CHAPTER 3:

Materials and Methods

3.1 Introduction

The experiment was conducted at the Animal Production Institute of the Agricultural Research Council (ARC) at Irene in Pretoria where 32 does aged one to four years and including the Indigenous, British Alpines, Saanen and Toggenburg breeds (eight goats per breed) were used from parturition early in October 2008 up to a weaning of the Indigenous goats in mid-December 2008.

The experiment was a simulation of a small scale farming system where animals are raised in a semi-extension farming system with limited management intervention.

3.2 Experimentation

3.2.1 Location

The ARC – Irene experimental farm is situated between latitudes 25°53’04” and 25 °53’ 10” South, and longitudes 28 °11’05” and 28 °13’39” East, on the interior plateau of South Africa known as the Highveld. The farm size is approximately 800 ha with an altitude of over 1400m above sea level and a mean annual rainfall of 708 mm. Vegetation is Acocks’ Bankenveld (Veld Type 61) and is predominantly mixed grassland falling into the Grassland Biome categorization (Acocks, 1988).

3.2.2 Animals

A total of 32 goats (aged one, two and four years) which included eight British Alpines, eight Toggenburg, eight Saanen and eight Indigenous goats, were obtained for this trial. They were initially separated by breeds in different camps during the breeding season to avoid crossbreeding; mating took place naturally and thereafter all goats were mixed for spring kidding. One animal (Toggenburg N°3) died during the trial in week four.

3.2.3 Experimental design

The experiment was a one way (feeding system) analysis of variance where eight goats were randomly selected from each breed for the measurement of 1) blood metabolites); 2) milk yield and components and 3) phenotype characteristics. This is described in Table 3.1.

Table 3.1 Diagrammatic representation of the experimental design

Breed	N	Treatments		Measurements													
		Autumn & Winter	Spring & Summer	Blood metabolites				Milk yield & components						Phenotype characteristics			
				Glu	*Cho*	*FFA*	*BUN*	*MY*	*LAC*	*Fat %*	*MP*	*MUN*	*SCC*	*A*	*Usz*	*BCS*	*Uat*
Ind.	8	All goats on Kikuyu +Maize Silage	Kikuyu + maize Silage + Ewe & lamb Pellets	*	*	*	*	*	*	*		*	*	*	*	*	*
Tog	8			*	*	*	*	*	*	*	*	*	*	*	*	*	*
B.A.	8			*	*	*	*	*	*	*	*	*	*	*	*	*	*
Snn	8			*	*	*	*	*	*	*	*	*	*	*	*	*	*

Legends: N = Number of goats per breed; glucose (Glu), cholesterol (Cho), free fatty acids (FFA), blood urea nitrogen (BUN); milk yield (MY), lactose (LAC), fat percentage (Fat %), milk proteins (MP), milk urea nitrogen (MUN) somatic cell count (SCC);: age (A), udder size (Usz), body condition score (BCS) and udder attachment (Uat).

Table 3.1 shows that this study measured three different sets of data which corresponded to three different experiments:

Experiment 1: Phenotype characteristics (breed, BCS, udder characteristics) and age of four different breeds of does were measured and correlated to milk yield and composition in an attempt to evaluate the relevance of using body characteristics in predicting milk yield and composition in both the indigenous and the improved dairy goats.

Experiment 2: Consisted of collecting blood samples in an attempt first, to analyse and determine the role of glucose, BUN, FFA and blood cholesterol as nutritional level indicators in the lactating goat and second, to study the correlation (if any) existing between these blood parameters and the phenotype characteristics.

Experiment 3: Related to milk characterization (milk yield and constituents: lactose, fat percentage, MUN, milk proteins and SCC) of four different breeds of goats raised under a semi-intensive production system where grazing animals were fed a minimum supplemented support aimed to meet maintenance requirement in protein and energy; the ultimate objective being to evaluate the capacity of adaptation of these different breeds of goats in the African small scale farming system.

3.2.4 Research plan

The experiment was conducted in a manner that simulated the kind of management usually found in the African small scale farming systems where little management intervention is applied and where goats are left alone to browse all year round on pasture. In this trial all the 32 goats were gathered in one camp for the night and in the morning they were released on a kikuyu pasture ("*Pennisetum clandestinum*") for grazing. As appearing on picture 3.1 (below) a supplement made of maize silage was provided in winter while ewe and lamb pellets were added to the diet in spring during lactation.

Picture 3.1: A view of the kikuyu grazing in winter: does were supplemented with maize silage; while in spring (during lactation), a ration of ewes and lamb pellets was fed.

At the beginning of the experiment, all does were vaccinated against pulpy kidney and pasteurellosis; thereafter they were dewormed with 1ml SC injections of Moxidectin against "*Haemonchus contortus*". From parturition blood and milk samples were

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collected weekly in the morning before feeding during a period of eight weeks (mid-October to mid-December). BCS, age, udder size and udder attachment recorded at the beginning of the trial were also recorded every week (by an experienced observer) during milk and blood sampling. The diagrammatic representation of this research procedure is presented in Table 3.2.

Table 3.2. Schedule of Research plan

Months	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Activities												
All Goats on pasture	X	X	X	X	X	X	X	X	X	X	X	X
Pregnancy					X	X	X	X	X			
Kidding										X		
Lactation										X	X	X
Winter sup..						X	X	X		X	X	X
E & L. Pellet										X	X	X
Weaning												X
Phenotype scoring										X	X	X
Body condition. Scoring										X	X	X
Milk,& blood Collection										X	X	X
Lab Analysis										X	X	X

This research plan was initially designed for three-month duration. But, with some does (mostly Indigenous) ending lactation unforeseeably at two months, the investigation period was also limited at two months. All blood and milk samples were sent to the laboratory for analysis. During week 8, a blood sample from Saanen No7 was broken and could not be analyzed. Regrettably, all week five milk samples were not analyzed on MUN and SCC. This was also the case with week eight blood samples which went to the laboratory in mid-December (year-end holiday) and could not be analyzed either. These three incidents were reflected in our records as missing data.

3.3 Data collection

3.3.1. Milk sampling

The technique used: hand milking.

Manpower: One technician + one assistant.

Materials: One bucket with lukewarm water containing 10% disinfectant

One tray containing 32 x 200 ml flasks with sealing lids

One microtablet of 0.02% bronopol (milk preservative) in each flask

Sterile needles and syringes

Cotton-wool + alcohol

1 X 500 ml measuring cylinder

1 bottle of oxytocine

1 X 20 litre steel container (for milk collection)

Procedure: The technician washed his hands in lukewarm water containing 10% disinfectant (Savlon). At the same time he very gently and very tactfully washed the doe's udder with special attention to its teats (necessary to ensure a hygienic milk collection, but also to familiarize the goat with the human's hands and physical contact). Then, the technician used alternatively his left and right hands to hold and press respectively the left and the right half udder of the doe, while at same time pulling his hands from the top of the udder to the bottom towards the teats from which milk is ejected. As the udder becomes emptier, the technician's hand pressure becomes firmer and harder to force the last drop of milk towards ejection.

During milking the assistant used his hands very tactfully (the goat has the tendency to kick anything that approaches her udder) between the doe's legs in order to collect milk that is ejected from the teats. As soon as this first session of milking is terminated, the technician washes his hands and injects a pre-arranged (by the technician) 1ml IM oxytocin into the doe which is immediately released into a separate pen where it is fed with maize silage and lambs and ewe pellets and kept away from the kids for four hours (8 am to 12 am). Milk samples for biochemical analysis is collected in a 200ml flask in the following manner: The assistant ensures himself that the milk preservative (0.02% bronopol) is effectively present in each 200 ml flask before he pours in the milk sample, seals the flask and writes on it the number of the goat whose milk has been just

collected. When all milk samples are collected, they are taken to a laboratory (Lactolab, at ARC – Irene) for milk analysis.

After four hours, a second milking session was performed. While the 8 am milking session was for quality analysis in the laboratory, the second (12 am) milking is for quantity measurement. This was done by pouring all the milk collected from one doe into the measuring cylinder on which the amount of milk collected is easily reflected. The calculation of the daily milk yield was done as follows:

Milk yield (in litres) after 4 hours x 6 = goat daily milk yield.

Milk samples were collected weekly in the morning before feeding over a period of two months.

3.3.2 Blood sampling

The technique used: Jugular venipuncture

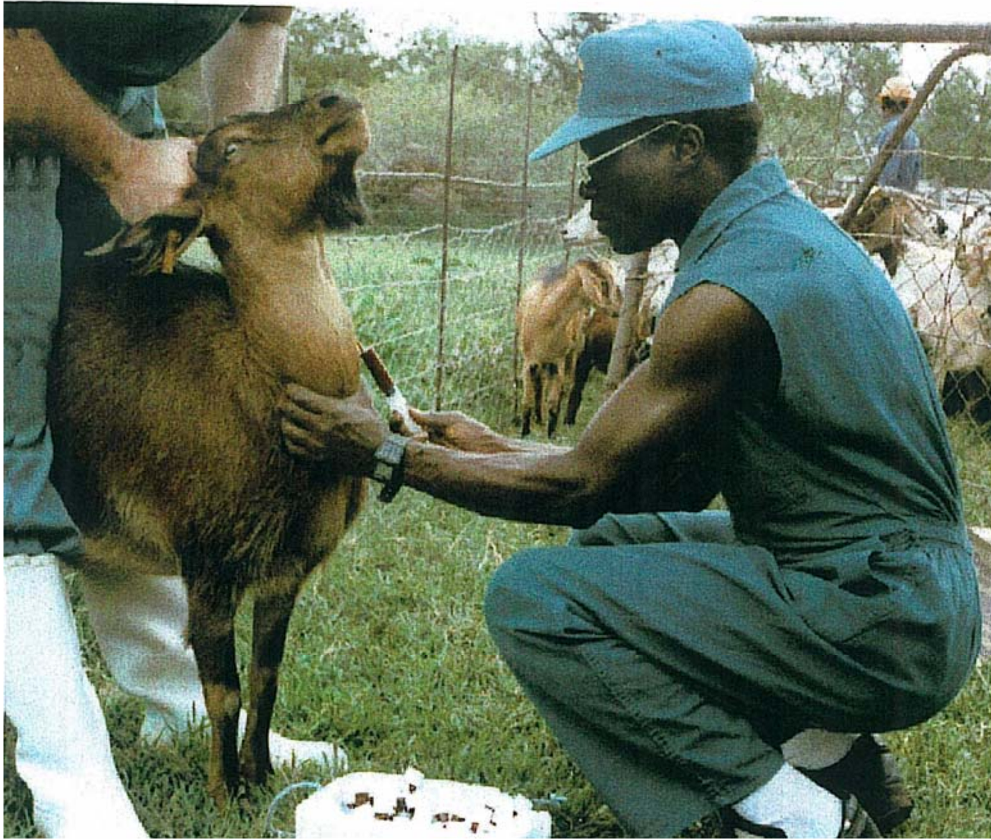
Manpower: One technician + one assistant

Materials: Cotton wool + alcohol
Sterile needles and syringes
Heparinised test-tubes
Cooler box (in polystyrene) + ice cubes
One pair of scissors
One permanent marker

Procedure: The assistant put the goat between his knees in order to hold it firmly but gently standing on its feet; at the same time, from his hands, he held the goat's head elevated in such a way that the goat's neck could be largely accessible to the technician hands. The technician used his right hand to disinfect (with alcohol on cotton-wool) the part of the neck where he intended to introduce the needle (sometimes shaving the area was necessary when the goat was too hairy). After disinfection the technician put his left hand and maintained a gentle grip in the lower region around the neck of the goat. This light pressure results in the goat's jugular vein becoming visible. Secondly, with the left hand still on the neck of the goat, he felt through palpation with his right hand the exact size, location, and direction of the vein. Thirdly, the technician inserted slowly and very skilfully a sterile needle in the direction of the vein while respecting an angle that could

allow an easy flow of blood inside the needle; when this happens, the indication is that the vein has been punctured.

The technique of blood collection through jugular venipuncture is depicted in picture 3.2



Picture 3.2: Blood collection through jugular venipuncture in the Indigenous goat.

Then the technician attached a 10 ml heparinized test tube to the needle and ensured that 10 ml of blood was collected before he removed the needle slowly while applying cotton wool and alcohol for one minute (in order to prevent bleeding and/or infection) on the area of injection. Each test tube was marked with the corresponding goat number before it was deposited on ice cubes in the cooler box. When blood samples from all goats were collected, the cooler box was taken to the centrifuge where the test tubes were centrifuged for 10 minutes at 3000G before blood plasma (separated from cells) could be aspirated in sterile tubes, kept again on ice cube and brought to Onderstepoort (University of Pretoria) for blood glucose, blood cholesterol, BUN and FFA analysis.

3.3.3. Recording of phenotype characteristics

A new technique was developed to determine the phenotype scoreThe technique used: based on visual appraisal, palpation, and teeth examination.

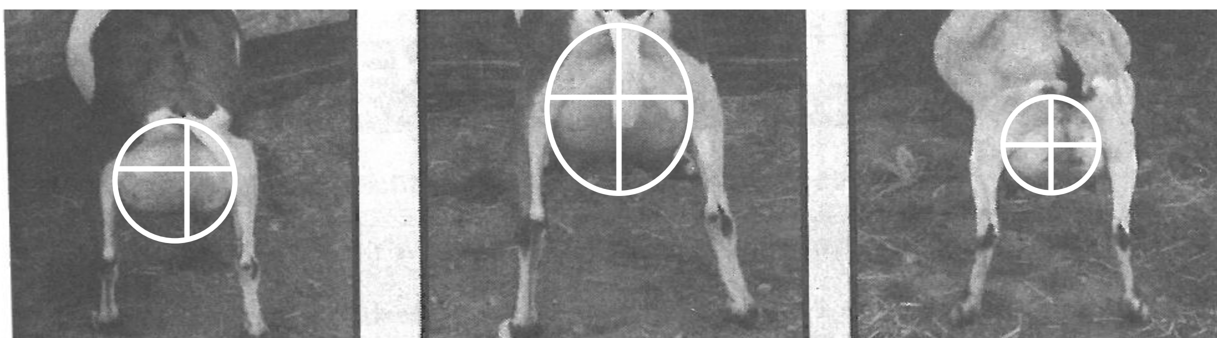
Manpower: Three assistants

Materials: writing papers, measuring tape and ball-pens

Procedure: All the goats gathered in the kraal were admitted one by one in the crush pen where assistant one proceeded with the measurement of udder size, udder attachment.

3.3.3.1 Measurement of udder size and udder attachment

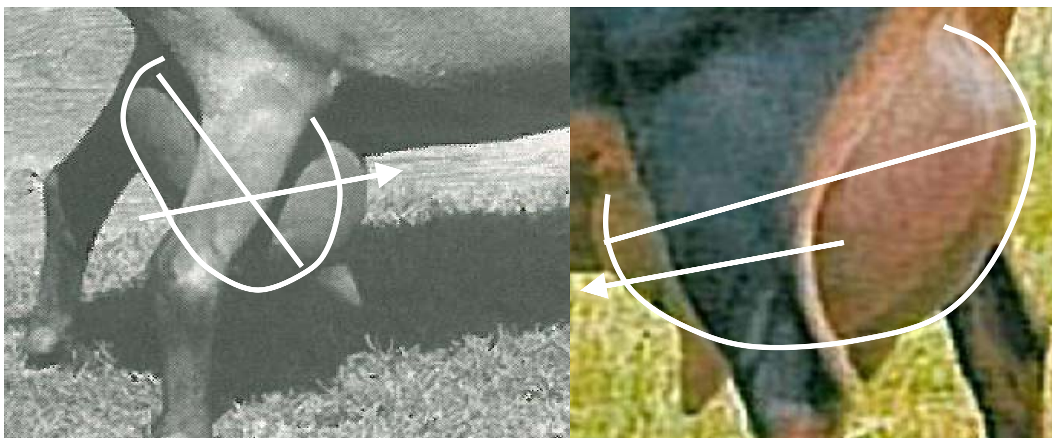
As was done by Milerski *et al.* (2006) the udder size was objectively assessed by using a measuring tape. However, because the goats could not stand still (mostly the case of the Indigenous and the Alpine breeds: when she felt a hand contact with her udder sometimes she reacted by kicking back violently), it was difficult to take an accurate measurement. The assistant did therefore take an estimated measurement. When it exceeded (or equalled) 20 centimetres it was seen as "large." Between 20 and 15 centimetres it was "medium" and anything below 15 centimetres was seen as "low" as illustrated in picture 3.3 (below). This is illustrated in picture 3.3 (below)



Picture 3.3: Udder Size: Left = medium (± 15 cm width, ±15 cm length) centre = large (>20cm width, >20cm length); and right = small (<15cm width, <15cm length).

Udder attachment was assessed visually, by comparing the median line of the udder to the line of the perineal region; when both lines almost paralleled the plane of the belly, the udder was recorded as "well attached"; when the median line of the udder tended to

discard itself from the belly and pointed in the direction of the soil, the udder was seen as "hanging;" this is illustrated in picture 3.4



Picture 3.4: Left: hanging udder. Right: well-attached udder

3.3.3.2. Assessment of BCS

Assessment BCS was done through palpation in accordance with the principle that, on a scale point of 1 to 5 , 1 means an extremely emaciated (cachectic) goat which is near death; and 5 an extremely obese (overly fat) goat having deep patchy fat over its entire body. The BCS examination is conducted by manual assessment of the fat cover thickness and the prominence of bone at the tail head and the loin area (Coffey *et al*., 1999; Nix, 2004; Villaquiran *et al*., 2007).

In practice Technician 1 first looked at the general aspect of the animal, its sternal and lumbar regions; secondly, through palpation around the shoulders, the back bones, the ribs and the hips of the goat, he evaluated the level of thickness of several muscles (*muscle semitendinosus* at the back of goat; *Muscle longissimus thoracis* around the ribs; *muscle longissimus lumborum* around the hips at the lumbar region and finally the *M longissimus dorsi* around the spine process) before he assigns a number corresponding the most approximately to the animal body condition (usually 3, 2.5, 2 or 1.5).

The ideal BCS 3 should have a non-prominent backbone with the croup as well covered as muscles which should be fully but moderately covered by fat; the spine and the transverse process should be rounded and smooth in such a way that hard pressure needs to be exerted in order to feel the ends of the transverse process. The chondrosternal

joints of the sternal region should be perceived only with a thorough fingertips palpation (Santucci *et al*., 1991).

BCS 2 should correspond to a slightly raw-boned animal with a continuous ridge still visible on its backbone; the croup should be protuberant with a thin fat cover, a prominent spine, and a sharp transverse process whose ends should be felt easily by fingertips. About one-third to one-half of the length of the transverse process should be discernible and sternal fat still wider and thicker should be grasped and lifted by the thumb and forefinger (Villaquiran *et al*., 2007).

BCS 1 should correspond to an extremely emaciated animal with no fat cover on a highly visible backbone showing a prominent spine; the flank should be hollow and the ribs easy to count while the croup stands out as well as a sharp transverse process (Luginbuhl *et al*., 2009).

After the evaluation assistant 1 announced in a loud voice his decision (usually 1.5, 2, 2.5 or 3) and the number was either spontaneously recorded by the assistant 3 or discussed among the three assistants before final agreement.

Announcing loudly a decision (as done earlier while assessing udder size and udder attachment) ensured that the final decision was made on common agreement after a clear, fair and transparent evaluation.

3.3.3.3 Age determination

From assistant 1, the goat was transferred to assistant 2 who proceeded with teeth examination for the determination of age. The principle was that at one year old, one pair of central incisors is present; two years old should have two central, two medial and two lateral incisors. At three years, the table or grinding surface should be narrow, while at four years a yellow-brown ring should be seen on the white table surface, the roots of incisors being protruding. Assistant 2 (like assistant 1) announced his decision in a loud voice (usually, 1, 2 or 4 years old) and the number was immediately recorded by assistant 3, who also recorded the animal breed. The latter was not subjected to discussions since the breed of each goat (Saanen, Toggenburg, British Alpines or Indigenous) was obvious at first glance. For each goat data were carefully recorded.

3.4 Biochemical analyses.

3.4.1 Milk analysis

Milk samples were analysed on lactose, fat percentage, milk proteins, milk urea nitrogen (MUN) and somatic cell count (SCC) at Lactolab (Pty) Ltd, a SANAS accredited laboratory at the dairy building, ARC campus of Irene. At Lactolab a high-capacity Milkoscan fully automated, mid-range infrared spectrophotometer was used for the determination of fat, protein, lactose, milk urea and somatic cell count.

At the laboratory, the technician ensured that the milk samples received were in a reasonably good condition: the sample should not have started to curdle or separate, and must be free of dirt and other foreign particles. After that, the technician proceeded with pre-heating the sample in order to evenly distribute fat globules in milk. For maximum accuracy milk samples were heated to 40º C (37 to 42º C range) immediately before analysis. Overheating of samples can cause separation of fat called “oiling off”.

On the infrared spectrophotometer, a milk sample drawn up by the pipette was taken into the reaction chamber, where it was mixed with a dye solution (ethidium bromide) from the dispenser. The dye was given time to react with the DNA of each cell. The suspension was placed on a rotating wheel by means of a nozzle. The blue light caused the dye to become fluorescent, which was then counted by the detector. This counting was based on the principle that each and every single cell DNA was dyed with a specific dye, in this case ethidium bromide. The detector part of the spectrophotometer then counted the exact number of cells that passed by on the rotating disk.

3.4.1.1 Somatic cell count

In the case of SCC, the count was multiplied automatically by the working factor to give the number of somatic cells multiplied by 1000 per 1 ml milk. The IR-wavelengths used were in the 2 – 10µm range.

3.4.1.2 Lactose

In estimating the lactose content of milk the Milkoscan makes use of a compact IR (infra-red) system which is equipped with one beam, one cuvette and two mirrors. The

IR light is passed through the hydroxyl groups of lactose at approximately 9.6 µm.; the 605 milkoscan analyser uses the polarimeter as a reference method (IDF standard: 28: 1974) and the percentage weight as base unit.

3.4.1.3 Milk proteins

For the determination of protein content, the Milkoscan makes use of its compact IR (infra-red) system which is equipped with one beam, one cuvette and two mirrors. The IR light is passed through a secondary amide group of peptide bonds at approximately 6.5µm. Milk protein is analyzed using the Kjeldjal true protein method (IDF standard 20B; 1993, part 4) with the percentage weight as a base unit.

3.4.1.4 Milk fat percentage

The fat percentage is determined with the Milkoscan making use of its compact IR (infra-red) system which is equipped with one beam, one cuvette and two mirrors. The IR light passed through the carbonyl groups of ester bonds of the glyceride at approximately 5.7µm traditionally referred to as the "A" filter, and through the CH groups at approximately 3.5 µm traditionally referred to as the "B" filter. Milk fat is analyzed with the Milkoscan analyser calibrated against the "Rose-Gottlieb method" as described in the IDF standard 1D; the percentage weight is used as a base unit.

3.4.1.5 Milk urea nitrogen

(MUN) content is determined only one filter, all the others are used for reference. The Milkoscan makes use of its compact IR (infra-red) system which is equipped with one beam, one cuvette and two mirrors and analyses milk urea through the reference method where Foss uses the "differential pH" with the mg as a base unit.

3.4.2 Blood analyses

Blood samples were analysed for glucose, blood urea nitrogen (BUN), plasma cholesterol and plasma free fatty acids (FFA) concentrations at the Department of

Anatomy and Physiology (Faculty of Veterinary Science/Onderstepoort; University of Pretoria).

3.4.2.1 Glucose analysis

Plasma glucose concentration was determined by the use of ACE™ Glucose reagent (reagent number: NAE2-27) intended for the quantitative determination of glucose in serum using the ACE™ clinical chemistry system.

The procedure followed was:

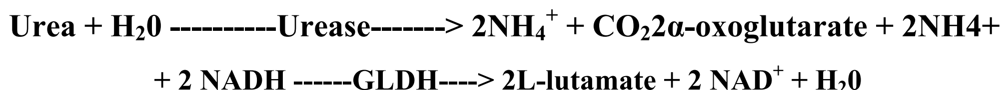
Glucose + O_2 + H_2O ------- GOD---------------> Gluconic acid + H_2O_2

2 H_2O_2 + 4 Aminophenazone + phenol ------POD-----> quinineimine + 4 H_2O

In the ACE glucose method, glucose is determined after an enzymatic oxidation in the presence of glucose oxidase. The formed hydrogen peroxide reacts under a catalysis of peroxidase with phenol and 4-aminophenazone to form a red-violet quinoneime dye as indicator. The absorbance of the reaction is bichromatically measured at 505 nm/ 692nm.

3.4.2.2 Plasma urea concentration**.**

It was determined by the use of a colorimetric method whereby a NExCT™ reagent (Reagent Number: NAE5-9) is intended for the quantitative determination of urea in serum and plasma using the NExCT™ clinical chemistry system. The principle of the procedure is as follows:



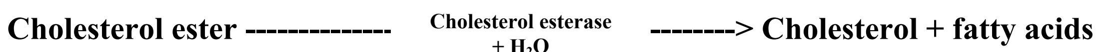
Urea + H_20 ----------Urease-------> $2NH_4^+$ + $CO_2 2\alpha$-oxoglutarate + 2NH4+

+ 2 NADH ------GLDH----> 2L-lutamate + 2 NAD^+ + H_20

The reaction rate is measured biochromatically by the ACE Alera Analyzer (Alfa Wasserman Siemens medical solutions) at 340 nm/ 647nm.

3.4.2.3 Plasma Cholesterol

The NExCT™ Cholesterol reagent kit (Reagent number: NAE2-12) is intended for the quantitative determination of cholesterol concentration in serum using the NExCT™ clinical chemistry system. The principle of this procedure is as follows:



Cholesterol ester -------------- Cholesterol esterase + H_2O --------> Cholesterol + fatty acids

The cholesterol liberated by the esterase, plus any free cholesterol originally present in the plasma are both oxidized by cholesterol oxidase:

Cholesterol + 02 ------- $_{\text{Cholesterol esterase}}$ **-------> Cholestene-3-one + H_2O_2**

The liberated peroxide reacts with phenol and 4-aminoantipyrine in a peroxide catalyzed reaction to form a quinoneimine dye, which absorbs at 500nm:

H_2O_2 + 4 Aminoantipyrine + Phenol ------ Peroxidase-----> Quinoneimine + $4H_2O_2$

The change in absorbance is measured bichromatically at 505nm/692nm and is directly proportional to the amount of cholesterol present in the sample.

.3.4.2.4.Plasma FFA: free fatty acids concentration was determined by an enzymatic colorimetric method based on the method of Falholt combined with the modified colorimetric technique of Novak. This method is based on the extraction of phosphate buffered plasma with a chlororoform heptane-methanol mixture, formation of the cobalt complex and on the subsequent determination of metal with 1-nitroso-2-naphtol. The absorbance was read after 30 minutes in a spectrophotometer at either 500nm or 450 nm (De Villiers *et al.*, 1997)

3.4.3 Feed analyses

Feed analysis was performed at Nutrilab (University of Pretoria-Department of Animal and Wildlife Sciences). Kikuyu grass (*Pennisetum clandestinum)* and maize silage were analysed for GE, CP, ME, Ca and P. The ewes and lamb pellets was not analysed because the label provided by the manufacturer (Epol) was indicating the pellet composition on its contents. Results on feed analyses are represented in Table 3.3.

Table 3.3: Chemical composition of samples of kikuyu (*Pennisetum Clandestinum*) and ewes and lamb pellets fed to does from week two to week eight

Forage	DM(1) g/100g	N(2) g/100g	CP(3) g/100g	GE(4) MJ/Kg	Ca(5) g/100g	P(6) g/100g	Ca : P
Kikuyu	25	3.6	22.3	6.8	0.472	0.316	1.5 : 1
Maize silage	45	1.5	7.2	11.8	0.194	0.171	1.1 : 1
E&L pellets(7)	88		13				

Legends: Superscripts (1) Dry Matter; (2) Nitrogen; (3) Crude Protein (4) Gross Energy; (5) Ca: Calcium; (6) P: Phosphate; (7) Ewe and lamb pellets (commercial product) composition as labelled : Fat 250g/kg; Urea : 100g/kg; Vitamin A: 5g/kg.

3.4.3.1 Gross energy (GE)

The determination of Gross Energy in food was done with the Method reference MC-100 Modular calorimeter. The procedure consisted first in ensuring that the water tap connected to the chamber is open and the computer is on, before placing the sample inside the chamber; secondly, the technician opened the oxygen bottle and switched the chamber on. When the computer indicated that the chamber was ready, the technician entered the sample ID number, the sample mass and pressed "Enter". The calorimeter run for approximately 5 minutes to ignite and burn the sample; during this time it performs the following: 1) Testing temperature 2) pre-period 1 and 2 3) Bomb firing, 4) main period 5). Cooling and washing the bomb and then the result appears on the screen of the computer.

3.4.3.2 Crude protein (CP)

CP in animal feed was analysed after Dumas method (AOAC Official Method 968,06, 2002). The principle is that N_2 freed by pyrolysis and subsequent combustions, is swept by the CO_2 carrier into a nitrometer. CO_2 is absorbed in KOH and volume residual N_2 is measured and converted to equivalent protein by a numerical factor. The apparatus and reagents involved are the N_2 analyzer and its accessories, the balance accurate to 0,01mg and a barometer Hg type readable to 0.1mm. The instrument can be operated only in accordance with the instructions of the manufacturer; in this case: Coleman Model 29A Nitrogen Analyzer for which the operating directions D-360B are obtainable from Coleman Cat. 29-904)

3.4.3.3 Calcium (Ca)

Ca determination was performed in accordance with the AOAC official method 927,02 2002 applicable to animal feeds only. It is a Dry ash method which makes use of 2g finely ground test portion into SiO2 and ignited in the furnace to C-free ash. Later the residue is combined in consecutive procedures of mixture involving chemical products like HCl, HNO_3 NH_4OH, $(NH_4)_2C_2O_4$ before heating to 70^oC and titrate with 0.02M $KMNO_4$. The presence of paper may cause colour to fade and correction for blank must therefore be done before calculating the percentage of Ca. This procedure is referenced JAOAC 10, 177 (1927); 19, 93.574 (1936); 28, 80 (1945) CAS7440-70-2 (Calcium).

3.4.3.4 Phosphorus (P)

P determination was done by means of the AOAC Official Method 965.17 applicable in animal feed and pet food. It is a photometric method making use of a spectrophotometer with the molybdovanadate as a reagent and a phosphorus standard solution made of a stock solution (KH_2PO_4 in H_2O) mixed to a working solution. After the preparation of the standard curve the determination is made by reading the percentage titration at 400nm. This method of analysis, revised in March 1996, is referenced JAOAC 48, 654 (1965); 59, 937 (1976) CAS- 7723-14-0 (phosphorus).

3.5. Statistical analyses.

Experiment 1 and 2 analysis of variance (ANOVA) was used to test for differences between 4 breeds of goats, 3 ages, 3 body condition scores, 3 udder sizes and 3 udder attachments. Data were acceptably normal with the homogeneous treatment variances but milk characteristics (milk fat percentage, lactose, milk proteins, MUN and SCC) were logged to stabilise treatment variances. Treatment means were separated using the Bonferroni adjustment for multiple comparison SPSS at 5% level of significance (Snedecor & Cochran, 1980).

Experiment 3 analysis of variance (ANOVA) for unbalanced data was used to test for differences between eight goats (Indigenous) and 24 dairy goats (eight times three different breeds of goat) on milk yield and composition. The data were acceptably normal with homogeneous treatment variances, except for CCN which had to be transformed to $\log_{10}$ to stabilize treatment variances. Testing was done at the 5% level. Treatment means were separated using Fisher's protected t-test least significant difference (LSD) at the 5% level of significance (Snedecor & Cochran, 1980). Data were analysed using the statistical program GenStat ® (2005).

The study of correlations was done with SAS statistical software version 9.2 (SAS, 1999), while the statistical multiple regression equations analysis was done on phenotype parameters using the stepwise procedure (at alpha procedure entry 0.25 in Minitab statistical software 14).

CHAPTER 4:

Results and discussion: Effect of goat breed on milk yield and components

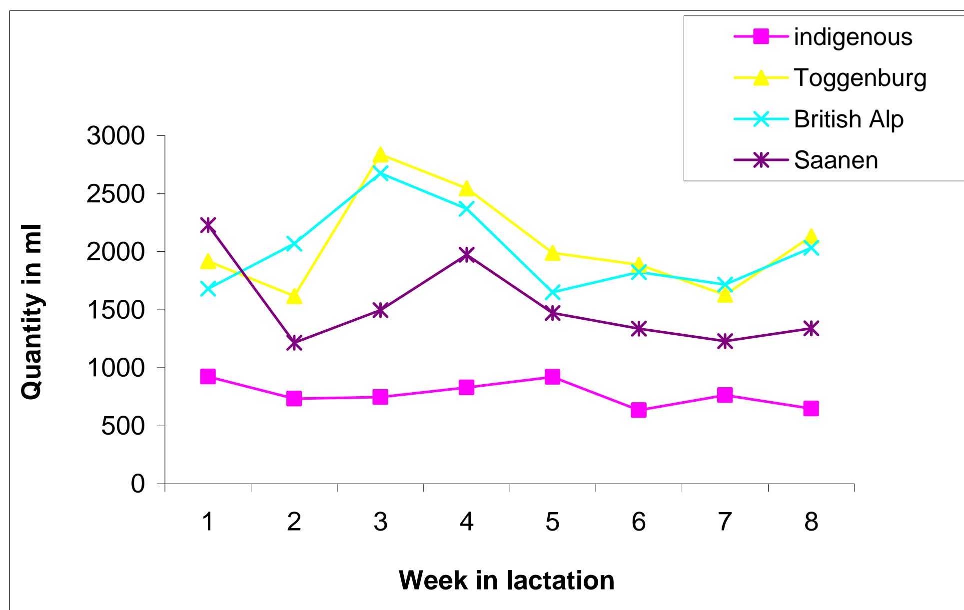
4.1. Milk Yield

Average values obtained for milk yield are presented in Table 4.1 and the trends for different breeds are illustrated in Graph 4.1.

Table 4.1: Mean milk yield (±SD) in ml from Indigenous and Dairy does during the first eight weeks lactation

Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Indigen.	924 ±270.9[a]	733.7 ±321.8[a]	746 ±260.6[a]	829.5 ±315.5[a]	921 ±313.5[a]	634.5 ±353.6[a]	762.5 ±361.9[a]	648 ±213.2[a]
Dairy	1899.5 ±656.1[b]	1769.5 ±825.5[b]	2338.0 ± 915.5[b]	2285.2 ±724.1[b]	2698 ±5087.3[b]	1686 ±706.5[b]	1536.7 ±432.5[b]	1857 ±672.0[b]
P value	$p<0.001$	$p< 0.001$	$p< 0.001$	$p< 0.001$	$p< 0.001$	$p<0.001$	$p< 0.001$	$p<0.001$

Means per same column with different superscript letters ([a b]) significantly ($p\leq 0.05$) differed



Graph 4.1: Mean milk yield of Indigenous and dairy does during the first eight weeks of lactation.

Results on milk yield found in this study are consistent with those from Shamay *et al.* (2000); lower than those found by Fernandez *et al.* (2008) and higher than those reported by Makun *et al.* (2008). These differences are probably due to the fact that milk yield is subject to much variation both between and within breeds (Richardson, 2009). In Table 4.1 and Graph 4.1, it can be seen that milk yield from dairy does (Saanen, Toggenburg and the British Alpines) was higher ($p< 0.001$) than the Indigenous milk yield during the entire period of study. The dairy breed superiority in milk yield is general knowledge in animal science. Dairy breeds have long been selected for milk production; their metabolism is entirely under a homeorrhetic control whereby, at the onset of lactation, many – perhaps even most – maternal tissues undergo further adaptations to support lactation through the mobilization of body resources at the expenses of other processes for the solely objective to support the ongoing galactopoiesis (Bauman *et al*., 2008). Moreover, the milk yield of indigenous goats in the tropics is generally low; probably because these goats are meat or dual purpose types, while dairy breeds of goat are, as said earlier, highly selected for milk production (Akinsoyinu *et al*., 1977). This was verified by Katanos *et al.* (2005) who investigated the partitioning, yield and milk constituents of milk in some imported dairy goats and some crosses between them and the local goats. Results showed that daily milk yield was higher in the Saanen and the Saanen cross Alpines compared to the Saanen cross local and to the local breed of goats. They concluded that the milk yielding of the Saanen and the Alpine genotypes was superior. This is supporting the results found in this study (in Graph 4.1) where the Toggenburg, Saanen and Alpines milk yield is higher than the indigenous does milk yield. In Graph 4.1 one can also notice in week one a decline in the Saanen, the Alpines and the indigenous does' milk yield. A decline that was associated with the BCS decline (from 3.0 to 2.5 and 2.0) in dairy breed as is shown in Table 4.2 below.

Table 4.2: BCS in all goats during eight weeks of lactation (n = 8)

Weeks/lactation	0	1	2	3	4	5	6	7	8
Breeds									
Indigenous	3	3	3	3	3	3	3	3	3
Toggenburg	3	2.5	2	2.5	2	2	2.5	2	2.5
Brit. Alp.	3	2.5	2.5	2	2	2	2	2	2
Saanen	2.5	2	2	1.5	1.5	1.5	2	1.5	2

This decline suggests that, in goat dairy breeds body reserves were massively mobilized to support the high milk production. In an attempt to correct the declining BCS, farm management supplied the does with an *ad libidum* provision of ewes and lamb pellets. The general decline in milk yield during the first week (Graph 4.1) deserves attention since the classic lactation curve in goat milk yield usually displays the highest milk yield in early lactation (see Graph 1.1) before a gradual decline towards mid-lactation; this is not what appeared in Graph 4.1, where it is observed that, except from the British Alpines, milk yield dropped in all does during the first week. A possible explanation for this general milk yield decline could be that, in that year (2008), the first rain fell only on the 27, 28 and 29 September, pouring 35.4mm of water over the experimental farm (25mm are the minimum required for grass to start re-growth); as a consequence, the mid-October kidding, two weeks later, coincided with the emergence of new shoots and shrubs on the good early spring pasture which, however, was inadequate to compensate for the long-lasting negative energy balance under which the goats were raised. It is indeed well documented (Church, 1979; Perry, 1980; Meissner, 1994) that during early lactation, post-parturient ruminants are always in a negative energy balance because their reduced appetite does not allow them to match the highly lactation increased energy demand. Under such circumstances Rapetti *et al.* (2005) suggested that good forage (hay) does enhance milk performance, but low quality forage, even if highland fresh grass is available, cannot guarantee good quantitative and qualitative milk performance. We therefore anticipate that the early lactation increased energy demand exacerbated by the poor nutritional supply from early spring grazing, resulted in the decline of milk yield, observed in all does week one milk yield performance seen in Graph 4.1.

As for the indigenous goats, their milk production remained significantly ($p < 0.001$) lower, with no significant change in their BCS which still averaged 3.0. This can be explained by the fact that Indigenous goats are not "milk making machines". Most milk yields of the Indigenous goats in the tropics are generally low (Akinsoyinu *et al.*, 1977). The Indigenous goats are dual or meat type animals; their metabolism responds to a central homeostatic control where resource partitioning prioritizes the maintenance of a

constant internal equilibrium. This homeostasis is reflected firstly by stability of BCS in indigenous does at three; secondly by stability in milk yield performance seen in Graph 4.1 (in contrast to the erratic milk yield performance of dairy breeds).

Results as seen in Graph 4.1 also suggest that within dairy breeds milk yield performance was not similar between does' breeds. From the moment the concentrate supplement was fed (week two), milk yield increased substantially in all dairy breeds; and the tendency for the Toggenburg (nicknamed "Guernsey goat") to produce more milk than the Saanen and British Alpines became evident (week three).

The supplied ewes and lamb pellets contained 130g/kg CP; this amount of CP has the potential to increase milk yield of lactating goats (Morand-Fehr *et al*., 1980). Other authors (Landau, 1993; Vadhanabhuti *et al*., 1995; Mackle *et al.,* 1999; Salim *et al*., 2002; Min *et al*., 2005; Hart, *et al*., 2005; Zucali *et al*., 2007; Sahlu *et al*., 2007; Gomes-Cortes *et al.,* 2009; Kamal *et al*., 2010) also support the concept that concentrate supplementation indeed affects milk yield and constituents in lactating does. This explains why milk yield increased in all does of dairy breed in week two.

However, milk production depends on many factors and not solely on feeding (Raynal-Ljutovac *et al.,* 2008; Pulina, 2002). Several factors in production and feeding and their interactions can influence milk yield and constituents (Morand-Fehr *et al*., 2007). This was evidenced in this study by the case of the British Alpine (in Graph 4.1 week one); while milk yields from all dairy breeds of goat dropped in week two, the Alpine milk yield, in contrast, increased significantly at this specific moment. The Alpine's milking capability did not seem to be affected by the poor nutritional supply from pasture. Their production record remained high for the rest of the investigation period. Min *et al*. (2005), studying the milk yield performance of Alpine dairy does, reported that does grazing on forage alone produced milk inexpensively, while other high-producing dairy goats needed moderate levels of concentrate supplementation for economic success. The latter supports the higher milk yield performance of Alpine does recorded in this study.

4.2. Milk Constituents

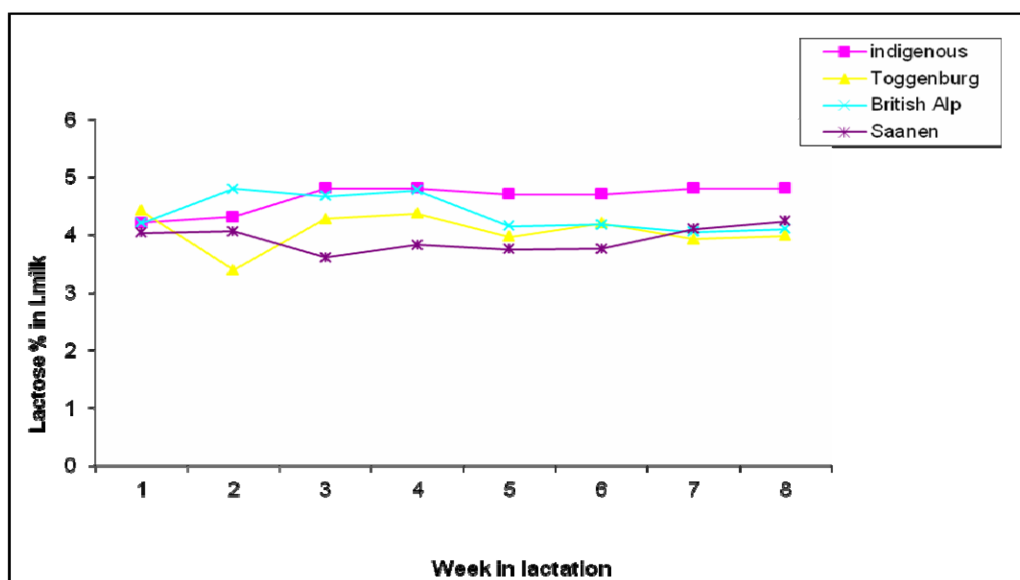
4.2.1 Lactose concentrations

Results on lactose content of goat milk found in this study are presented in Table 4.3 and Graph 4.2. Lactose is the most stable constituent of goat milk (Lu, 1993; Torii *et al*., 2004; Katanos *et al*., 2005; Contreras *et al*., 2009; Fernandez *et al*., 2008; Raynal-Ljutovac *et al*., 2008). The lactose percentage recorded in this study display a general tendency for stability; this concurs with Voutsinas *et al.* (1990) who claimed that lactose was fairly constant with no substantial changes over lactation period.

Table 4.3: Difference in mean lactose concentrations percentage (±SD) in milk from Indigenous and dairy does during the first eight weeks of lactation

Variables	Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
Indigenous	4.2 ± 0.93	4.3 ±0.84	4.8 ± 1.04	4.8 ±0.62 [a]	4.7 ±0.65 [a]	4.7 ± 0.44 [a]	4.8 ±0. 34 [a]	4.8 ±0.34 [a]
Dairy Breeds	4.2 ±0.57	4.1 ± 0.24	4.3 ± 1.06	3.9 ± 0.84 [b]	4.0 ± 1.06 [b]	4.0 ±0.72 [b]	4.1 ± 0.78 [b]	4.1 ± 078 [b]
p-value	0.487	0.620	0.134	p<0.001	p<0.01	p <0.005	p<0.001	p<0.001

Mean per column followed by different superscript ([a b]) letters differed significantly (p ≤0.001)



Graph 4.2: Lactose percentage in milk from Indigenous and dairy breeds during the first eight weeks of lactation

In dairy goats a decrease in milk lactose concentration may be indicative of stress and/or infection in the mammary gland (Merin *et al.,* 2004; Leitner *et al.,* 2004; Bernacka, 2007; Kifaro *et al*., 2009). An increase in milk lactose content in goat milk may suggest a decrease in feed intake (Dahlborn *et al.,* 1987; Min *et al.,* 2005;) or severe heat exposure (Sano *et al.,* 1985) which may also results in a decreased feed intake.

Graph 4.2 and Table 4.3 reveal that lactose percentage in milk from dairy breeds remained below 4.7 especially in week two and in week five. This in milk lactose production of goats could have been seen as an indication of stress or at least as an on-going crisis in the dairy does metabolism; especially since at the same time, lactose concentration displayed a remarkable stability in the indigenous does with a significant ($p < 0.001$) difference in lactose concentration (from week four to week eight). This superiority in lactose percentage in indigenous does may derive from the fact that the Indigenous breed produced the lowest amount of milk. Low-yielding goats tend to have a high blood glucose concentration but a poorer uptake for glucose than the high producing goats (Chang *et al.,* 1996). Graph 5.1 indeed shows that the Indigenous does had a higher glucose concentration than the lactating dairy does. Since glucose is the unique precursor to lactose, one can understand why under this report the indigenous goats had higher lactose than all the dairy does.

4.2.2 Concentrations of milk proteins

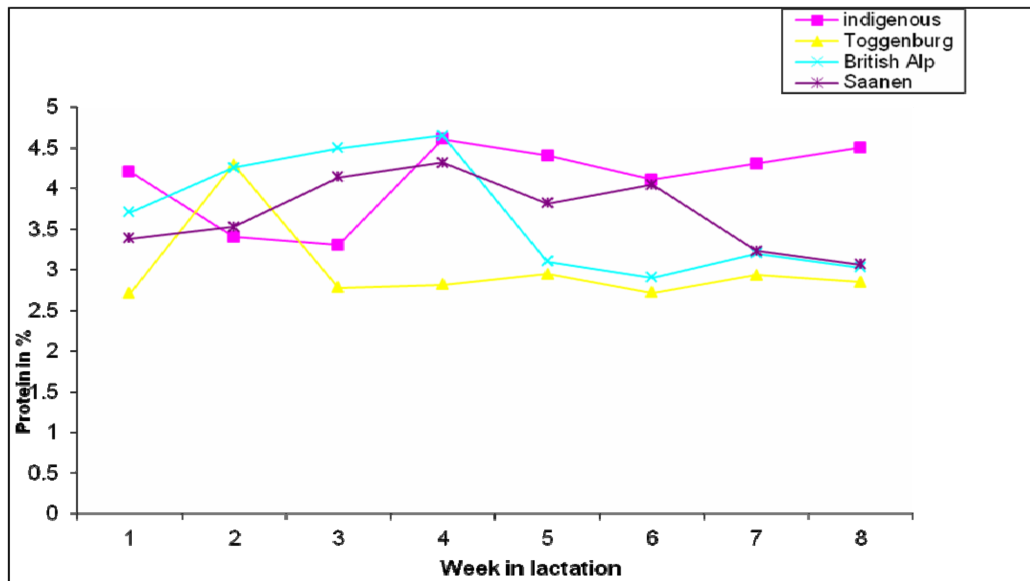
Results on milk proteins are presented in Table 4.4 and Graph 4.3.

Table 4.4: Difference in mean concentrations of proteins percentage (±SD) in milk from Indigenous and dairy does during the first eight weeks of lactation

Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Indigenous	4.2 ±1.25 [a]	3.4 ±1.80	3.3 ±0.89	4.6 ±1.25.	4.4 ±0.76 [a]	4.1 ±1.60 [a]	4.3 ±0.94 [a]	4.5 ±0.91[a]
Dairy Breeds	3.2 ±0.69 [b]	4.1 ±0.75	3.8 ±1.28	4.0 ±1.41	3.3[b] ±0.90	3.3[b] ±1.36	3.1 ±0.61 [b]	3.0 ±0.44 [b]
p-value	p< 0.01	0.163	0.898	0.246	p<0.001	p<0.001	p< 0.001	p<0.001

Means per column followed by different superscripts ([a,b]) were significantly ($p \leq 0.001$) different

Milk protein values found in this study are comparable and fall into the range of those reported by Greyling *et al.* (2004); Torii *et al*. (2004); Katanos *et al.* (2005); Karzis *et al.* (2007); Casamassima *et al.* (2007); Rovai *et al.* (2007); Fernandez *et al.* (2008); Raynal-Ljutovac *et al.* (2008) and Contreras *et al.* (2009).



Graph 4.3: Concentration of proteins in milk from Indigenous and dairy breeds during the first eight weeks of lactation.

In Table 4.4 and in Graph 4.3, it appears that the indigenous milk proteins concentration is significantly ($p<0.01$) higher than the dairy breeds milk; especially in week one and from week four to week eight. In contrast, the Toggenburg, which produced the highest milk yield (Graph 4.1), show the lowest milk protein concentration in Graph 4.3. These results are in accordance with those of Zumbo *et al*. (2007) who studied the quantitative and qualitative milk characteristics of the “Rossa mediterranea” goats. Their results showed a negative correlation ($r = -0.18$; $p < 0.05$) between quantity and quality in does milk. Many other authors (Rabasco *et al.,* 1993; Landau *et al*., 1993; Todaro *et al.,* 2005) have reported and supported this negative genetic correlation existing between quantity of milk and 1) proteins and 2) fat contents of milk. Body reserves are made of fat and muscle body content (Vera-Avila *et al*. 2009). It is therefore not surprising that the indigenous does, the low-yielding breed of the trial displayed a

highest fat and proteins percentage among the lactating does. Mba *et al.* (1975) working on milk composition of West African Dwarf, Red Sokoto and Saanen goats observed that milk of the West African Dwarf contained more butter fat, more protein and more lactose than milk of the Red Sokoto and the Saanen..This explains why in this study milk from Indigenous was higher in milk protein than milk from the dairy breeds.

In Graph 4.3 the British Alpine's performance in protein concentrations is once again outstanding during the first four weeks of lactation. The Alpine's exceptional performance was already observed on milk yield (Graph 4.1) and milk lactose (Graph 4.2). The Alpine dairy goats grazing on forage alone can produce milk inexpensively (Min *et al*., 2005). However, from week four, the Alpine's milk protein concentration declined drastically (supplanted by the indigenous doe's milk proteins); this probably happened as a late response to the "dilution effect": the negative correlation existing between milk yield and milk protein concentrations reported by Zumbo *et al*. (2007).

4.2.3 Milk fat concentrations

Results on milk fat concentrations are presented in Table 4.5 (below) and Graph 4.4 (next page).

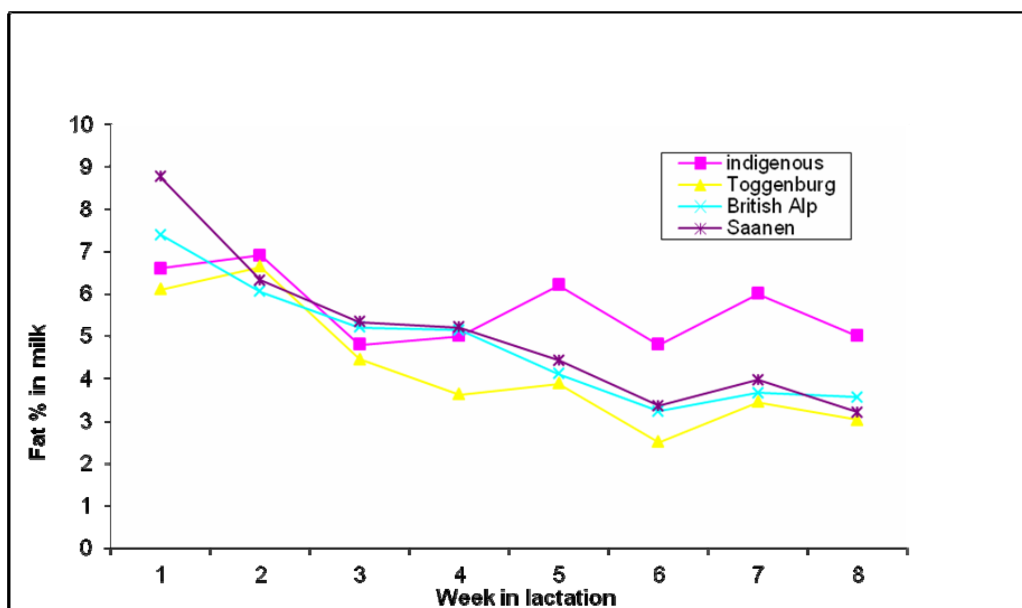
Table 4.5: Difference in mean concentration of fat percentage in milk (± SD) from Indigenous and dairy does during the first eight weeks of lactation

Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Indigenous	6.6 ±4.38	6.9 ±1.56	4.8 ±2.46	5.0 ± 1.58	6.2 ±4.62[a]	4.8 ±2.84[a]	6.0 ±2.96[a]	5.0 ±3.07[a]
Dairy Breeds	8.0 ±4.02	6.9 ±2.12	4.9 ±2.18	4.6 ±2.42	3.9 ±1.60[b]	3.3 ±2.25[b]	3.5 ±0.91[b]	3.2 ± 0.98[b]
p-value	0.220	0.526	0.855	0.513	p< 0.001	p< 0.001	p< 0.001	p< 0.001

Means per same column with different superscript letters ([a b]) significantly ($p \leq 0.001$) differed

Values found in this study are within the range of those reported by Chilliard *et al.* (2003); Greyling *et al.* (2004); Katanos *et al.(* 2005); Nudda *et al. (*2006); Alvarez *et al*. (2007); Bouattour *et al*. (2008); Fernandez *et al,* (2008); and Contreras *et al*. (2009).

In Graph 4.4 there is a general tendency for milk fat decline from week one to week eight. Mioc *et al.* (2007) observed a decrease in short-chained fatty acids concentration with the advancing lactation. Chilliard *et al.* (2003) explained this decline by at least two phenomena: firstly, the "dilution effect" whereby a low fat concentration coincides with an increased milk volume; secondly by a decreased fat mobilization which decreased the plasma NEFA availability, especially in C18:0 and C18:1, for mammary lipid synthesis. Milk fat content and proportion of acids with 18 carbon atoms are indicators of lipomobilization (Santucci *et al.*, 1991).



Graph 4.4: Milk fat percentage between Indigenous and dairy breeds during the first eight weeks of lactation.

Morand-Fehr *et al.* (2007) reported that milk fat content was stable at the first stage of lactation and decreased later under the effect of dilution. This opinion was already expressed by Zeng *et al.* (1997) and by Chilliard *et al.* (2003) who all indicated that, in goats, milk fat content is high after parturition and decreases during the major part of lactation. This decline was also observed by Bouattour *et al.* (2008) who explained that, the response of milk fat secretion is usually higher during early lactation because *de novo* lipogenesis is usually more active after peak lactation than before it; after peak

lactation dietary fatty acids would probably be partitioned more to the adipose tissues synthesis.

Fernandez *et al.* (2008) stated that in general, fat and protein content were higher at the beginning than at the end of lactation when milk volume decreased. Those explanations clarify the general milk fat concentrations decline seen in all does in this study. Indigenous goat milk fat concentration was significantly ($p<0.001$) higher as compared to the dairy breed milk fat (especially from week five to week eight). This kind of results was observed by Mba *et al,* (1975) who found an higher milk fat in the dwarf African than in the Red Sokoto and Saanen. Their conclusion was that milk from dairy breeds imported in tropical environment tended to fall. The explanation given was that high temperatures depress the production of acetic acid in the rumen; and a low level of ruminal acetic acid could in turn depress butterfat production.

Notwithstanding the influence of other related factors such as breed, nutrition and climate, production level is the factor that had the strongest influence on milk constituents, especially on fat percentage (Iloeje *et al.,* 1981; Todaro *et al.,* 2005; Fernandez *et al.,* 2008). In this study, it has been observed that goats with lower milk production level had a higher fat percentage: the indigenous does displayed the lowest milk yield (Graph 4.1), but the highest milk protein concentration (graph 4.3) and the highest fat content of milk (Graph 4.4). At the same time the Toggenburg produced the highest milk yield (Graph 4.1) but the lowest milk proteins (Graph 4.3) associated to the lowest milk fat concentration (Figure 4.4) especially from week two to week six. These results were earlier reported by Zygoyiannis *et al*. (1986) and also by Berhane *et al.* (2006) who all observed a significant negative correlation existing between milk yield and concentrations of fat and proteins; a negative correlation which is coming as a support to the "Dilution effect" reported by Zumbo and Di Rosa (2007) (Table 4.4 and Graph 4.3)

Interestingly, in Table 4.5 and Graph 4.4, there is a tendency for stability in the Indigenous does' milk-fat concentration especially from week four to week eight. This stability in the Indigenous goat's performance has been earlier discussed with the goats milk yield (Figure 4.1), the Indigenous does'lactose content of milk (Graph 4.2) and the Indigenous does'protein concentration in milk (Graph 4.3). Stability in the Indigenous

goat performance has a reference in the role of the central homeostatic control upon the indigenous does' general metabolism.

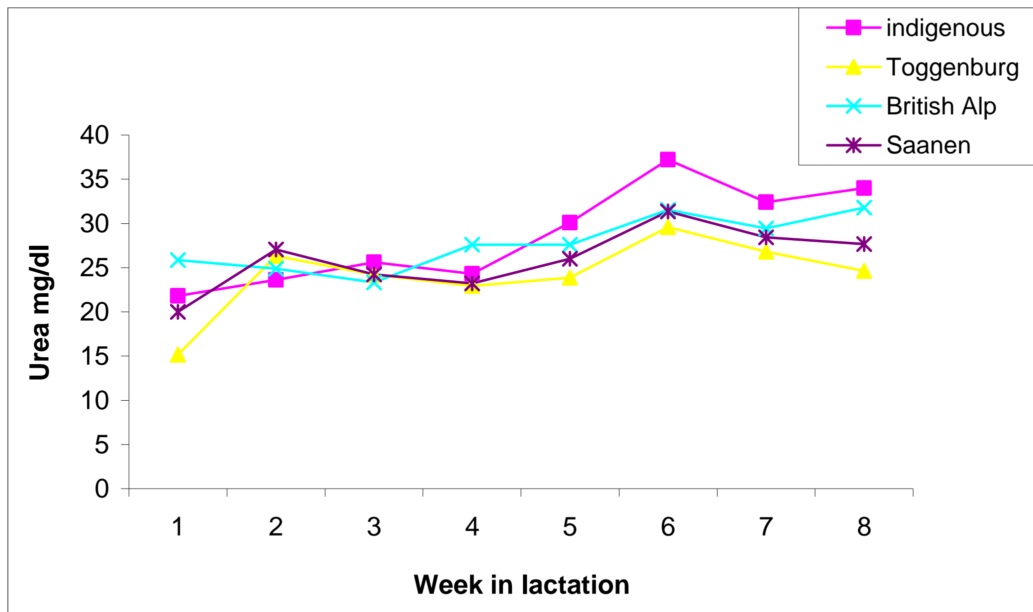
4.2.4 Milk urea nitrogen (MUN) concentrations

Results on goat MUN concentrations are displayed in Table 4.6 and Graph 4.5.Those results are in the range of those reported by Bava *et al*. (2001) and Bonanno *et al*. (2008).

Table 4.6: Mean MUN concentration (±SD) in milk from Indigenous and Dairy does during the first eight weeks of lactation

Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Indigenous	21.8 ±8.86	23.6 ±8.50	25.6 ±11.56	24.3 ±11.50	-	37.2 ± 11.13	32.4 ±7.34	34.0 ±9.91
Dairy Breeds	20.4 ±11.17	26.7 ± 6.86	24.2 ±5.19	23.5 ±7.18	-	31.2 ±10.40	28.4 ±7.87	28.2 ±9.34
p-value	0.105	0.690	0.115	0.668	-	0.432	0.266	0.360

No significant difference was found between means



Graph 4.5: MUN concentration in milk from Indigenous and Dairy does in the first eight weeks of lactation.

In Graph 4.5 all goats MUN are gradually increasing from week one to week eight. There is a high correlation between blood urea nitrogen (BUN) and MUN (Oltner *et al*., 1983; Khaled *et al*., 1999) which is simply justified by the fact that BUN is isotonic to MUN (Pulina *et al.*, 2002; Sherwood *et al.*, 2005; Bonanno *et al.*, 2008). In this study, results on BUN are presented in Graph 5.2. When comparing Graph 4.5 to Graph 5.2, there is a striking resemblance between BUN and MUN concentrations in week three. In both cases there is a clear increase from week three to six. The similarity found on both tendencies is lending support to the existence of a positive correlation existing between milk yield and MUN (Todaro *et al*., 2005). Observing performance of all does MUN concentrations on week one, there is an increase in the Toggenburg and the Saanen MUN, which is in contrast firstly with the British Alpines and the indigenous does week one MUN stability and secondly, with all does week one BUN decrease (as it appears later on Graph 5.2).

These results can be explained by the fact that in early lactating goats nutrients partitioning do not depend on dietary intake, which was low as attested by all does week one decrease in both Milk yield (Graph 4.1) and BUN (Graph 5.2). This may support what was hypothesized earlier: During lactation (especially in early lactation) goat dairy breeds physiology responded to a homeorrhetic central mechanism which resulted in the mobilization of body reserves (whence the subsequent BCS decline associated to a week one MUN increase) in order to support milk yield. These changes took place while the indigenous does' week one MUN remained unchanged proving their strong dependency upon the homeostasis central command. As for the Alpines does, whose performance did not depend on the rangeland capacity (early spring growing kikuyu), they displayed an outstanding performance: maintaining stability in week one MUN and increasing week one milk yield (Graph 4.1) in an environment where food inadequacy dictated a decline in all doe's milk yield (Graph 4.1)

On Graph 4.5 there is again a tendency for the Indigenous does' MUN concentration to be higher from week four onwards. A general elevation in MUN is, in dairy farm practice, an indication that urea is either misused (excess in CP dietary source) or wasted metabolically (on-going ureogenesis) (Bonanno *et al*., 2008). In the case of the Indigenous does, the elevation in MUN seems to be an indication of an on-going

ureogenesis process subsequent to the advancing lactation. This interpretation is based on the following facts: Firstly, ureogenesis and gluconeogenesis are linked processes (Bergman, 1983; Belyea *et al*., 1990). In this study the increase in the Indigenous BUN concentration (Graph 5.2, week six to seven) was followed (and attested) by an increased Indigenous blood glucose concentration in week seven (Graph 5.1,). Secondly, BUN being isotonic to MUN, the latter was also elevated as from six onwards. Under such circumstances the indigenous BCS was also expected to decline but somehow (homeostasis?) the Indigenous BCS remained unchanged.

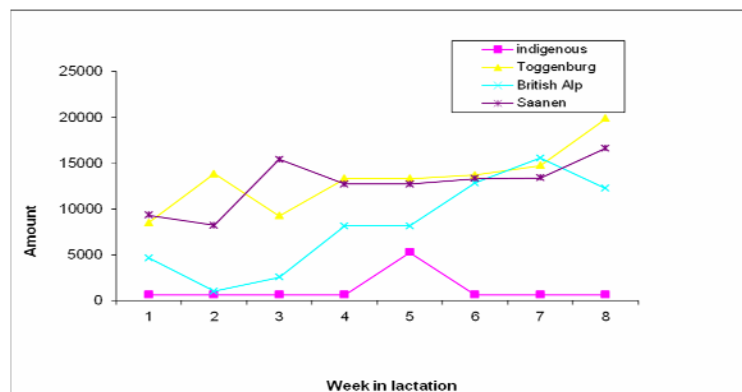
4.2.5 Milk somatic cell count

Results on SCC concentrations are presented on Table 4.7 and on Graph 4.6

Table 4.7: Difference in mean (x1000) Somatic cell count (SCC) concentration (± SD) between milk from Indigenous and Dairy does during the first eight weeks of lactation

Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Indigenous	626.8 ±493.8 [a]	627.8 ±10080 [a]	628.8 ±11485	629.8 ±8847	-	631.8 ±1912 [a]	632.8 1398 [a]	633.8 ±1658.3 [a]
Dairy Breeds	20649 ±8754 [b]	17577 ±8349 [b]	217075 ±9778	236422 ±9695	-	30509 ±7557 [b]	32083 9272 [b]	35334 ±8957 [b]
p-value	p<0.001	p<0.001	0.947	0.021	-	p<0.001	p<0.001	p<0.001

Means per column followed by different superscripts ([a,b]) were significantly (p≤ 0,001) different



Graph 4.6: Mean SCC (x1000) concentration in milk from the Indigenous and Dairy breeds during the first eight weeks of lactation.

Values found in this study are comparable to those reported by Zeng *et al.* (1995), Zeng *et al.* (1997) and Paape *et al*. (2007). At the first glance on Graph 4.6, the general impression reflects an erratic performance in all does SCC. These disparities were already been observed by Fernandez *et al.* (2008) who worked on SCC and quality of goat milk in Mexico and concluded that there were important individual differences among doe's milk SCC.

Haenlein (2002) studied the relationship between SCC in does to mastitis and productivity; he found that milk samples SCC differed significantly before, during and after milking. Earlier studies conducted by Zeng *et al.,* (1996) on the effect of breed and milking method on SCC of goat milk indicated significant variations among goat herds. Zeng *et al*. (1997) indicated that SCC and daily milk yield varied throughout lactation depending on numerous factors such as morning versus evening milkings, stage of lactation, parity and breed. Mena *et al*. (1999) studied the SCC in all farms having more than 50 goats in Seville (Spain); significant differences ($p<0.001$) were found according to herd size:1,072,000 cells/ml for farms with few numbers of animals and 2,209,000 for larger herds.

Graph 4.6 shows a significant difference ($p<0.001$) between the Indigenous doe's milk SCC and the dairy goats milk SCC (especially from weeks one to three; and from weeks five to eight). Among the dairy breeds however, the Alpines tended to have the less SCC up to week five. There is also a clear tendency of elevation in all dairy breeds SCC from week five to week eight. Meanwhile, in the indigenous does which scored the lowest milk SCC, stability prevailed in the exception of an increase in week five. This stability in the indigenous milk SCC is reminding the stability reflected in the indigenous milk yield (Graph 4.1), milk lactose (Graph 4.2) and milk fat percentage (Graph 4.4) where it was explained that the indigenous does were under a homeostatic control which was reflected by stability in its milk yield and components.

As for the dairy breeds milk SCC elevation, it can be explained by Petzer *et al.* (2008) who investigated the value of using the SCC in the assessment of the dairy goats udder health; a higher SCC in mid and late lactation was found, as compared to SCC from early lactation milk. They said that breed, stage of lactation and milk yield needed

to be taken into account when using SCC as a measure of udder health in goats. This warning is in agreement with Barth *et al*. (2010) who recently said that a high variability of SCC in goats' milk can be caused by infection, but also by physiology (estrus, stage of lactation,) and any other factor not controllable by farm management.

In summary, this erratic SCC performance seen in Graph 4.6 seems difficult to explain and lends a support to Lerondelle *et al.* (1992) who said that the use of SCC for predicting mammary infections is difficult in goats; healthy goat udders can indeed have high SCC levels in their milk normally. Haelein (2002) stated that, although a maximum of PMO remains acceptable at 1 x 10^6 ml^{-1}, it is not advisable to use SCC (as it is the case in dairy cows), as an index of goat mammary health status.

Further researches need to be conducted to ascertain the reason why the Indigenous and the Alpine goats do present a reverse pattern of SCC levels respectively in the beginning (from week one to two) and in a more advanced stage of lactation (week three to eight).

4.3 Effect of breed on milk yield and components

The effect of breed on milk yield and constituents is presented in Table 4.8**.**

Table 4.8: Effect of breed on mean milk yield and constituents (±SD) in milk of lactating does herded in the same environment

Variables	Fat (%)	Lactose (%)	Protein (%)	MUN (ml/dl)	SCC (x1000)	M. Yield (ml)
Breeds						
B. Alpine	5.1 ±0.39	4.6 ±0.13 [a]	4.6 ±0.30 [a]	27.3 ±1.12	8905 ±167 [ab]	1.9 ± 1.40[a]
Indigenous	5.6 ± 0.56	4.6 ±0.19 [a]	5.0 ±0.44 [a]	28.8 ±1.70	800.1 ±2410 [a]	0.9 ± 1.89 [b]
Saanen	5.6 ±0.27	3.8 ±0.09 [b]	5.7 ±0.21[b]	26.1 ±0.84	13096 ±1181 [b]	1.6 ± 9.1 [a]
Toggenburg	4.5 ±0.32	3.6 ±0.11[bc]	3.0 ±0.25 [c]	24.1 ±0.98	12551 ±1386 [b]	2.0 ± 1.1 [ac]
p-value	0.065	p<0.01	p<0.01	0.017	p<0.01	p<0.01

Means per column followed by a different superscripts ([a, ab, bc]) do significantly (p≤0.01) differ

Table 4.8 shows that goat breed had an influence on lactose, milk proteins, SCC and milk yield. The data in Table 4.1 and Graph 4.1 suggested that the indigenous herded in the same environmental conditions as dairy breed of goat (Saanen, British Alpines and Toggenburg) yielded lower milk than these dairy breeds; and among dairy breeds, milk yield performance could be schematized as : Saanen < B Alpine < Toggenburg breeds. Each breed of goat achieving its own milk yield record in an environment where feeding management was the same is a clear demonstration that individual factors attached to does genotype are responsible for differences in milk yield performance. Our results are in agreement firstly with Mioč *et al.* (2007) who studied the factors affecting milk yield and constituents in the Czech Republic and found that daily milk was significantly affected by breed (Saanen higher than Alpine goats). Secondly, our results are also in agreement with Sanogo *et al.* (2010) who investigated milk yield performance of Crossbred sahelian goats in Mali and concluded also that daily milk production was highly affected by breed.

As for lactose, Table 4.8 shows that it is dictated by breed. Lactose is the most important osmotic solute for milk yield (Bell, 1995). Lactose importance in determining milk volume is such that, if lactose secretion ceases, milk volume will be greatly reduced (Pulina, 2002); anything that affects lactose, also affects milk yield (Rook *et al.*, 1966). The view that milk secretion rate depends on lactose secretion was expressed by Linzell (1973); it has been reviewed in this study on the correlation matrix presented in Table 4.9. Results in this Table 4.9 (next page) surprisingly indicate a lack of correlation between lactose and milk yield; but in this same study when the correlation matrix excluded BCS and focused on differences between indigenous and dairy breed of goats, milk yield showed a positive correlation with lactose in all lactating does (Table 4.10, next page). Therefore, if breed determines milk yield (Table 4.8) and milk yield depends on lactose (Table 4.10), then breed controls also lactose; that is what is reflected in Table 4.8. Table 4.8 also shows that breed has an effect on milk protein. Table 4.9 (next page) shows a negative correlation existing between milk yield and milk protein.

Many authors (Kennedy *et al*., 1980; Bouloc, 1987 Rabasco *et al*., 1993; and Todaro *et al.,* 2005) have reported and supported the view that a negative correlation

exists between milk yield and protein percentage. In this study Table 4.8 suggested that milk yield was influenced by breed.

Table 4.9: Correlation matrix between BCS, milk components and blood parameters from all does during eight weeks of lactation.

Variables	BCS	Glucose	Cholesterol	Urea	Fatacids	Milkyield	Lactose	MilkProtein
BCS	**1**	0.087	**-0.185**	-0.106	**-0.198**	**-0.243**	**0.187**	0.018
Glucose	0.087	**1**	**-0.299**	-0.140	**-0.251**	**-0.198**	-0.042	0.121
Cholesterol	**-0.185**	**-0.299**	**1**	**0.220**	-0.060	-0.084	**-0.271**	-0.024
Urea	-0.106	-0.140	**0.220**	**1**	0.041	-0.092	-0.030	-0.006
Fatacids	**-0.198**	**-0.251**	-0.060	0.041	**1**	**0.285**	0.007	0.095
Milkyield	**-0.243**	**-0.198**	-0.084	-0.092	**0.285**	**1**	0.008	**-0.210**
Lactose	**0.187**	-0.042	**-0.271**	-0.030	0.007	0.008	**1**	**-0.257**
MilkProtein	0.018	0.121	-0.024	-0.006	0.095	**-0.210**	**-0.257**	**1**
Milkfat%	0.079	**0.165**	0.080	**-0.237**	**-0.234**	-0.083	**-0.311**	**0.397**
MilkUreaN	-0.039	-0.056	0.031	**0.223**	-0.010	**-0.264**	0.053	**0.151**
SCcount	**-0.216**	-0.015	**0.185**	0.143	0.079	-0.009	**-0.702**	0.135

Values in bold are significantly different from 0 with a significance level alpha=0.05

Table 4.10: Correlation matrix between milk components and blood parameters of does from indigenous (Ind.) and dairy (D) breeds.

Breeds: Dairy & Indigenous	Ind	D	Ind	D	Ind	D	Ind	D	Ind	D	Ind	D	Ind	D	Ind	D	Ind	D	Ind	D
Fat %																				
Protein		+																		
Lactose		-	+	-																
S.C.C					±	-														
Milk urea				+																
Milk yield					**+**	**+**	**+**	**+**		-										
Glucose	±				÷															
Cholesterol			-		÷	-		+			-	-		-						
Blood urea Nitrogen	+	-	±					+	**+**	**+**				-	+					
F. Fat Acids		-		+	-		+					+		-						
Milk & Blood Components	M Fat %		Protein		Lactose		SCC		MUN		Milk yield		Glu		Cho		BUN		FFA	

Legend: (+) means positively correlated; (-) negatively correlated; (±) positive tendency to correlate; (÷) negative tendency to correlate.

Therefore, milk proteins being in a reverse relational equation (dilution effect) with milk yield should explain why breed is also negatively correlated to milk protein. Looking at Table 4.4 and Graph 4.3, one can see that each breed of goat displayed its own milk protein record just as it was the case with the goat's milk yield performance. This is an additional proof that, in the lactating does, breed does indeed influence milk proteins. Concerning the goat milk SCC, Table 4.8 showed that it was dictated by breed; but, results obtained with Indigenous does SCC and the conflicting theories supporting on one hand the gradually increasing SCC (Table 4.7 and Graph 4.6) and on the other, an initial increase followed by a gradually decreasing SCC do not allow us to draw a clear picture on the real driving forces acting behind the SCC in the goat's milk. Further studies are needed to review firstly the influence of breed on milk SCC, and secondly the milk SCC negative correlation with milk lactose seen in this study in Table 4.9.

Table 4.9 on correlation matrix showed also the existence firstly, of a negative correlation between SCC with both BCS and lactose; and secondly a positive correlation existing between SCC and blood cholesterol. Those results will be discussed later, separately, in the relevant chapters.

4.4 Conclusions

Data relative to the effects of goat breed on milk yield and components suggest that:

- Breed has an impact upon milk yield which, in turn, is positively correlated with lactose and negatively correlated with both milk fat and milk protein (Dilution effect); breed has therefore, a control upon lactose, milk fat and milk protein
- Milk yield of dairy goat is superior to milk yield of the indigenous; but milk from indigenous does has a higher lactose, milk proteins, milk fat and MUN content
- MUN appears to be a direct reflection of BUN concentrations as shown by the correlation matrix in Table 4.9 and table 4.10.
- In goats, SCC in milk is not a reliable mammary health status index; the SCC relationship with breed (Table 4.8) and lactose (Table 4.9) found in this study needs to be ascertained.

- The onset of lactation exacerbated by a poor nutritional supply, shifted the nutritional partitioning process of goats into an homeorhetic regime in all dairy breeds, while a strict homeostatic control prevailed in the indigenous goat.
- With the provision of feed supplement, Toggenburg had the highest milk yield (Graph 4.1) of the trial. The British Alpine scored second and demonstrated the independency of its milking capability from grazing quality. Saanen does yielded less milk than the other dairy breeds (but more milk than the indigenous does). It lost most body condition.