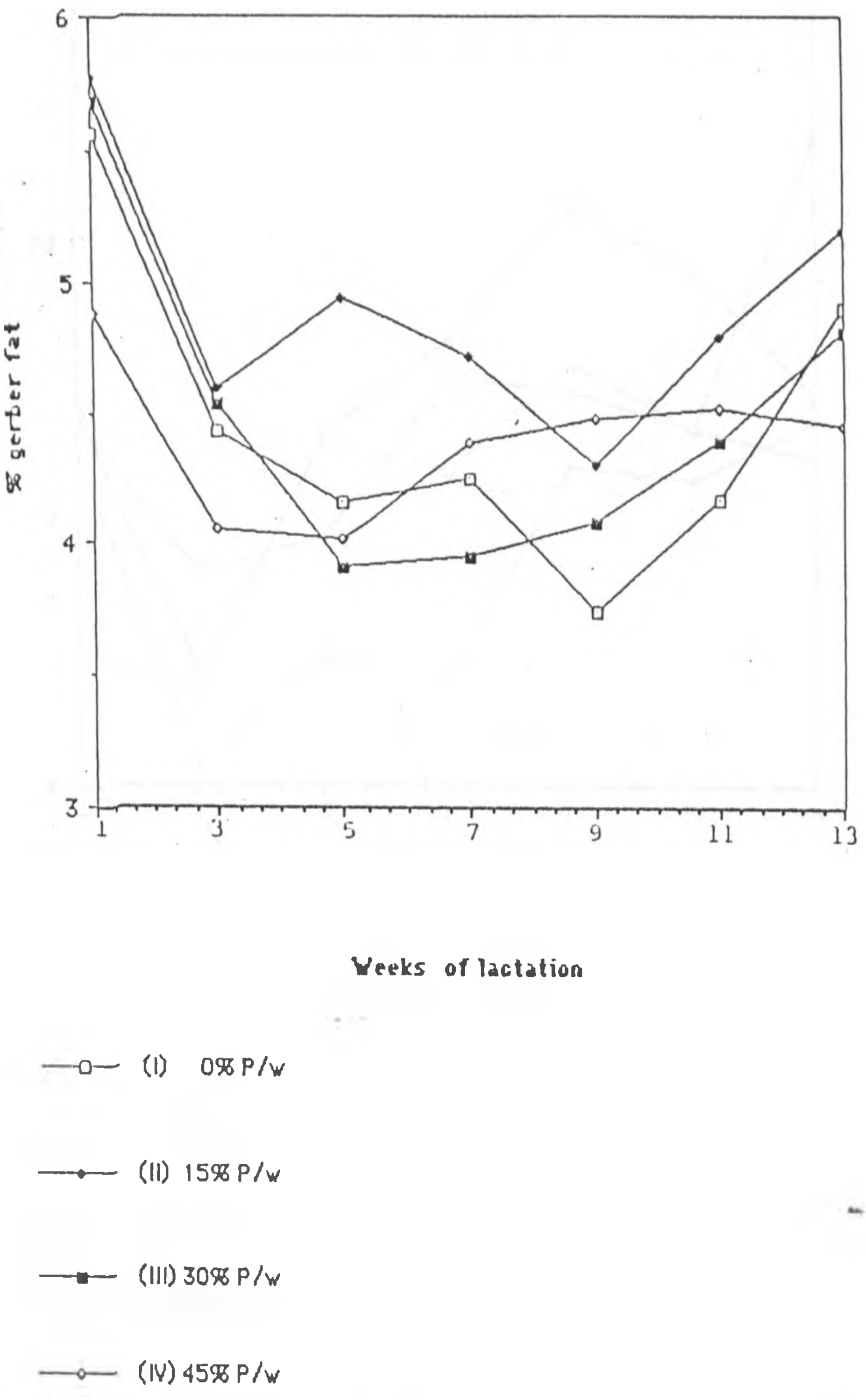


Figure 9: %BF of Galla goat milk.

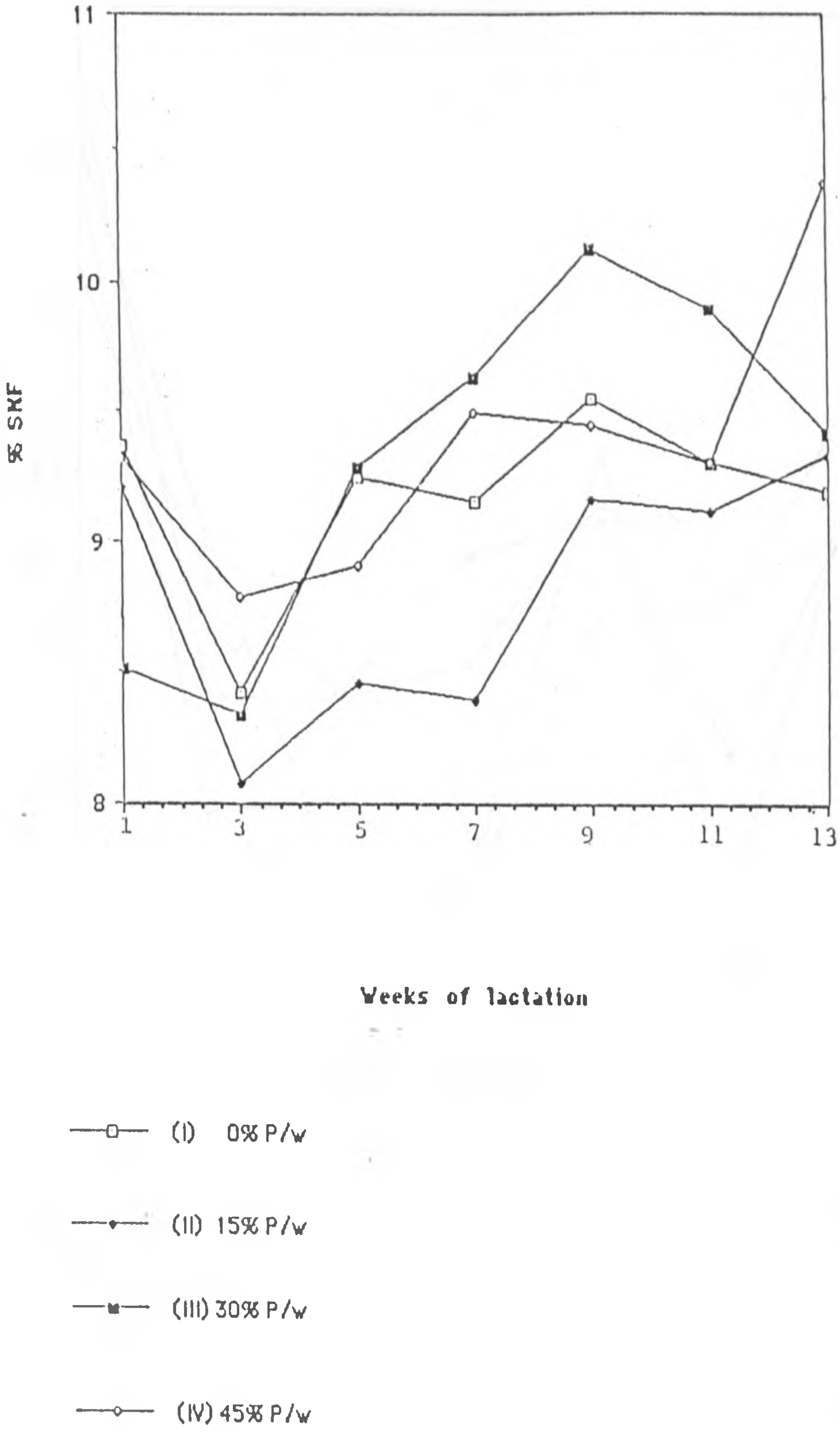


Figure 10: %SNF of Galla goat milk.

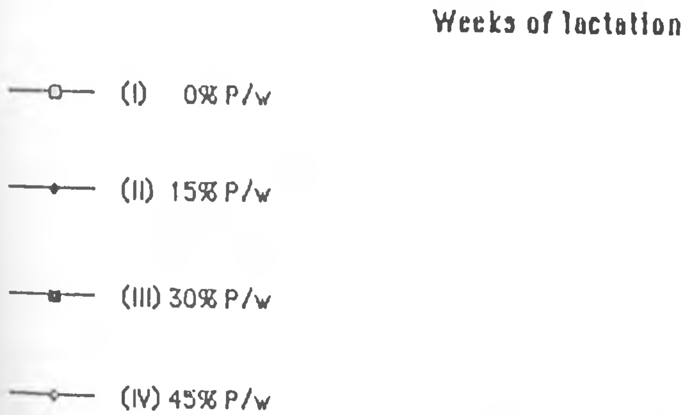
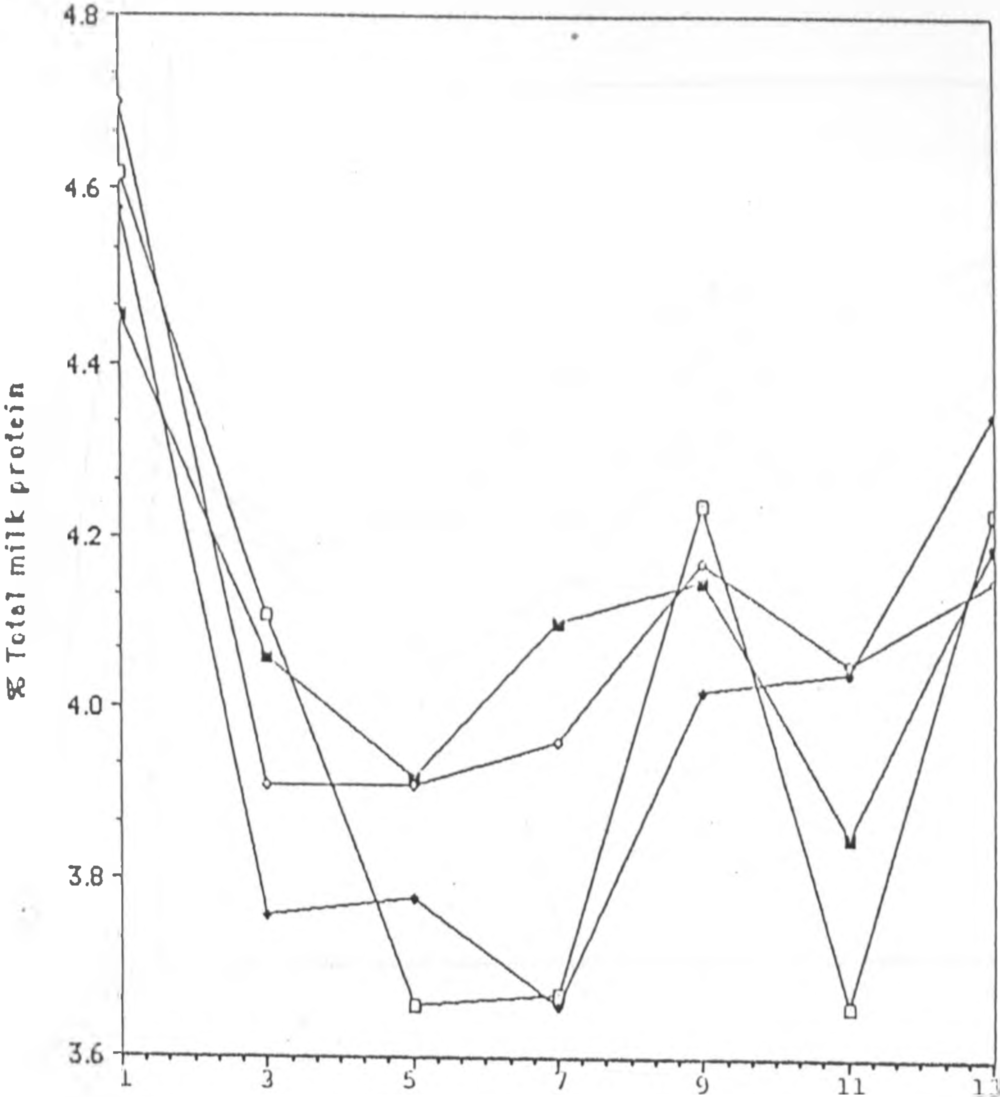


Figure 11: %Total crude protein of Galla goat milk.


% Total milk protein
4.8
4.6
4.4
4.2
4.0
3.8
3.6
1
3
5
7
9
11
13

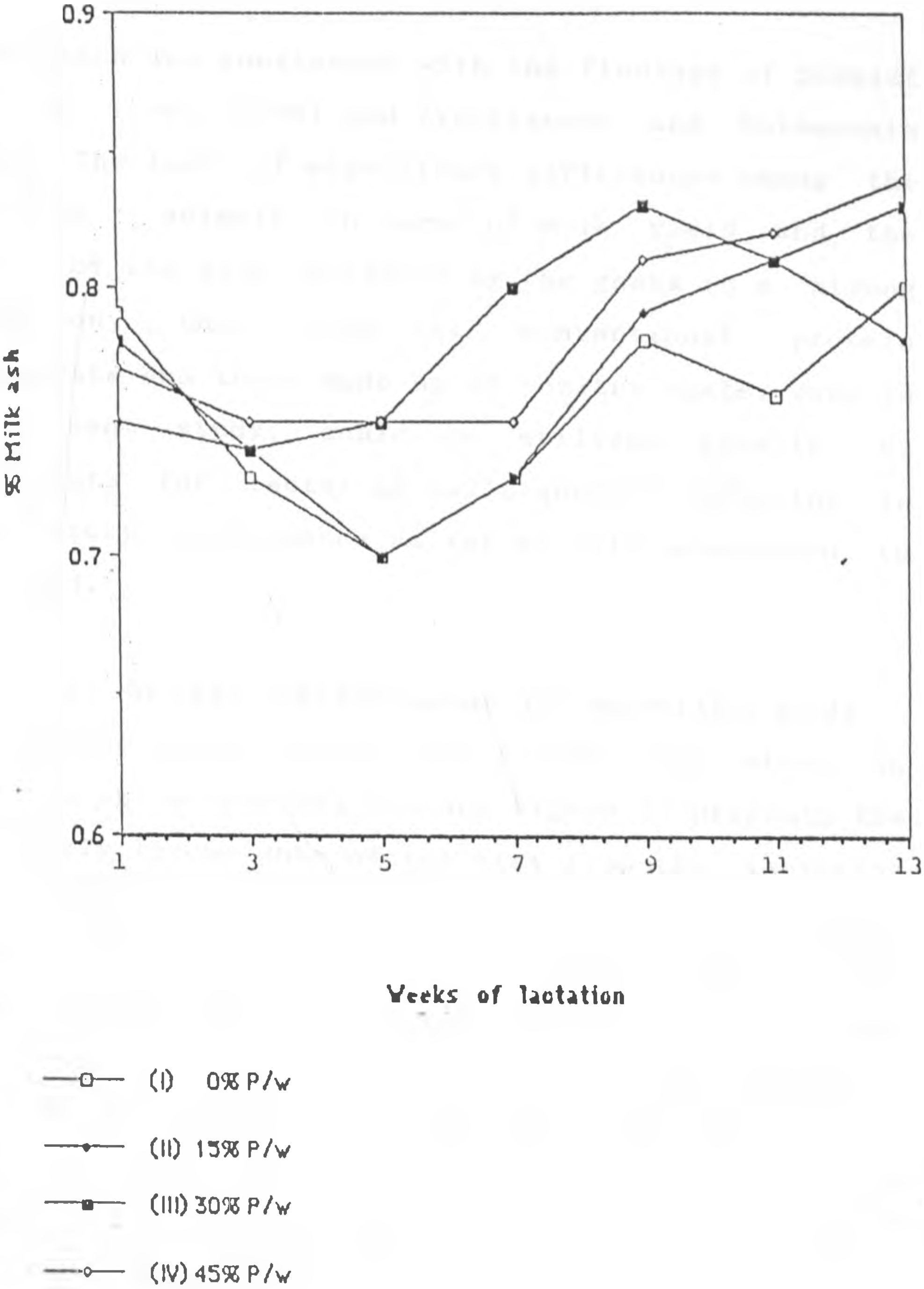


Figure 12: %Ash content of Galla goat milk.

trend which was consistent with the findings of Schmidt and van Vleck (1974) and Zygoyiannis and Katsaounis (1986). The lack of significant differences among the treatment animals in terms of milk yield and the quality of the milk produced by the goats is a strong indication, that both the conventional protein concentrate and those made up of poultry waste, used in the present study, could be utilized equally as supplements for lactating Galla goats, resulting in satisfactory performance as far as milk production is concerned.

4.1.3.3. Growth performance of suckling kids.

Average daily weight gains (ADG) are shown in Table 14, while Appendix VII and Figure 13 presents the mean weekly liveweights of the kids from the lactating does offered the experimental diets. The treatment diets the does received did not significantly affect ($P>0.05$) the daily average growth rates of kids. The trend for the weekly ADG of the kids showed a higher rate of growth in all the four treatments at the onset of the experiment and that this declined gradually with advancement of lactation of the does. Significant differences ($P<0.05$) in the kids growth rates were shown in the 7^{th} up to the 9^{th} week of lactation (Table 14 and Figure 13). Factors that led to the drop of weight of kids during that period are however, difficult to explain.

Table 14: Weekly average weight gain of kids from does of Experiment I.

Interval in weeks of lactation	Kids' weight gains (g/day)				Significance
	Treatments				
	I	II	III	IV	
1-2	97.0 ± 9.2	91.7 ± 10.1	97.6 ± 10.2	95.1 ± 9.4	
2-3	83.3 ± 9.1	83.8 ± 10.0	81.7 ± 10.2	80.0 ± 9.4	
3-4	69.3 ± 7.9	71.9 ± 8.7	69.7 ± 8.8	75.0 ± 8.1	
4-5	61.8 ± 8.1	68.9 ± 8.9	80.5 ± 9.1	55.7 ± 8.3	
5-6	68.2 ± 8.4	52.5 ± 9.2	52.8 ± 9.3	58.0 ± 8.6	
6-7	53.9 ± 9.4	78.0 ± 10.4	49.6 ± 10.5	54.9 ± 9.7	
7-8	81.1 ± 11.4[a]	36.4 ± 12.5[b]	69.1 ± 12.7[a]	33.9 ± 11.7[b]	*
8-9	43.1 ± 11.7[a]	29.1 ± 12.9[a]	-0.2 ± 13.1[b]	5.4 ± 12.1[b]	*
9-10	12.1 ± 11.6	28.3 ± 12.7	25.3 ± 13.0	22.7 ± 11.9	
10-11	22.2 ± 10.8	16.0 ± 11.8	17.7 ± 12.0	20.8 ± 11.1	
11-12	18.0 ± 13.3	0.6 ± 14.6	22.0 ± 14.9	30.5 ± 13.7	
11	55.5 ± 3.1	50.6 ± 3.4	51.4 ± 3.5	48.4 ± 3.2	

* = Means followed by different superscripts differ significantly at ($P<0.05$)

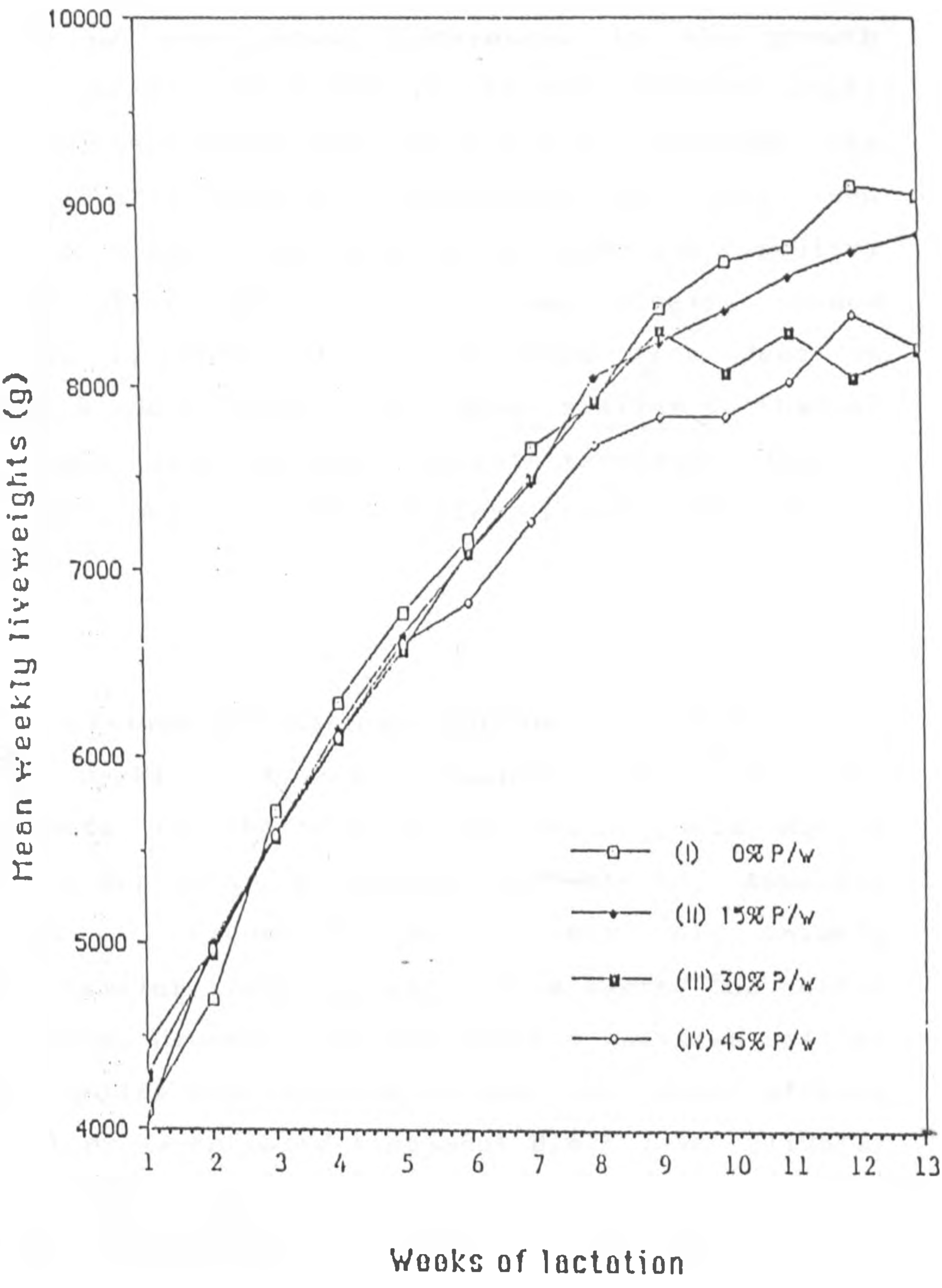


Figure 13: Least squares mean weekly liveweights of Galla goat kids (Expt.I).

Lack of significant differences in the growth rates of the kids from does having the poultry waste based treatment diets and the control, confirms the findings of other studies. Hadjipanayiotou (1984) who offered 3 diets containing 0, 15 and 30% poultry litter for Treatment A, B, and C respectively, found that ADG of 140g and 147g for kids from does on Treatment B and C respectively were similar to that of (146 g/day) kids on the control treatment diet A containing only crushed barley grain and premix components.

4.1.4. Liveweight change during lactation.

The weekly liveweight changes and liveweight measurements for the experimental Galla goats during the study period are presented in Table 15, Appendix VIII and Figure 14 respectively. All animals showed a similar trend of weight loss during the entire study period. However, for the first 4 weeks as well as for the entire experimental period, the does offered the poultry waste based treatment diets lost slightly more weight from 87.4 to 141.8 and 63.1 to 69.2 g/doe/day, compared to 74.4 and 61.4 g/doe/day for the control respectively. This concurred with other reported studies suggesting that during the first few weeks post partum goats tend to lose weight as they mobilize adipose tissues for the extra energy required to support high milk production (Forbes, 1986; and Skea, 1988).

Table 15: Least Squares Means with SE for liveweight changes for Galla goats of Experiment I.

Period intervals	Least squares mean liveweight loss (g/doe/day)				significance
	Treatment				
	I	II	III	IV	
Entire 12 week period	-61.4 ± 8.4	-63.9 ± 8.9	-69.2 ± 8.6	-63.1 ± 8.9	ns
Week 1-4	-74.4 ± 27.1	-102.6 ± 28.8	-141.8 ± 27.6	-87.4 ± 28.6	ns
Week 5-8	-102.5 ± 27.7	-133.9 ± 29.4	-99.6 ± 28.2	-65.0 ± 29.2	ns
Week 9-12	0.7 ± 12.4	-23.1 ± 13.1	1.4 ± 12.6	-15.8 ± 13.0	ns

ns = not significant difference (P>0.05)

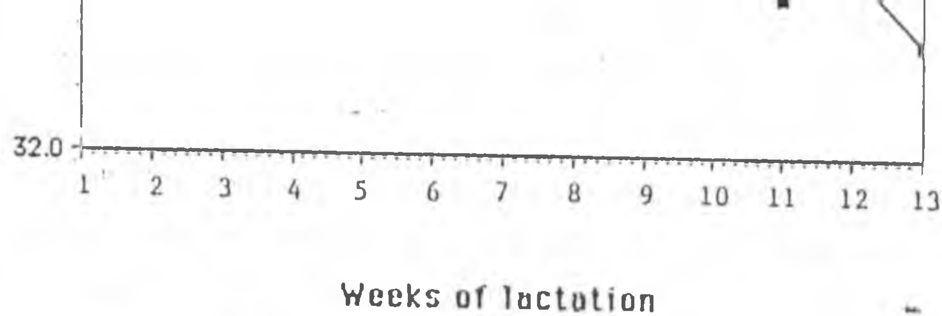
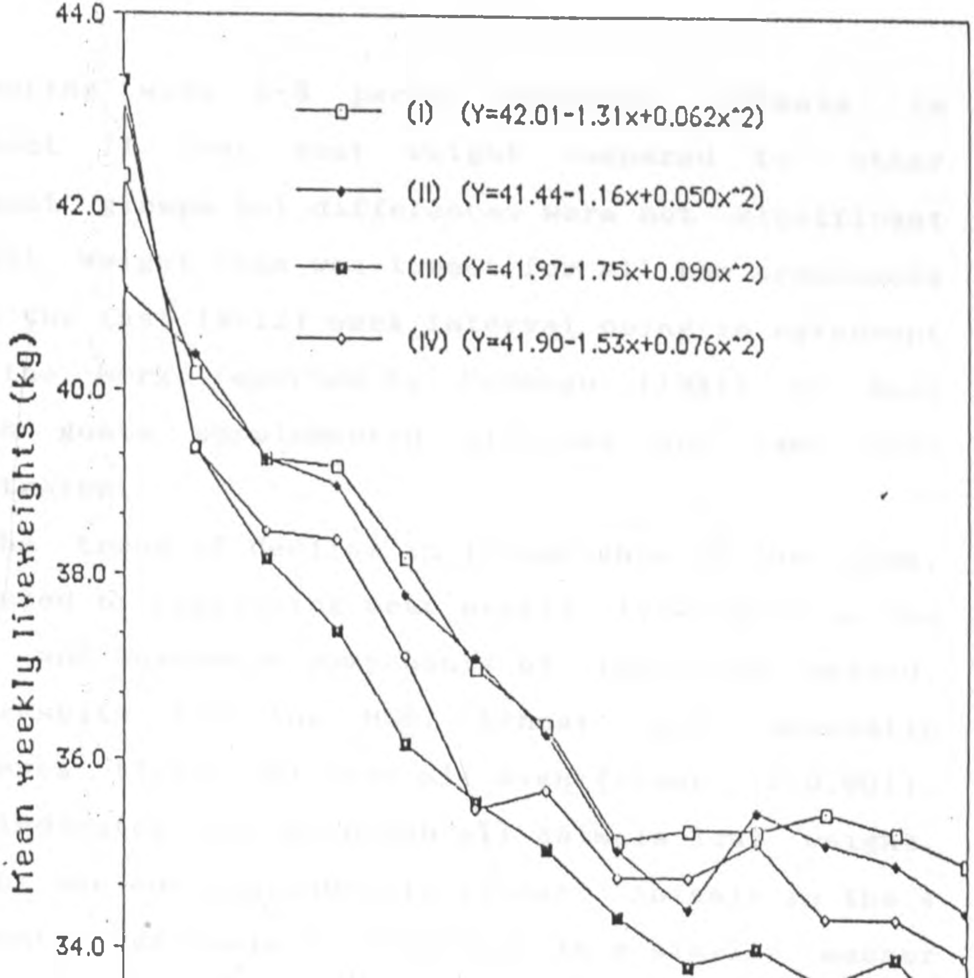


Figure 14: Least squares mean weekly liveweights of lactating Galla goats (Expt.I).



44.0
42.0
40.0
38.0
36.0
34.0
Mean weekly liveweights (kg)
(I) (Y=42.01-1.31x+0.062x^2)
(II) (Y=41.44-1.16x+0.050x^2)
(III) (Y=41.97-1.75x+0.090x^2)
(IV) (Y=41.90-1.53x+0.076x^2)

During week 5-8 period interval, animals in Treatment II lost most weight compared to other treatment groups but differences were not significant (P>0.05). Weight loss was lowest for all the treatments during the last (9-12) week interval being in agreement with the work reported by Kayongo (1981) on East African goats supplemented with ewe and lamb nuts concentrates.

The trend of decline in liveweights of the does, was tested by regressing mean weekly liveweights on the Linear and Quadratic components of lactation period. The results for the MSR, Linear and Quadratic components (Table 16) were all significant (P<0.001). This indicates that although all animals lost weight, the loss was not continuously linear. Animals in the 4 treatments were able to stabilize in a similar manner with the advancement of lactation, as shown by the positive quadratic relationship between the same covariates.

The loss in body weight of lactating goats has been a phenomenon observed in several other studies with Galla Goats (Skea, 1988 and Ruvuna *et al.*, 1989) and East African goats (Kayongo, 1981). Skea (1988) reported that a female Galla goat could lose from 10 to 15% body weight during the rearing phase of their kids from birth to weaning. Ruvuna *et al.* (1989) reported maximum body weight loss during lactation of 2% and 6% for East African and Galla goats respectively. In the present study, comparable results of the goats body weight losses ranging from 2.8 to 12.7% were demonstrated. Hadjipanayiotou (1984) using lactating Chios ewes and Damascus goats reported no significant

Table 16: Summary of results of the regression of liveweight (kg) on lactation period of Galla goats used in Experiment I.

Treatments	MSR	Intercept (kg)	b_1	b_2
I	32.93***	42.01	-1.31***	0.062***
II	31.10***	41.44	-1.16***	0.050***
III	48.25***	41.97	-1.75***	0.090***
IV	39.64***	41.90	-1.53***	0.076***

*** = Significance ($P<0.001$)

MSR = Mean Square Regressions

b_1 & b_2 = partial regression coefficients for the linear and quadratic components of X (period) respectively differences in liveweight changes post partum when fed poultry litter diets at 15 and 30% inclusion levels compared to those on conventional concentrate (control) diet. Lack of significant differences between the treatments implied that there were no adverse effects due to poultry waste inclusion in the diets as the nitrogen source on liveweight changes of the goats used in this study.

4.2. EXPT.II: DIGESTIBILITY STUDY.

4.2.1. Diet chemical composition and intake.

Table 17 shows the increasing trend for Ash, CF, NDF and ADF and decreasing DE components with increasing levels of poultry waste in the concentrate diets offered to the goats in the present experiment. These reflect the contribution of the poultry waste into the diets which is in agreement with the findings of several workers (Bhattacharya and Taylor, 1975; Kayongo and Irungu, 1986). However, variations with the other diet constituents were small.

All the concentrates were completely consumed without significant leftovers (Table 18). A significant ($P<0.05$) increase in hay DM intake ranging from 488.7 to 634.2 g/doe/day was observed with increasing levels of poultry waste in the concentrates. This may imply that the animals on poultry waste based diets had to increase DMI to meet energy requirement, although energy content was not determined in the current study. Poultry waste has been reported to be low in digestible energy (Bhattacharya and Taylor, 1975). This trend however, was consistent with that observed in Experiment I with the same animals. However, intake by animals in the present experiment was almost half of that recorded in Experiment I (Tables 8 and 18 respectively). The lower hay DM intake and hence total feed DMI observed in the Experiment II compared to that of Experiment I could be accounted for by the stage of lactation of the animals (Campling and Lean, 1983; Forbes, 1986). In Experiment I intake was measured between day 1 and day 90 of lactation. Yet in

Table 17: Mean values for the chemical composition of the diets used in Expt.II.

Item	% Composition									DE
	DM	OM	ASH	EE	CP	CF	NFE	NDF	ADF	Mcal/kgDM
Treatment diets										
I (0% P/w)	94.36	88.98	5.38	7.12	14.53	11.63	63.81	49.63	13.79	3.16
II (15% P/w)	94.83	89.22	5.61	7.34	14.85	12.43	61.87	50.20	13.36	3.12
III (30% P/w)	95.11	88.54	6.57	6.05	14.48	13.51	62.47	51.50	15.34	2.96
IV (45% P/w)	94.75	87.71	7.04	6.54	14.91	14.27	58.91	54.24	15.72	2.71
Chloris gayana hay	95.16	83.52	11.64	2.56	6.82	40.51	34.93	77.39	47.33	2.25

Table 18: Least Squares Mean values with SE for DM intake of feeds used in Expt.II.

Consumed feeds	Nutrient intake				Significance
	Treatment				
	I	II	III	IV	
Hay DM intake					
g/doe/day	488.7 ± 23.6[a]	556.9 ± 23.6[b]	568.4 ± 23.6[bc]	634.2 ± 23.6[d]	*
Concentrate DM intake					
g/doe/day	450.3 ± 0.2	448.8 ± 0.2	446.2 ± 0.2	444.5 ± 0.2	-
Total feed DM intake					
g/doe/day	938.9 ± 22.1[a]	1005.7 ± 22.1[b]	1014.6 ± 22.1[bc]	1078.7 ± 22.1[d]	*
Total DE intake					
Mcal/doe/day	2.52	2.65	2.60	2.63	-

* = Means followed by different supersceipts in the same row differ significantly (P>0.05)

Experiment II the stage of lactation had gone beyond 90 days (Sec. 3.2.1.4).

4.2.2. Digestibility coefficients of feeds.

The dietary treatments did not significantly (P>0.05) affect the mean digestibility coefficients for DM, OM, CP, CF, NFE, Ash, NDF and ADF (Table 19). Except for the NFE and Ash, the mean digestibility coefficient values for the nutrient constituents were highest for the control diet and followed closely by the mean values for Treatment II. Those for Diet III and IV were the lowest and had more or less similar values. Thus there was a general trend of decline in digestibility for all the nutrients in the litter based diets as the level of poultry waste was raised. Comparable findings of decreasing digestibility for all nutrients with increasing poultry waste have also been reported by Bhattacharya and Fontenot (1965); Kargaard and van Niekerk (1978); Malick *et al.* (1980); Hadjipanayiotou (1984); Kayongo and Irungu (1986); and Odhuba *et al.* (1986). When examined closely, the values for DE (Table 18) did not seem to vary much. The amount in the diets which ranged from 2.5 to 2.6 Mcal DE in Treatment I through IV was however, far adequate to meet the daily requirement for energy of 1.79 Mcal DE/doe (NRC, 1981).

The possible explanation for the decrease in digestibility in the poultry litter based diets could probably stem from the increasing levels of CF and ash contents in the diet as a result of high levéls of the fractions contributed by the poultry waste. The high crude fibre (CF) content which normally is poorly

Table 19: Least Squares Mean values with SE for the invivo digestibility coefficients of the feeds used in Expt. II.

Variable	Treatment				Significance
	I	II	III	IV	
DM	60.3 ± 1.5	58.5 ± 1.5	55.8 ± 1.5	55.7 ± 1.5	ns
OM	64.5 ± 1.5	63.0 ± 1.5	60.0 ± 1.5	60.0 ± 1.5	ns
EE	69.8 ± 2.0	66.3 ± 2.0	63.3 ± 2.0	60.0 ± 2.0	ns
CP	67.7 ± 3.0	63.7 ± 3.0	62.3 ± 3.0	60.7 ± 3.0	ns
CF	59.5 ± 1.8	56.2 ± 1.8	54.2 ± 1.8	54.2 ± 1.8	ns
NFE	71.5 ± 1.8	72.8 ± 1.8	69.7 ± 1.8	69.8 ± 1.8	ns
ASH	26.0 ± 2.3	24.8 ± 1.8	23.5 ± 2.3	26.3 ± 2.3	ns
NDF	63.7 ± 2.0	63.3 ± 2.0	60.2 ± 2.0	58.0 ± 2.0	ns
ADF	49.8 ± 1.7	47.8 ± 1.7	43.0 ± 1.7	46.0 ± 1.7	ns

ns = Non significant different (P>0.05)

digested (van Soest, 1965; Malick *et al.*, 1980; Whiteman, 1980; and McDonald *et al.*, 1981), and the high ash component (Kargaard and van Niekerk, 1988; Malick *et al.*, 1980 and Aderibigbe and Church, 1987) quite likely influenced the decline in digestibility of supplemental diets. Kargaard and van Niekerk (1978), who included molasses in the rations observed reduced performance of the animals on poultry waste containing diets which was attributed to the high ash content of the resulting diets, hence a possible adverse mineral interaction which results in the formation of an insoluble matter. Malick *et al.* (1980) observed decreases in digestibility coefficients of DM, OM, CP and NFE with increasing poultry excreta litter (PEL) in the rations for buffalo heifers. These authors attributed this to reduced acceptability and available energy contents of the PEL containing diets due to the higher fractions of CF and ash. In the present work the reported high levels of ash and ADF (Table 17) of the poultry waste based diets were the possible causes of the reduced digestibility. If the hypothesis of an adverse mineral interaction is accepted, then an investigation into which minerals are involved needs further consideration.

Another possible reason for the reported low digestibility of the nutrients as poultry waste levels increased in the diets may partly have been affected by the concentrate to forage ratio. In the present work the concentrate to forage ratio declined from 45:55 to 41:59 as the poultry waste increased while that of the control remained high (48:52). Decreasing concentrate to forage ratio as a factor causing a reduction in the digestibility of diets has also been reported by other workers (Schmidt and van Vleck, 1974, Badamana, 1987). However, it should be borne in mind that even though digestibility values for Experiment II were meant to evaluate the diets used for the feeding trial (Experiment I), the concentrate to forage ratio for the latter experiment were much lower than that for the former. Thus Experiment I had 30-31:69-70 concentrate to forage ratio for all the four treatments as opposed to 41-48:52-59 for Experiment II. Then it is expected that digestibility coefficients for Experiment I should be much lower than those reported for Experiment II.

On the other hand, the lack of significant differences observed in the digestibility of most nutrients in the diets used in the present work, indicates similarity in the effects of both the conventional and non-conventional type of concentrates in the treatment diets. This confirms similar findings reported by several investigators (El-Sabban *et al.*, 1970; Lowman and Knight, 1970; Yu Yu *et al.*, 1972; Smith and Calvert, 1976; and Kayongo and Irungu, 1986). The lack of differences among the treatment means in terms of digestibility implies, in addition, that the poultry waste used in the present experiment was quite useful as a nitrogen source for the Galla goats.

4.2.3. N-Balance.

Among the treatment means, only total N intake and faecal N were significantly (P>0.05) different (Table 20). The treatment diets did not (P>0.05) significantly affect the absorbed N, urinary and

Table 20: Least Squares Mean values with SE for N balance in Galla goats used in Experiment II.

Variable	Treatment				Significance
	I	II	III	IV	
N Utilization					
Total N intake	16.3 $\pm$0.2[a]	17.2 $\pm$0.2[bd]	17.0 $\pm$0.2[bc]	17.9 $\pm$0.2[d]	*
Faecal N	6.1 $\pm$0.5[a]	7.4 $\pm$0.5[ab]	7.8 $\pm$0.5[b]	8.2 $\pm$0.5[bc]	*
Absorbed N	10.1 $\pm$0.4	9.9 $\pm$0.4	9.2 $\pm$0.4	9.7 $\pm$0.4	
Urinary N	2.1 $\pm$0.4	2.3 $\pm$0.4	1.6 $\pm$0.4	2.6 $\pm$0.4	
Retained N	8.1 $\pm$0.5	7.6 $\pm$0.5	7.6 $\pm$0.5	7.1 $\pm$0.5	
N Retained/N Intake	0.5 $\pm$0.0	0.4 $\pm$0.0	0.5 $\pm$0.0	0.40$\pm$0.0	
N Retained/N absorbed	0.8 $\pm$0.0	0.8 $\pm$0.0	0.8 $\pm$0.0	0.76$\pm$0.0	

* = means followed by different superscripts in the same row differ significantly (P>0.05)

retained N. The increasing faecal N losses in the poultry litter containing diets is a reflection of the corresponding decrease in digestibility, at higher poultry waste inclusion rates, as shown in Table 19. However, the loss of N through urine was low for all the treatment diets and all animals remained in a positive N-balance. Animals in Treatment I retained slightly more N (6.2%) than animals in Treatments II and III, and much more N (12.3%) than those of Treatment IV. However, lack of significance in N retained may be attributed to higher N intake by the goats on poultry waste containing diets. The results agree with those of Malick *et al.* (1980) who using buffalo heifers found no significant ($P>0.05$) difference in N retained between the control and poultry excreta litter fed groups. Bhattacharya *et al.* (1965) who replaced 0-100% of plant protein in sheep ration by poultry litter nitrogen demonstrated a sharp decline in nitrogen retention with increasing poultry waste inclusion. Holzer and Levy (1976), using Hereford x local cross-bred bull calves (8 months old), observed a negative balance on non-supplemented straw group as expected, while the poultry litter (PL) supplemented straw group was three times as high as that on non-supplemented straw.

5. CONCLUSION.

Based on the context in which this study was carried out, the following conclusions may be outlined:-

1. Throughout the study, feed acceptability was high with no ill-health effects being observed among the treatment goats.

2. Hay intake by lactating Galla goats for all the treatments and digestibility of such diets were not significantly affected by treatments, though there was a trend for an increase in hay intake and a decrease in digestibility coefficients by the poultry waste diets.

3. Neither the conventional type of concentrate (made up of plant protein) nor the non-conventional ones (made up of poultry litter NPN), irrespective of poultry waste inclusion levels in the test diets, significantly ($P>0.05$) affected the performance of lactating Galla goats in terms of milk yield and composition.

4. All dietary treatments offered to the lactating Galla goats did not significantly ($P>0.05$) affect the growth performance of their kids.

5. All treatment diets did not significantly ($P>0.05$) affect the liveweight changes of the lactating Galla goats.

6. Therefore, poultry waste supplements can be used to partially or completely replace conventional type of concentrates offered to lactating Galla goats without affecting their performance.

SCOPE FOR FURTHER RESEARCH.

1. This study only tried to identify the optimum range for which poultry waste can be included in the rations of lactating goats. There is a need, therefore, to research further on the exact level using shorter level intervals of inclusions so that appropriate recommendations for Kenyan conditions can be made.

2. Use of poultry waste in combination with molasses in feed mixtures for ruminant feeding affects the digestibility of the diets in many ways including, possibly through mineral interactions. The level of molasses in the concentrate as well as in the whole diet and the particular type of minerals involved in this interaction needs further investigation for a feasible solution.

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APPENDICES.

Appendix I. Mean values for total daily milk yield I with SE (hand milking plus kid suckling).

Period in weeks	Milk yield (mls)			
	Treatment			
	I	II	III	IV
At Kidding	987.1 ± 53.7	985.5 ± 63.8	927.1 ± 67.7	1080.3 ± 66.6
1	852.9 ± 65.3	1078.8 ± 66.4	945.1 ± 67.4	874.5 ± 72.7
2	772.1 ± 54.4	913.8 ± 71.8	855.9 ± 72.5	832.3 ± 63.5
3	784.8 ± 72.8	838.5 ± 62.7	875.8 ± 84.7	837.6 ± 93.6
4	719.4 ± 46.1	777.8 ± 59.6	840.8 ± 87.0	792.5 ± 80.5
5	717.1 ± 60.1	721.5 ± 57.2	735.8 ± 58.8	658.7 ± 58.3
6	637.8 ± 53.8	597.0 ± 50.2	552.6 ± 49.6	670.1 ± 72.5
7	578.7 ± 64.6	579.3 ± 40.2	554.6 ± 55.3	586.1 ± 57.8
8	568.1 ± 51.2	497.9 ± 42.1	471.0 ± 30.3	442.6 ± 29.1
9	442.2 ± 40.6	444.8 ± 30.5	538.1 ± 50.1	451.7 ± 32.9
10	404.8 ± 32.9	474.0 ± 40.8	454.2 ± 40.3	440.4 ± 47.4
11	386.2 ± 26.6	391.3 ± 19.8	368.0 ± 29.1	374.1 ± 24.6
12	365.3 ± 25.6	389.7 ± 35.8	318.6 ± 26.3	346.7 ± 25.4

Appendix II. Mean values for the daily milk yield I (hand milking excluding kid intakes).

Period in weeks	Milk yield (mls)			
	Treatment			
	I	II	III	IV
At Kidding	444.2 ± 44.9	501.8 ± 66.7	457.1 ± 52.3	466.0 ± 42.6
1	319.5 ± 31.6	458.8 ± 60.8	295.1 ± 33.2	374.5 ± 39.5
2	296.0 ± 32.8	338.8 ± 30.5	260.9 ± 27.3	299.0 ± 28.8
3	294.3 ± 34.2	333.5 ± 29.0	214.8 ± 22.7	271.0 ± 31.7
4	267.1 ± 26.9	307.8 ± 27.8	210.8 ± 16.8	211.5 ± 20.5
5	245.7 ± 29.9	261.5 ± 26.4	190.8 ± 24.2	182.5 ± 15.1
6	161.6 ± 13.5	222.0 ± 23.5	167.6 ± 13.8	170.1 ± 19.9
7	169.1 ± 14.0	189.3 ± 19.5	144.6 ± 12.7	157.6 ± 12.4
8	149.1 ± 13.6	167.9 ± 17.5	116.0 ± 10.8	133.1 ± 11.3
9	147.1 ± 14.1	154.8 ± 16.4	122.6 ± 13.7	118.4 ± 10.6
10	123.9 ± 5.5	134.0 ± 12.7	114.2 ± 14.4	107.1 ± 11.3
11	124.3 ± 10.2	126.3 ± 11.9	80.0 ± 10.4	117.0 ± 9.4
12	108.1 ± 5.2	119.7 ± 14.5	78.6 ± 11.7	99.1 ± 8.4

Appendix III. Kids' daily milk intakes (Method I)
(kid suckling after hand milking).

Period in weeks	Milk intakes (mls)			
	Treatment			
	I	II	III	IV
At Kidding	456.0 ± 39.2	404.0 ± 44.5	369.2 ± 34.1	469.2 ± 35.2
1	448.0 ± 37.5	532.0 ± 34.0	511.5 ± 41.3	403.8 ± 29.1
2	404.0 ± 38.9	476.0 ± 43.7	465.4 ± 40.4	430.8 ± 33.2
3	412.0 ± 43.7	424.0 ± 32.3	530.8 ± 46.7	457.7 ± 44.4
4	380.0 ± 36.1	392.0 ± 42.4	500.0 ± 55.5	469.2 ± 42.9
5	396.0 ± 35.5	368.0 ± 44.2	430.8 ± 37.9	384.6 ± 36.7
6	400.0 ± 50.7	300.0 ± 28.3	303.8 ± 34.4	403.8 ± 50.1
7	348.0 ± 48.7	312.0 ± 35.3	323.1 ± 42.4	346.2 ± 33.8
8	352.0 ± 35.6	264.0 ± 32.1	280.8 ± 22.9	250.0 ± 23.0
9	248.0 ± 28.9	228.0 ± 20.4	319.6 ± 38.4	268.0 ± 23.6
10	236.0 ± 27.6	268.0 ± 31.5	261.5 ± 28.9	269.2 ± 32.2
11	220.0 ± 17.3	212.0 ± 18.5	215.4 ± 23.3	207.7 ± 18.3
12	216.0 ± 18.9	216.0 ± 26.3	184.6 ± 21.3	200.0 ± 16.6

Appendix IV. Mean values with SE for the total daily milk yield II (suckling plus hand milking).

Period in weeks	Milk yield (mls)			
	Treatment			
	I	II	III	IV
At Kidding	776.9 ± 73.5	845.6 ± 58.9	878.7 ± 60.8	819.9 ± 50.2
1	710.4 ± 55.3	801.7 ± 52.3	794.1 ± 59.4	883.0 ± 74.0
2	822.9 ± 76.6	841.4 ± 46.4	881.8 ± 82.0	852.0 ± 67.8
3	777.9 ± 57.0	816.2 ± 76.3	890.5 ± 93.3	846.6 ± 73.6
4	748.0 ± 57.0	785.9 ± 81.7	777.1 ± 84.7	784.0 ± 55.6
5	666.8 ± 51.0	752.8 ± 68.1	750.4 ± 80.8	661.3 ± 65.4
6	655.0 ± 56.1	607.1 ± 65.7	574.4 ± 60.0	668.8 ± 82.3
7	519.3 ± 46.3	453.5 ± 39.0	547.7 ± 49.9	505.8 ± 54.3
8	469.5 ± 44.4	489.7 ± 47.7	482.5 ± 34.2	544.1 ± 61.6
9	472.2 ± 28.5	416.5 ± 24.9	418.4 ± 49.3	438.8 ± 44.8
10	466.2 ± 38.9	457.1 ± 34.5	532.8 ± 50.5	447.6 ± 28.1
11	382.8 ± 32.4	397.9 ± 25.0	434.6 ± 51.5	405.9 ± 25.2
12	393.2 ± 32.2	354.1 ± 41.3	326.3 ± 36.3	346.6 ± 33.6

Appendix V: Kids daily milk intakes (Method II)
(kid suckling before hand milking).

Period in weeks	Milk intakes (mls)			
	Treatment			
	I	II	III	IV
At Kidding	766.7 ± 73.1	820.0 ± 58.8	845.0 ± 65.9	790.5 ± 53.0
1	676.2 ± 57.7	780.0 ± 53.1	780.0 ± 61.4	866.7 ± 72.2
2	800.0 ± 76.2	820.0 ± 45.7	865.0 ± 80.9	823.8 ± 67.6
3	757.1 ± 55.9	795.0 ± 76.9	865.0 ± 94.9	823.8 ± 73.6
4	733.3 ± 57.9	770.0 ± 82.4	765.0 ± 84.4	766.7 ± 55.3
5	652.4 ± 51.0	735.0 ± 68.9	740.0 ± 80.9	647.6 ± 65.3
6	642.9 ± 55.5	595.0 ± 65.9	560.0 ± 62.6	652.4 ± 83.0
7	504.8 ± 46.0	440.0 ± 39.3	535.0 ± 49.4	490.5 ± 54.7
8	457.1 ± 43.4	475.0 ± 48.6	475.0 ± 33.9	528.6 ± 62.2
9	461.9 ± 28.0	405.0 ± 24.6	405.0 ± 48.9	423.8 ± 45.2
10	457.1 ± 38.8	445.0 ± 35.2	520.0 ± 50.6	438.1 ± 20.0
11	371.4 ± 31.7	385.0 ± 25.4	425.0 ± 51.7	395.2 ± 25.3
12	381.0 ± 31.3	340.0 ± 41.9	315.0 ± 37.9	338.1 ± 34.1

Appendix VI: Mean values with SE for the daily milk yield II (hand milking after suckling).

Period in weeks	Milk yield (mls)			
	Treatment			
	I	II	III	IV
At Kidding	9.8 ± 2.54	25.6 ± 8.80	33.7 ± 11.57	29.5 ± 15.14
1	34.2 ± 17.84	21.7 ± 5.13	14.1 ± 4.94	16.3 ± 5.78
2	22.9 ± 3.56	21.4 ± 2.50	16.8 ± 4.05	28.2 ± 6.16
3	20.7 ± 3.82	21.2 ± 6.28	25.5 ± 11.49	22.8 ± 6.26
4	14.6 ± 2.92	15.9 ± 3.52	12.1 ± 2.03	17.3 ± 5.54
5	14.4 ± 2.58	17.8 ± 6.01	10.4 ± 1.89	13.7 ± 2.79
6	12.1 ± 1.93	12.1 ± 2.26	14.4 ± 2.37	16.5 ± 5.46
7	14.6 ± 2.45	13.5 ± 2.10	12.7 ± 1.92	15.3 ± 2.45
8	12.3 ± 2.30	14.7 ± 2.57	7.5 ± 1.30	15.5 ± 2.27
9	10.3 ± 1.22	11.5 ± 2.03	13.4 ± 2.21	15.0 ± 2.56
10	9.1 ± 1.51	12.1 ± 2.09	12.8 ± 2.25	9.5 ± 1.93
11	11.4 ± 2.11	12.9 ± 2.45	9.6 ± 1.99	10.6 ± 2.30
12	12.2 ± 1.66	14.1 ± 3.05	11.3 ± 4.51	8.5 ± 1.33

Appendix VII: Least squares mean values with SE of weekly liveweight measurements of kids.

Period in weeks	Kids' weekly liveweights (g)			
	Treatments			
	I	II	III	IV
Kidding	4268.0 ± 155.4	4224.0 ± 154.6	4373.1 ± 171.6	4542.3 ± 114.0
1	4702.9 ± 168.2	5002.3 ± 177.2	4946.8 ± 170.2	4974.3 ± 156.7
2	5721.6 ± 99.0	5606.9 ± 104.3	5583.2 ± 100.2	5589.1 ± 92.3
3	6276.0 ± 264.4	6032.0 ± 267.9	6107.7 ± 301.2	6400.0 ± 248.4
4	6768.6 ± 165.4	6650.9 ± 174.2	6565.2 ± 167.4	6603.2 ± 154.1
5	7162.7 ± 237.2	7076.4 ± 249.9	7100.5 ± 240.0	6830.9 ± 221.0
6	7664.2 ± 259.0	7466.9 ± 272.8	7498.2 ± 262.1	7250.1 ± 241.3
7	7914.0 ± 320.5	8054.3 ± 337.7	7931.4 ± 324.4	7669.8 ± 298.6
8	8432.5 ± 350.9	8240.2 ± 369.7	8311.3 ± 355.1	7837.7 ± 326.9
9	8685.9 ± 389.2	8416.5 ± 410.0	8082.1 ± 393.9	7841.1 ± 362.6
10	8776.1 ± 400.1	8604.3 ± 421.5	8293.4 ± 404.9	8030.5 ± 372.8
11	9101.9 ± 484.2	8745.6 ± 510.1	8051.0 ± 490.4	8388.9 ± 451.1
12	9054.7 ± 444.0	8834.1 ± 467.7	8205.3 ± 449.3	8213.0 ± 413.6

Appendix VIII. Least squares means with SE of weekly liveweight measurements of lactating does.

Experimental weeks of lactation	Liveweights (kgs)			
	Treatment			
	I	II	III	IV
Kidding	42.2 ± 1.28	41.1 ± 1.30	43.3 ± 1.30	43.1 ± 1.30
1	40.2 ± 0.72	40.4 ± 0.75	39.4 ± 0.72	39.4 ± 0.76
2	39.3 ± 0.75	39.3 ± 0.79	38.2 ± 0.76	38.5 ± 0.79
3	39.2 ± 0.81	39.0 ± 0.85	37.4 ± 0.81	38.4 ± 0.85
4	38.2 ± 0.84	37.8 ± 0.88	36.2 ± 0.85	37.1 ± 0.89
5	37.0 ± 0.92	37.1 ± 0.97	35.6 ± 0.93	35.5 ± 0.98
6	36.4 ± 0.80	36.3 ± 0.84	35.1 ± 0.80	35.7 ± 0.84
7	35.2 ± 0.79	35.1 ± 0.84	34.4 ± 0.80	34.8 ± 0.84
8	35.3 ± 0.75	34.5 ± 0.79	33.9 ± 0.76	34.8 ± 0.80
9	35.3 ± 0.77	35.5 ± 0.81	34.1 ± 0.78	35.2 ± 0.81
10	35.5 ± 0.83	35.2 ± 0.87	33.7 ± 0.83	34.4 ± 0.88
11	35.3 ± 0.84	35.0 ± 0.89	34.0 ± 0.85	34.4 ± 0.89
12	35.0 ± 0.77	34.5 ± 0.81	33.2 ± 0.79	34.0 ± 0.81