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**MILK PRODUCTION OF SOUTH AFRICAN
BOER AND INDIGENOUS FERAL GOATS
UNDER INTENSIVE AND EXTENSIVE
FEEDING SYSTEMS**

by

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Dissertation submitted in partial fulfillment of the requirements for the degree

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Dedicated to my family and friends

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CHAPTER 1

GENERAL INTRODUCTION

With poverty, malnutrition and a growing population in the rural areas of South Africa being the order of the day, solutions have to be found to help, feed and provide a possible source of income to these people. One of the possibilities of alleviating the problem, is to look towards an easy-care, hardy and productive animal that can serve as a source of protein and possible livelihood. Such a potential animal that can help feed and uplift the rural population is the goat.

Goats can be seen as one of the most important sources of animal protein (milk and meat), especially in the rural areas of South Africa. The high demand for goats and their products can be attributed to their hardiness and ability to survive and produce under harsh environments with low rainfall and minimal nutritional supplementation. Under these conditions goats can selectively utilize a wide variety of sparse, coarse feeds, grasses, leaves and twigs, often unpalatable to other livestock. With their unique feeding habits, goats spend up to 60% of their feeding time browsing. The browsing ability of goats allows the animals to change their diet according to the seasonal availability and growth rates of plants. Goats are also able to increase their dietary protein intake during droughts and dry periods (Louca *et al.*, 1982). Several anatomical and physiological adaptations have been suggested to be responsible for the browsing nature of goats. These include a high tolerance for bitter, salty and sour substances (Louca *et al.*, 1982; Knights & Garcia 1997).

The poorer communities of the rural areas, with limited resources, could benefit from the goat as a source of animal protein and an instrument to combat nutritional deficiencies. The therapeutic properties of goat milk have long been realised, especially for infants (Egwu *et al.*, 1995). The fact that

goats also have lower maintenance requirements, compared to the cow for example, makes this animal ideal for milk production by small-scale farmers and rural households. This is one of the reasons why goats are sometimes referred to as the "poor man's cow" (Steele, 1996). The ability of goats to also provide meat, skin and fibre emphasizes the contribution that this small ruminant can make towards helping to feed and clothe the nation.

Regarding milk, the FAO has projected the demand for milk in the developing tropical countries to be approximately 242 million tons of milk by the year 2000. The projected supply is estimated at 177.6 million tons at that time, leaving a shortage of 64.4 million tons (Sarma & Yeung, 1985). Goat milk is an option and has the potential to help alleviate the shortage, as the vast source of milk is obtained from cattle. Goat milk production has the comparative advantage in that goat enterprises need lower initial capital investment requirements, concurrent with lower overall risks. Yet very little is known about the milk production potential of South African indigenous goat breeds. It is known that many rural communities of this country, small scale and subsistence farmers milk goats for household consumption (Casey & Van Niekerk, 1988).

The main objective of this study was to determine the potential (quantity and quality) of milk production from Boer and Indigenous goats under intensive and extensive nutritional regimes. The extensive milk production nutritional regime being representative of the rural small scale farming systems, where milk is produced off natural pastures with no nutritional supplementation. The intensive nutritional regime represents the commercial farming system, where supplementation with concentrates is cost effective. Other objective was to determine the relationship between the doe's milk production and the kid's preweaning growth rate. Thus the goat with its unique characteristics is evaluated as a possible milk producer, to help in the social upliftment of the rural communities.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The human consumption of cow milk is decreasing in the Western world. High capital and running costs and an ever-spiralling feed price make it difficult to make the price affordable to the consumer. Cows are expensive to keep, large to feed, awkward to handle and ruinous to the land in winter. So, small ruminants such as sheep and goats can be an alternative for milk production (Mills, 1989).

Van der Nest (1997) pointed out that goats provide a small, but nevertheless acceptable and affordable source of animal protein in the form of meat and milk. This is particularly true for the low-income rural communities of South Africa, who cannot normally afford these products. Casey and Van Niekerk (1988) emphasized the fact that in the rural areas of South Africa, the local, unselected Boer and Indigenous feral goats, are milked for home consumption. Keeping of dairy goats is, however, currently a small industry in South Africa. It is further indicated that these two breeds (Boer and Indigenous feral goats) can be regarded as very adaptable, thriving in all climatic regions of Southern Africa, including the tropical, sub-tropical bush and semi-desert regions of the Karoo and greater Kalahari. Their excellent reproductive performance can be seen as an indicator of environmental compatibility.

Boer goats have a reputation of high fertility, with conception rates averaging 98% for does bred under good management and nutritional environments (Campbell, 1984). Van der Nest (1997) indicated reproduction efficiency to be one of the main factors determining the overall productivity of the animal. It determines the number of excess stock for sale and the meat and milk available for human consumption.

2.2 MILK YIELD

Although not all goats are kept for milk production, it is consumed in most countries where they are bred and the value of milk as an important source of animal protein is recognised (Devendra & Burns, 1970). Milk yield depends on various factors such as breed, nutritional regime, frequency of milkings, litter size and hormonal stimulation. In the first lactation Saanen goats produce a peak of two to three litres per day and a total of 600 litres for the whole lactation, whilst in the first lactation crossbred (Saanen x Tswana does) goats produce a peak of one to two litres per day and a total of 300 litres for the total lactation period (Donkin, 1993). In a pilot study involving Toggenburg x East African does placed on local farms in Kenya, milk yield averaged one litre per day (Boor *et al.*, 1987). Furthermore, Casey and Van Niekerk (1988) reported 1.5 to 2.5 litres/day for Boer goat does in South Africa. Hence, it was reflected that milk yield of the indigenous goats in the tropics are generally low (Akinsoyinu *et al.*, 1977).

Milk secretion is assisted by direct neural stimulation of contractile elements in the udder (Zaks, 1962). The neuro-hormonal complex regulating milk ejection and its importance for milk withdrawal has been reviewed by Denamur (1953) and as is seen in the cow, ejection of milk occurs in the goat after stimulation of a neuro-endocrine reflex, involving the release of oxytocin. Fright, agitation and unusual situations during milking inhibit both the liberation of oxytocin in the hypothalamus and the action of oxytocin on myoepithelial cells of the mammary glands. The intravenous injection of 1 ml oxytocin results in milk ejection within 0.33 minutes (Gall, 1981). Dynsemin (1974) reported that within two minutes after stimulation by the milking machine, oxytocin decreased to a low level, whilst McNeilly (1972) pointed out that during suckling and hand milking oxytocin release occurred at any time. No relation between milk yield and oxytocin liberation could be found. However, udder stimulation seems to be important for sustained lactation yield (Gall, 1981). In lactating goats, prolactin levels increase following

parturition and the onset of lactation. This correlation was also found between prolactin levels and milk yield (Hart, 1974).

2.2.1 Physiology of milk production

Milk production results from a number of milk secretion cells and from the synthetic activity of each cell (Chilliard, 1992). Montaldo *et al.* (1995) reported that the synthetic and secretory capacities of the mammary gland are limited by the amount of alveolar tissue. The last phase of mammogenesis (lobulo-alveolar growth) takes place during the second half of pregnancy. Chilliard (1992) indicated that this lobulo-alveolar growth takes place under genetic and endocrine control of oestrogen, progesterone, prolactin, BST and other hormones. These are also implicated in the differentiation of mammary cells into cells that are able to synthesize milk (lactogenesis, stage I). However, Forsyth (1983) reported that the onset of copious milk secretion (lactogenesis II) at parturition, is due to elevated prolactin and adrenal steroid secretion, simultaneous with progesterone withdrawal.

The decrease in milk yield after the lactation peak (that determines milk persistency), results primarily from a decrease in the number of secreting cells (Chilliard, 1992). Wilde *et al.* (1987) reported that the synthetic capacity and efficiency of mammary cell secretion is achieved through local mechanisms with the mammary gland. These researchers, further indicated that elucidation of the mechanisms of this intramammary control on milk synthesis offers the possibility of direct manipulation of specific mammary functions. Working with the mouse, Chilliard (1992) found that a stronger milking stimulus caused by new younger pups was able to increase the longevity of the secretory cells. Thus, maintaining the number of cells at peak values and milk yield at two-thirds of peak values. Hence, Knights *et al.* (1988) suggested that better milk persistency was due to maintenance of cell numbers.

During concurrent pregnancy and lactation, there is a sharp decrease in milk yield during late pregnancy. This is primarily due to increased oestrogen secretion that inhibits milk synthesis (and to some extent to foetus competition for nutrients). There is, however, a large proliferation of new secretory cells that will produce more milk during the following lactation (Knights *et al.*, 1988). This proliferation phase is probably stimulated by drying off the animals before the next lactation (Mephram, 1983).

2.2.2 Endocrine control of lactation

Young (1947) found that mammary growth and milk production are processes that require a special type of metabolic control. Oestrogen, progesterone and placental lactogen play a positive role in the growth of the mammary gland (De Louis *et al.*, 1980). Kühn (1977) characterized the hemeorhetic control of lactogenesis as both a "release" of inhibition and a "push" to commence synthesis. Progesterone concentration in the blood begins to decrease gradually during the last weeks of pregnancy, and then decreases drastically (Bauman & Currie, 1980). As a result the progesterone inhibition on mammary differentiation is released. Simultaneously oestrogens are increased in the maternal circulation, and this is followed by the prepartum surge in prolactin. According to Kühn (1977), prolactin represents one of the key components of the "push", necessary for the final stages of differentiation that result in the mammary tissue, acquiring the ability to synthesize milk components.

Meites and Clemens (1972), as well as Schams and Karg (1972), reported an existence of synergism between oestrogens and prolactin. This possibly also causes the increase in the number of prolactin receptors in the mammary tissue, which occurs during the prepartum period (Djiane & Durand, 1977; Djiane *et al.*, 1977). Blocking the prepartum release of prolactin in dairy cows with the drug 2-brono-2-ergocryptine resulted in a 40 to 50% reduction in subsequent milk production (Akers *et al.*, 1979). This effect is overcome by the simultaneous administration of exogenous prolactin. In addition,

prolactin is released as a result of the suckling or milking stimulus and in dairy cows, the magnitude of the release decreases as lactation progresses. Trials with the rat further demonstrate that in mammary adipose and liver tissue, adaptations in the lipid metabolism are reversed if exogenous prolactin is administered. Prolactin receptors have been identified in adipose tissue and the liver (Kelly *et al.*, 1974; Posner *et al.*, 1974; Bolander *et al.*, 1976).

Prolactin was found to be involved in the homeorhetic control to support lactation needs, by decreasing the synthesis of lipid reserves and increasing mobilization of adipose lipid stores (Bauman & Currie, 1980). Hypertrophy of the gastrointestinal tract is another maternal tissue adaptation which occurs with the onset of lactation in the ruminant (Tulloh, 1966; Cripps & Williams, 1975; Mainaoy, 1978). Prolactin has been implicated in the hypertrophy and increased absorptive capacity which occurs in the gastro-intestinal tract of rats during the onset of lactation (Mainaoy, 1978). A role of prolactin in the regulation of calcium metabolism in Avian species has also been reported (Spanos *et al.*, 1976). Studies with goats suggest that this phenomenon is unlikely, because decreasing prolactin release for a period of 44 days, had no effect on milk yield. The overlapping systems in endocrine control may have allowed other hormones to compensate for the absence of prolactin (Hart, 1974).

In non-ruminant species, the blocking of prolactin release during lactation, results in the cessation of lactation (Fluckiger & Wagner, 1968; Mayer & Schutze, 1973). However, daily injection of several drugs, which apparently stimulate prolactin release with no adverse side-effects, results in a 50% increase in milk yield by lactating ewes (Bass *et al.*, 1974). Oestrogen injection increases the number of prolactin receptors in the rat liver (Posner *et al.*, 1974) and this effect is amplified or mediated by prolactin (Posner, 1976). Thus oestrogen may function in a manner analogous to its role in mammary lactogenesis.

Exogenous administration of prostaglandin fed to rats in late pregnancy resulted in decreased adipose tissue and increased mammary tissue activity of lipoprotein lipase (Spooner *et al.*, 1977). Growth hormones has also been suggested to co-ordinate metabolism, particularly during the maintenance of an established lactation (Cowie, 1976; Bines & Hart, 1978). The administration of growth hormones to lactating cows, increases milk production (Machlin, 1973).

Otto and Scott (1910) discovered that posterior pituitary extracts cause a rapid but temporary increase in milk flow in the goat. A number of workers believed that the pituitary also increases the rate of milk formation (Hammond, 1913; Maxwell & Rothera, 1915; Simpson & Hill, 1915). Denamur (1953) reported that oxytocin could cause an increase in milk yield in goats. Hourly milkings, using oxytocin has been found to cause a sustained rise in plasma prolactin concentration (Greenwood & Linzell, 1968; Bryant *et al.*, 1970). This supports the hypothesis of Benson and Folley (1957), that oxytocin may have a physiological role to play in maintaining and perhaps regulating the route of milk secretion, by releasing prolactin.

2.2.3 Effect of the suckling stimulus on milk production

A positive effect of suckling on milk production in goats has been clearly demonstrated in experiments by Louca *et al.* (1975) and Zygoiannis and Katsaounis (1986). In both experiments non-suckling goats produced significantly less milk than their suckling counterparts. It was observed that the milk yield of goats which had been suckled, dropped dramatically when the kids were weaned. There is also evidence that suckling has a positive effect on milk production in the cow (Preston & Leng, 1987).

Zygoiannis (1987), working with indigenous goats (*Capra Prisca*), found that early weaning of kids significantly decreased milk yield and did not permit the goat to exercise its full lactation potential. Folman *et al.* (1966) and Guirgis *et al.* (1980) working with Awassi sheep on different suckling regimes,

showed that restriction and suckling during the first 9 or 9-17 weeks of lactation considerably reduced the quantity of marketable milk. Similar rates of decline were found by Zygoiannis and Katsaounis (1986) in their study on milk yield and milk composition in goats. Flamant and Morand-Fehr (1982) reported that the rapid decline of milk yield in both groups after a peak of lactation was due to the removal of the suckling stimulus. The suckling stimuli induce prolactin secretion and prolactin plays a role in the initiation and maintenance of lactation in both cows and goats. It is therefore reflected that the differences in milk yield are due to prolactin stimulation of the udder, which depend on the intensity of the suckling stimulus (Hayden *et al.*, 1979).

2.3 NUTRITIONAL BENEFIT OF GOAT MILK

In many countries, goat milk is marketed as a health food, with relative advantages over other types of milk from different animal species (Egwu *et al.*, 1995). Haenlein (1980; 1984), highlighted certain biochemical differences which bring major metabolic advantages of goat milk over that of cow milk. There is currently evidence to show that a significant proportion of consumers unable to thrive on cow milk, survive and flourish on goat milk (Beck, 1989; Busch, 1990). The composition of goat milk has been shown to have several nutritional advantages compared to that of cow milk (Chandan *et al.*, 1992). Knights and Garcia (1997) pointed out that the average fat globule size of goat milk (3.5 μm), is significantly smaller than that of cow milk (4.5 μm), while goat milk also has a higher percentage of small fat globules than that of cow milk. These properties facilitate easy digestion, anti-allergic reactions and lower lactose content for lactose intolerant individuals (Williamson & Payne, 1978).

It is known that goat milk is a valuable source of amino acids (histidine, aspartic acid and tyrosine) and has a relatively high content of C6 to C14 fatty acids, in addition to a high Vitamin A, nicotinic acid and choline ascorbic content, compared to the milk of other animal species (Haenlein, 1992). The level of selenium is similar in goat and human milk, but significantly higher

than levels found in the milk of cattle. Goat milk is often utilized when infants show allergic reactions to both cow milk and soya-based formula milk. It is suggested that goat milk is a viable dairy option to meet the nutritional requirements of infants, children and adults (Chandan *et al.*, 1992). The lack of knowledge in basic immunology, and clinical experience is a reason for the neglect of goat milk as a viable alternative for patients sensitive to cow milk (Podleski 1992). Egwu *et al.* (1995) ascribed the ignorance regarding the benefits of goat milk to a lack of adequate education on the health-related importance of goat milk.

2.4 NUTRITIVE VALUE OF GOAT MILK

It is found that goat milk is richer in iron than human, cow and sheep milk (0.12 vs 0.007 vs 0.05 vs 0.03 mg/100 g, respectively), but poorer in copper (0.03 vs 0.04 vs traces vs 0.10 mg/100 g, respectively). Furthermore, goat milk has a selenium content (1.25 g/100 ml) similar to that of human, but higher than that of bovine milk. This aspect could be important, as selenium is an "anti-oxidant" factor reported to favour the prevention of cancer and cardio-vascular diseases (Steele, 1996).

2.5 PEDIATRIC USES OF GOAT MILK

Luthe *et al.* (1982) reported colic-like pains in infants, less than 3 months of age, to be associated with the cow milk formula, as well as breast fed infants whose mothers were consuming cow milk. Furthermore, Nestle (1987) and Host *et al.* (1988) reported a 7 to 20% cow milk protein intolerance in children between 6 and 12 months of age. These observations were further elucidated by Walker (1964), who showed that of 100 infants intolerant to cow milk proteins, only one failed to thrive on goat milk.

It was furthermore demonstrated that of the 300 patients manifesting allergic bronchial asthma due to cow milk consumption, 270 became symptomless within 6 weeks of substitution with goat milk. Goat milk was used for further therapeutic applications, which amongst others include intestinal resection,

coronary by-pass, childhood epilepsy, cystic fibrosis, cholesterol deposition in tissues and general physiological well-being of children. It is recommended, therefore, that extension to the rural communities should be done on the consumption of goat milk, to curb the taboo existing in many areas on goat milk use (Schwabe *et al.*, 1964; Greenberger & Skillman, 1969).

2.6 EFFICIENCY OF MILK PRODUCTION IN GOATS

A comparison of the milk yields in goats, cows and buffaloes in West Malaysia carried out by Devendra and Burns (1970), suggested that goats were more efficient milk producers in terms of live weight and their lower maintenance needs, when compared to buffalo and cattle. The conversion of nutrients to milk is generally more efficient in goats and the biological advantage of the goat as a milk producing animal has been greatly underestimated. Goats convert energy and protein to milk more efficiently than cattle or sheep (24% and 23.7%, respectively) (Devendra, 1978; NRC, 1981; 1988).

2.7 FACTORS AFFECTING MILK YIELD

2.7.1 Nutrition

Lactation is a critical period in the production cycle, which involves extra nutritional demands on mechanisms regulating the fluid and energy balance. Water and feed intake is thus expected to increase, to meet the requirements for milk production (Hossaini *et al.*, 1993). Linzell (1967c) found feed deprivation in the Moroccan goat to have a marked effect on milk yield, similar to that in other goat breeds. Sahlu and Goetsch (1998) indicated energy intake to be one of the most limiting factors in milk production. Similarly, Gall (1981) stated that the main limiting factor of milk secretion may be the availability of glucose, because in the udder it is converted to lactose, which largely controls the movement of water into milk.

The mammary gland absorbs about 70 g glucose per kg milk formed (Linzell & Peaker, 1971). Of the glucose entering the circulation, 60 to 85% is used by the mammary tissue of the goat (Annison & Linzell, 1964). There is little glucose stored in the body and a reduction in feed intake will quickly affect milk yield through lowered blood glucose levels (Gall, 1981). Linzell (1967c) furthermore found that when lactating goats were fasted, milk yield was reduced by about 90% within 8 hours. Thus, lowering the input of glucose to the mammary gland reduces milk secretion. Infusing glucose into the blood stream of high producing goats stimulates milk yield by as much as 62%. Although needed in high quantities, amino acids cannot easily become a limiting factor for milk secretion (Linzell, 1973). In normally fed goats the additional supply to blood vessels of amino acids do not directly affect milk yield (Champredon & Pion, 1979). A negative correlation between milk production and crude fibre content of the forage and a positive correlation between milk yield and the net energy of the forage has been recorded. However, the crude protein content of the forage has only a small effect, whereas the dry matter content of green forage has a beneficial effect of up to 16% (Morand-Fehr & Sauvant, 1980).

The effect of the nature of the forage (species, number of cuts, growth stage and storage technique) on milk production in goats depends on the forage intake and net energy content of the forage. Green feed and pelleted hay (in the diet) produce more milk. The percentage of milk protein seems to be little affected by the method of storage of the forage. The nature of the forage has a greater effect on goat milk production and composition of milk, because of differences in intake and digestibility related to crude fibre (Morand-Fehr & Sauvant, 1980). Because of the high metabolic rate and the requirements for milk secretion, the lactating animal has a special demand for minerals and trace nutrients, but both are readily provided as supplements in the diets. Thus, in practice, milk yield and composition is influenced mainly by dietary supplies of materials, providing energy and protein (Thomas & Rook, 1983).

2.7.2 Season of kidding

Most goats are seasonal breeders (Gipson & Grossman, 1990). Season of kidding has been observed to affect initial milk yield, peak yield and persistency (Mourad, 1992). Kennedy *et al.* (1981) studied some factors effecting the milk yield in the Alpine, Saanen and Toggenburg breeds and concluded that the month of kidding affected milk yield in the dams. Similarly, it has been reported that does kidding from January to March produced more milk than those kidding from April to July (Iloeje *et al.*, 1980). Singh *et al.* (1970) concluded that Beetal goats kidding from January to June produced more milk than those kidding between July and December. This is inconsistent with the findings of Velez (1992). Gipson and Grossman (1990), demonstrated that for the overall lactation curve, does kidding early in the breeding season (December through to March) have a lower initial and peak milk yield, compared to does kidding late in the season (April through to June). The effect of month of kidding on milk yield of dams was found to be not significant (Steine, 1975). Contrary to this, Mavrogenis *et al.* (1984) found a significant effect of month of kidding on milk production and lactation length in Damascus goats. Lactation milk yield is to some extent influenced by the season of kidding. For example, lactation starting early in the year will benefit from better feeding conditions, endocrine control and a fixed mating season (Gall, 1981). Furthermore, Zygoiannis (1988a) found that goats kidding in early December had a longer lactation period (28 days) than those kidding in late February. The does that kidded in late February had consistently higher milk yields during the first 16 weeks of lactation.

2.7.3 Breed and individual differences

The yield and the composition of milk secreted by the goat are ultimately determined by the animal's genetic potential for milk secretion and by the hormonal regulation of the developed mammary glands. Differences between breeds of dairy goats has been observed to effect the peak milk yield, time of peak yield and persistency (Gipson & Grossman, 1990).

Although the breed of goat has a distinct general effect on milk yield and composition, within breeds there is a wide range of yield and composition differences for milk in individual herds, and of individual animals within a breed. This is in agreement with reports by Devendra and Burns (1970), who pointed out that the yield of Indian goat breeds often show surprisingly large variations. Furthermore, it is indicated that dairy goats improve milk production when given an energy or protein supplement, but the response is limited by the milk potential of the breed (Rubino *et al.*, 1995).

2.7.4 Age of the doe

Devendra and Burns (1970) found that age of does exert a marked effect on milk production. Age is a source of variation in milk yield, which is closely related to body weight. Age accounts for 45% of the variation in body weight (Gall, 1981). Peak milk yield in the goat is attained between 4 and 8 years of age (Steine, 1975; Alderson & Pollak, 1980). Alderson and Pollak (1980) also reported that age ranked second to fat yield as a source of variation in milk yield.

Age and weight are confounded, and different opinions have been raised as to which of the two is the primary factor influencing milk yield (Gall, 1981). Rønningen (1967) and Lampeter (1970), using multiple regression analysis, compared the relative influence of body weight and age on milk yield. Rønningen (1967), concluded that variation in milk yield was mainly due to age, if body weight is static. Lampeter (1970) conversely showed that weight was the main source of variation if age was constant. These seemingly contradictory results may be explained by the different stages of lactation at which animals were weighed. Lampeter's (1970) observations were taken immediately after kidding and 5 weeks post partum, while Rønningen's (1967) does were weighed during the third to fourth month of lactation.

2.7.5 Stage of lactation

In cows milk yield rises quickly following calving to reach a peak after 4 to 8 weeks, with accompanying changes in live weight (Thomas & Rook, 1983). High energy demands necessitate a loss in live weight during the early stages of lactation. Like the dairy cow, the lactating goat is able to draw upon body reserves in early lactation to meet energy requirements when feed intake is lower than the nutrient demand (Sahlu & Goetsch, 1998). Energy derived from body reserves is utilized more efficiently than feed energy for milk production (Lu, 1987). Sahlu and Goetsch (1998) reported that the rate and extent at which a dairy goat is capable of drawing upon its body reserves to meet the energy requirements in early lactation, is critical in determining her ability to produce and sustain a high level of milk production. In the period immediately preceding parturition and lactation, to achieve highest lactation performance, it is imperative to prepare the doe for lactational demands.

Supplementary supplies of energy concentrates, even when reducing consumption of forages, generally increases the intake of dry matter and energy intake (Morand-Fehr & Sauvant, 1980). Milk production is improved by almost 20% by diets high in concentrates. Milk fat content is slightly lower, whilst protein and lactose content is higher when concentrates are provided (Kandos, 1972). At mid-lactation, reconstitution of body reserves takes priority to milk production and the maintenance of high production requires the overfeeding of energy to goats (Morand-Fehr & Sauvant, 1980). Similar results were found by Kandos (1972), indicating that during mid-lactation an increase in milk yield is accompanied by a weight gain.

2.7.6 Number of lactations

The quantity of milk produced by goats increases during successive lactations. It is well established that milk yield in goats is influenced by litter size and the number of lactations. The increase in milk yield with an

increase in number of lactations, could be as a result of the growth and development of the different body systems, especially the udder. It is however, not known to what extent this factor may influence milk production under conditions of restricted nutrient intake (Raats *et al.*, 1983). These researchers found milk yield to increase up to the 5th lactation. This trend was similar to that reported by Rønningen (1964a) and Horák and Pindak (1965) as quoted by Van Vleck and Iloeje (1978). The majority of reports suggest that maximum milk production is reached at an earlier age (Prakash *et al.*, 1971; Iloeje *et al.*, 1980). More recently Mourad (1992) reported that Alpine does reach peak milk production at the 5th lactation. Mourad (1992) stated lactational periods and milk yield of does to increase gradually with the number of lactations.

2.7.7 Lactation length

Milk yield in goats is influenced by year and season of kidding, age at first kidding and lactation length (Kantha, 1937; Amble *et al.*, 1964; Rønningen, 1964a; Rønningen & Gjedrem, 1966). Karam *et al.* (1971) furthermore observed that the duration of the lactation period had a significant effect on the total milk yield. These researchers found a correlation coefficient between the total milk yield and duration of lactation of 0.49. Working on three indigenous breeds of sheep in Turkey, Sönmez and Wassmuth (1964) found a low and positive correlation between the length of the lactation period and milk production. Prakash *et al.*, (1971) reported lactation length to account for 30.3% of the total variability in milk yield. It was further reported that lactation yield was significantly influenced by lactation length.

During thrice-daily milking in goats, milk secretion was increased in the short-term (hours or days), by removal of chemical feedback inhibitor and increased metabolic activity, and in the long-term (months) by increased cell numbers (resulting either from increased cell proliferation or from decreased cell death rate) (Henderson & Peaker, 1984; Chilliard, 1992). Wilde *et al.* (1987) reported that thrice-daily milking had no effect on the rate of lactose

synthesis in the mammary exploits, or on the activities of lactose synthases, galactosyl transfers and phosphoglucomutase (enzyme involved in lactose synthesis). However, hexokinase, which catalyses the initial activation of glucose for lactose synthesis, glycolysis and metabolism via the pentose phosphate pathway, was greater ($P < 0.05$) in the gland milked thrice daily (Henderson & Peaker, 1984). Of the two glycolytic enzymes measured, pyruvate kinase activity was not affected by thrice-daily milking, whereas lactate dehydrogenase activity was increased ($P < 0.05$). Glucose-6-phosphate dehydrogenase, a key enzyme of the pentose phosphate pathway, was also increased ($P < 0.05$) by thrice daily milking (Wilde *et al.* 1987). These researchers concluded that the local increase in milk yield on thrice daily milking was accompanied by both short- and long-term differences in enzyme activities between the twice and thrice-milkings. Furthermore it was observed that within only 10 days of the start of thrice-daily milking, there was a significant increase in the activities of the two key lipogenic enzymes, acetyl-CoA carboxyl and fatty acid synthases, and in galactosyl transfer activity in the gland receiving the extra milking.

2.7.8 Litter size

It is well established that milk yield in goats is influenced by litter size (Raats *et al.*, 1983). There are indications that mammary growth during pregnancy is regulated by the number of kids born and according to Hayden *et al.* (1979), the extent of mammary development depends on the number of placental units and on placental mass formed by lactogenic activity of placental origin. This would be a plausible effect, since milk yield would be adapted to the needs of the young to be suckled (Gall, 1981).

Ewes suckling twin lambs have been shown to produce significantly more milk than those with single lambs in sheep (Barnicoat *et al.*, 1949; Alexander & Davies, 1959; Ricordeau *et al.*, 1960). Snowden and Glimp (1991) found that from 28 to 56 days post partum, twins stimulated a 23 to 58% increase in milk yield, compared to single lambs. However, from day 70 to 98 post

partum, milk yield among ewes suckling twins was 71 to 149% higher than that from ewes suckling singletons. The effect of twins increasing late lactation milk yield (day 70 to 98 post partum) and persistence of yield, contradicts earlier reports that twins induce a greater yield at early lactation (day 14 to 42 post partum) and have little or no effect on persistency of yield, compared with the effect of single lambs (Gardner & Hogue, 1964; Treacher, 1983). This disparity may be a result of environmental circumstances or inherent differences between the populations sampled in the contradicting studies (Snowder & Glimp, 1991). Although a peak milk yield could not be determined from the data set, ewes with twins normally reach their peak yield in the 3rd week of lactation, compared to the 4th week in ewes with singles (Gibb & Treacher, 1982).

Snowder and Glimp (1991), furthermore found that the lactation curve decreased more rapidly between day 56 and 70 of lactation, declining 57 and 42% per ewe with singles and twin kids, respectively. It was indicated that the decrease in lactation during this period coincides with the fact that the lambs decrease their dependence on milk due to increased grazing and forage intake (Lyford, 1988).

The number of lambs suckled has a greater influence on milk yield, compared to the level of energy intake. Even though consuming more energy, ewes with single lambs on a higher feeding level produce less milk than ewes with twins on a lower feeding regime. No interaction was observed between the number of lambs suckled and level of feed intake on yield of milk (Gardner & Hogue, 1964). Gardner and Hogue (1964) stated that milk composition, as affected by number of lambs suckling, has not been reported in the literature. Snowder and Glimp (1991) reported a consistent difference in milk composition associated with the number of lambs, but this difference was not statistically significant. Milk fat percentage was elevated in ewes with twins, compared to those ewes with single lambs at the day of birth (9.8 versus 8.6%). Ewes with twins had higher milk fat levels and produced 38% more

milk energy than those with single lambs, but yielded only 27% more milk over a 90 day lactation period (Gardner & Hogue, 1964).

2.7.9 Body size and weight

Variation in body size within goat breeds and the effect of body size on milk production has received a lot of attention in the past (Gall, 1981). Larger does have to produce more milk than smaller does, in order to warrant their higher maintenance costs. With the high levels of milk production at the onset of lactation, does may not be able to consume sufficient energy and may have to draw on their body reserves (Morand-Fehr & De Simiane, 1977).

Feed capacity is an important breeding goal, along with milk yield. Because feed intake capacity, which is determined by physical and behavioural factors, is difficult to access directly, body size is commonly used as an indicator. Externally measured abdomen volume is closely related to rumen volume. Body size will determine the ability to consume coarse feeds, as time is needed for clearing the rumen contents by ruminations, which is again dependant on body weight (Gall, 1981).

Gall (1981) further reported that there is a positive correlation between milk yield and body weight, but body weight changes account for only 10% of the variation in milk yield. The storage of body fat during the dry periods, also influence milk production positively, at the onset of lactation. The capacity of the animal to mobilize body fat reserves is greater in animals which have been fed liberally during the dry period, and therefore have accumulated more fat. Mobilization of fatty tissue seems to begin during the last third of pregnancy (Chilliard *et al.*, 1978), and is related to the level of milk production (Chilliard *et al.*, 1979). Body weight losses of adult does at the beginning of lactation were found to be related to the milk yield during the 1st week of lactation only (Fehr & Sauvant, 1975).

2.7.10 Udder characteristics

Traditionally, the productive capacity of dairy goats, like that of other dairy animals, is judged to a large extent by the physical appearance and size of the udder (Gall, 1981). Mavrogenis *et al.* (1989) reported that in goats, udder characteristics, milk production, milking time and rate are traits with adequate genetic variation to allow selection responses. The correlation between udder perimeter and milk production was found to be 0.81 (Gall, 1980). This value is similar to the findings of Mavrogenis *et al.* (1989) and Montaldo *et al.* (1988), but higher than the value of 0.21 quoted by Mellado *et al.* (1991).

Other variables significantly correlated with milk production are teat perimeter (0.45) and udder cleft (0.31). A correlation between the volume of the milk-filled udder and quantity of milk present in the udder (0.79) has been recorded. Similarly, a positive correlation between milk yield and udder volume has been reported (Gall, 1981). According to Linzell (1966), the decline in milk yield in later lactation is due to a loss in both secretory tissues and a fall in rate of secretion per unit tissue. Furthermore, udder volume increases during pregnancy. Part of the more spectacular growth towards the end of pregnancy is due to increased lymph flow, accumulation of extra cellular fluid and oedema. Linzell (1966) concluded that there is a net increase in secretory tissue at each pregnancy. Udder volume is closely related to milk yield and can be measured directly with high accuracy in the live goat (Junge, 1963; Linzell, 1966; Gall, 1981). Prediction of milk production from external measurements of the udder can be based on udder and teat perimeter, which is in agreement with Montaldo *et al.* (1988).

2.7.11 Ambient Temperature

Milk production and its constituents are reduced in response to elevated ambient temperatures and humidity (Moore, 1966; Thomas & Rook, 1983). Lu (1987) suggested that heat stress in goats can be defined as the disruption of homeostasis by ambient temperatures greater than the animal's

upper critical temperature, resulting in heat production, primarily due to a rise in body temperature.

Although cows are efficient in dissipating the heat produced by metabolism, animals begin to suffer from heat stress at environmental temperatures above 28°C (Thomas & Rook, 1983). The yield of milk and of milk constituents, especially fat, is reduced, possibly in part through effects on the secretion of regulatory hormones, e.g. thyroxin, growth hormone and insulin (Webster, 1976).

Boer and Indigenous feral goats are known to be environmentally compatible. Such environmental compatibility occurs either by way of anatomical-physiological mechanisms, or by way of specific behavioural patterns or both (Gall, 1981). Goats are better adapted to hot than cold environments, because of their small size, large surface area to body weight ratio, ability to conserve water, the limited subcutaneous fat cover and the particular nature of their coats. Hence, adaptability has a direct bearing on milk production. Goats however, are able to provide sufficient milk for their kids and for the owners in all climatic regions of Southern Africa, which includes a Mediterranean climate, tropical and sub-tropical bush and semi-desert regions of the Karoo and greater Kalahari (Shkolnik & Choshniak, 1985).

Cold stress has a direct bearing on the production of animals, which do not adapt. Thompson and Thompson (1977) indicated that when lactating goats are exposed to cold, milk secretion is reduced - which could be as a result of reduced blood flow to the udder. Thomas and Rook (1983) furthermore reported that at -0.5°C , mammary glucose uptake, lactose secretion and milk yield was only 30% of the values at a thermo-neutral temperature (20°C). These changes seem to be the main reason responsible for lower milk secretion.

2.8 MILK COMPOSITION

A fair amount of work has been carried out in different countries on the composition of goat milk. The composition and characteristics of goat milk from different breeds and countries have been reported by many authors (Haenlein, 1980; Jenness, 1980). Most reports on the composition of goat milk give the analysis from a single goat or a small number of animals (Mba *et al.*, 1975; Storry *et al.*, 1983; Merin *et al.*, 1988).

Widely differing values for milk composition in Indian goats have been attributed to age (Mittal, 1979), breed, season, stage of lactation (Agrawal & Bhattacharyya, 1978; Kala & Prakash, 1990; Singh & Sengar, 1990) and plane of nutrition (Sachdeva *et al.*, 1974; Singhal & Mudgal, 1985). However, Snowden and Glimp (1991) reported milk composition not to differ among breeds. Consistent differences in milk composition were associated with the number of kids, but these differences were not significant.

2.8.1 Effect of diet on milk composition

Physio-chemical characteristics of a diet can cause changes in the composition of milk produced. These are caused by changes in the fermentation pattern in the rumen. The pattern of ruminal fermentation depends essentially on the amount and quality of fibre fraction in the diet. Concentrates rich in readily fermentable carbohydrates, a decrease in the forage to concentrate ratio of the diet and a decrease in particle size of the fibre tend to reduce the proportion of acetic acid produced and hence a reduction of butter fat percentage in milk (Sutton, 1976).

Similar decreases in milk production were not observed when goats are fed diets similar to those of cows. Morand-Fehr *et al.* (1991) reported that goats appear to be less sensitive than cows to a deficiency in dietary fibre as long as the forage to concentrate ratio of the diet is greater than 20:80. The energy balance of the animal is more important in the determination of milk

fat content, compared to the relative proportion of these two constituents (Sauvant *et al.*, 1987). Similarly, Giger *et al.* (1987) working on the same species, found that by varying the nature of the dietary concentrates, no difference in the protein and fat content of milk could be recorded. It was concluded that, in goats, energy balance is the factor most important in the determination of milk fat and protein content.

Morand-Fehr *et al.* (1991) reported that the physio-chemical characteristics of the diet normally have an indirect effect on the composition of goat milk produced by modifying the energy intake that would normally take place. Other researchers have indicated that milk production and composition are more dependent on the energy balance of the animal than on the composition of the diet (Giger, 1987; Sauvant *et al.*, 1987). Changes in the physical form of dietary fibre can lead to changes in milk composition (Murphy, 1995). When the source of dietary fibre are pelleted, the fat content tend to be higher, because of the ruminal fermentation time being reduced (Rook, 1976).

2.9 NUTRIENT PARTITIONING DURING LACTOGENESIS

The uptake of nutrients by the mammary gland during lactogenesis is very important. The period of lactation in which the animal's ability to co-ordinate the partitioning of nutrients assumes the most critical role is during the onset and development of copious milk secretion. At the initiation of lactation, marked alterations in the general partitioning of nutrients and metabolism of the whole animal must occur to accommodate the demand of the mammary gland. As indicated by other research workers, maternal tissues adapt to meet fetal needs during pregnancy, but these adaptations become even more pronounced in support of lactation. The nutrient needs of the mammary gland are of such magnitude relative to the total metabolism in a high producing dairy cow, that the cow should be considered an appendage on the udder rather than the reverse (Brown, 1969).

The uptake of nutrients for the synthesis of storage lipids is decreased during the initiation of lactation, and lipid-reserves are mobilized instead. Another key nutrient is glucose, and the maximally secreting mammary gland requires up to 80% of the glucose turnover. A co-ordinated response meets these needs and the rate of gluconeogenesis in the liver is increased dramatically. A portion of increase in liver gluconeogenic rates is from the intake, when lactation commences (Lindsay, 1971), but the total glucose synthesized per day increases even if a constant intake is maintained (Bennink *et al.*, 1972). The preference of other body tissues for nutrients to be oxidized for energy is also altered to allow partitioning of a greater percentage of the glucose to the mammary gland.

Nitrogen balance studies have demonstrated the importance of protein reserves in meeting amino acid demands for milk protein and glucose synthesis in early lactation. These reserves are substantial and may comprise 25 to 27% of the total body protein in a dairy cow. Mineral metabolism is another area with extensive changes at the onset of lactation. Deluca and Schnoes (1976) reviewed the system by which calcium metabolism is regulated via Vitamin D. The mechanism involves the liver, which converts Vitamin D₃ to 25-hydroxy-Vitamin D and stimulates intestinal calcium transport, mobilization of calcium from the bone, and renal reabsorption of calcium for lactogenesis. They concluded that the regulation of nutrient partitioning by homeorhetic and homeostatic mechanisms is extremely important in ensuring a high rate of milk production.

2.10 REGULATION OF NUTRIENT PARTITIONING

Both exogenous and endogenous nutrients are used by the mammary gland. Nutrients are more readily available during lactation because of increased endogenous nutrient mobilization. The liver plays an important role in glucose production. Adipose tissue (muscles) can release or take up fatty (amino) acids, glucose and acetate. The mineral metabolism in the bones and the gut, is also involved (Chilliard, 1992).

During lactation, the mammary metabolism is stimulated by galactopoietic hormones, among which somatotropin (BST) plays a central role. BST is also involved in the co-ordination of extra mammary metabolism in order to ensure the priority of the mammary gland for nutrients (Bauman & Currie, 1980). Treatment with BST rapidly increases milk yield, but feed intake response is delayed for 6 – 8 weeks. During this period body reserves are mobilised, but can be deposited again after several months of BST treatment in an adequately fed cow (Chilliard, 1988).

The primary effect of BST is to stimulate the mammary gland, probably via stimulation of somatomedin production. BST also decreases glucose and amino acid oxidation at the expense of adipose tissue long-chain fatty acids, and stimulates liver glucogenesis. Part of this adaptation is due to BST counteracting the insulin effects in various tissues. Lowered somatomedin secretion is partly responsible for "BST resistance" in underfed animals (Gluckman *et al.*, 1987). Insulin secretion and tissue response to insulin decrease in early lactating animals, whereas glucagon secretion is maintained or increased. This favours liver glucose production and adipose tissue mobilization and decreases glucose and amino acid utilization in adipose tissues and muscles, but not in the mammary gland (Chilliard, 1987). Thyroid hormone levels also lower during early lactation, possibly decreasing basal energy expenditure and protein turn-over (Aceves *et al.*, 1985). The respective effects of teleophoretic hormones such as BST and of the mammary drain nutrients in metabolic and endocrine adaptations to lactation are not completely understood (Chilliard, 1992).

2.11 EFFECT OF BODY CONDITION ON MILK PRODUCTION

Body condition scoring allows the assessment of subcutaneous fat deposition variations by palpating the tail, head and the loin area (Zygoiannis & Katsaounis, 1986). In the cow, body condition at calving is the result of body reserve mobilization and energy deposition cycles during the life cycle of the

dam, and more particularly during the previous lactation and dry periods (Chilliard, 1992). Broster and Thomas (1981) reported that by increasing the level of feeding before calving, the subsequent milk yield generally increases. This could be due to short-term effects, linked to better mammogenesis and lactogenesis during the last weeks of pregnancy and the first days of lactation or to better digestive adaptation. Furthermore, Chilliard (1992) reported that in a well-fed cow, body condition at calving has little effect on milk production. Fat cows generally have lower voluntary feed intake, but produce the same amount of milk, due to body lipid mobilization.

2.12 CONCLUSION

The demand for energy and animal protein among rural communities in South Africa is increasing on a daily basis. The economic situation has resulted in many rural people having no income to purchase nutrients. Attempts by government to supply these people with food have proved costly. However, the use of indigenous animals for production of energy and protein for human consumption in the form of milk and meat, has given people new hope. It is within this spectrum that goat milk has evoked the interest of many producers and researchers in the world and in Africa, in particular. Boer and Indigenous feral goats in South Africa were not originally bred for milk production, but could be utilized in the rural communities of South Africa to provide milk for families and in particular children. Hence, the object of this study was to determine the milk production potential of these breeds, under intensive and extensive feeding regimes, in helping to alleviate the animal protein shortage in human nutrition as currently experienced in South Africa.

CHAPTER 3

MATERIAL AND METHODS

3.1 LOCATION

This study was conducted at two different locations. An extensive and intensive group of animals were kept at Paradys experimental farm (UOFS) and the Small stock building on campus of the University of the Orange Free State, respectively. The experimental farm is situated approximately 20 km south of Bloemfontein. It is located at a latitude of 28.34° south, longitude of 25.89° east and an altitude of 1412 m above sea level. The small stock facility is situated west of the Faculty of Agriculture building on the main campus (Bloemfontein). This location is at 1422 m above sea level. The mean ambient temperature range is -7.4°C to 35.8°C. The relative humidity varies between 40 and 90%, whilst the mean annual rainfall varies between 500 and 550 mm and occurs predominantly during the summer months of December to April.

3.2 ANIMALS

Thirty six multi-parous does were available for this study. These animals were divided into four groups i.e. 18 (2x9) Boer goat does and 18 (2x9) Indigenous feral goat does. Two groups were subjected to an intensive feeding (high energy) regime and the other groups were subjected to an extensive natural feeding (low energy) regime. These groups were randomly allocated according to breed, into equal numbers of animals i.e. 9 Boer goat does and 9 Indigenous goat does in each feeding regime (Table 3.1).

3.3 ADAPTATION PERIOD

All the animals in the intensively fed (high energy) group were subjected to the particular diet prior to the observation period. The animals were adapted to the diet for two weeks prior to collection period. During the experimental period, clean fresh water was always available ad lib.

Table 3.1 Experimental design

Treatment	Boer goat does	Indigenous goat does	Total
Intensive (Treatment 1)	9	9	18
Extensive (Treatment 2)	9	9	18
Total	18	18	36

Treatment 1 = 2000g lamb, ram and ewe pellets/day

Treatment 2 = Natural pasture ad lib

3.4 HOUSING

The intensive group was housed in individual pens in a well ventilated shed throughout the experimental period, whilst the extensive group was maintained on natural pastures for the entire experimental period.

3.5 FEEDING REGIMES

The intensive group was fed a lamb, ram and ewe pelleted diet from Senwesko Feeds, Ltd. (Table 3.2) and each animal received 2000g/day. The intake was recorded daily by subtracting the weight of individual feed refusals from the total amount of feed offered to the individual animal. The extensive group was allowed to graze on natural pasture ad lib. The pasture consisted of 80% red grass (*Themeda triandra*), 15% of species finger grass (*Digitaria eriantha*), weeping love grass (*Eragrostis* species) and drop seed grass (*Sporobolus fimbriatus*) and 5% of other minor species. In this group feed intake could not be measured. Water was freely available to all the animals.

3.6 BLOOD SAMPLING

Blood samples were collected weekly from 5 animals per breed in the intensive and extensive groups (Thursdays and Fridays, respectively). These samples were taken by jugular vein puncture using an 18-gauge needle attached to a 7 ml vacutainer blood collecting tube. Serum was recovered by centrifuging the blood for 15 minutes at 2500 r.p.m. The serum

was then separated and stored at - 20°C until assayed for serum progesterone concentration.

Table 3.2 Chemical composition of the feed (lamb, ram and ewe pellets) as specified by Senwesko Feeds (Pty.) Ltd.

Nutrient	Lamb, ram and ewe pellets Reg. No. V1482 (Act 86/1947)	
	Min g/kg	Max g/kg
Total protein	130	(34.92%)
Urea	-	10
% of total protein derived from urea		
Moisture	-	120
Fibre	-	150
Fat	25	-
NH ₄ Cl	10	10
Calcium	10	15
Phosphorus	3	-

3.7 SERUM PROGESTERONE ASSAY

The progesterone concentration was determined using a Gamma Coat TM [¹²⁵I] progesterone radioimmunoassay kit (Sorin Diagnostics, France). The Gamma Coat progesterone kit procedure for progesterone determinations followed the basic principle of radioimmunoassay - whereby there is competition between a radioactive and non-radioactive antigen for a fixed number of antibody binding sites. The amount of [¹²⁵I]-labelled progesterone bound to the antibody on the plastic coated tube is inversely proportional to the concentration of progesterone present in the serum.

The assay procedure used involved the preparation of a standard curve in order to interpolate the unknown progesterone content of the sample. All the reagents were allowed to reach ambient temperature, after which they were

mixed thoroughly by gentle inversion, without foaming before use. The anti-progesterone coated tubes (CA-2162) were labelled according to the following sequence: T₁, T₂ for tracer, A, B, C, D, E, F for progesterone serum standards with 0, 0.3, 2, 5, 20, 60 ng/ml, respectively. This was followed by the labelling of two progesterone serum controls i.e. level 1 to 12 - which was then followed by the labelling of the unknown serum tubes according to animal numbers. 100 µl of the progesterone serum blank (A), end progesterone serum standards (B-F, respectively) were added to the appropriate duplicate tubes. Followed by the addition of 100 µl of each serum sample to the appropriate treatment serum tubes. 500 µl of [¹²⁵I] progesterone tracer (CA-2651) was added to each tube, followed by shaking to mix the contents. All the tubes were incubated in a water bath at 37 ± 2°C for 60-70 minutes, after which all the tubes were decanted. To remove any adhering liquid before placing the tubes upright, the tubes were dried on absorbent paper. All the tubes were then placed in the Gamma Counting System i.e. RIASTARTM QC, model 5410 (Packard).

In each of the five kits used, the intra-assay coefficient of variation was determined from the mean of 16 assays per sample. The inter-assay coefficient of variation was determined from the mean of the replication for 14 separate assays. The analysis was performed at the Endocrinology Laboratory at the University of the Orange Free State hospital (Universitas). The sensitivity of the assay was 0.11 ng ml.

3.8 PARAMETERS MEASURED

3.8.1 Milk recording

Milk yield was measured twice a week for each group, from within one week following parturition until the 100th day of lactation. Prior to the first milking the kids were separated from the dams for a two-hour period (06h00). Before the commencement of the first milking the kids were allowed to suckle the dams ad lib for 45 minutes, after which they were separated from the

dams. Immediately after the kids were separated, the first milking commenced. Each doe was injected with 1 ml oxytocin (Fentocin) intramuscularly, 5 minutes before milking. Thereafter, hand milking was performed in order to empty the udder. The second milking was done after an interval of two hours. Once again, after an injection of the oxytocin (1 ml). During this second milking period, each teat's milk output was measured individually and this milk output was used to measure the milk production of each doe. The total milk yield for the milking was calculated by adding the output of the two teats. The output of the left and right teat were recorded as MPL and MPR, respectively, whilst the total milk yield was recorded as TOTLR. Milk production after a 2-hour period was extrapolated to 24 hours, to give the daily milk production.

3.8.2 Milk Analysis

Milk samples from Tuesday and Friday milkings in the extensive group and those from Monday and Thursday milkings (intensive group) were stored in a refrigerator at 4°C until analyzed. The milk samples were analyzed for milk fat, protein, lactose and solid non-fat using a Milko-scan 103: "F.P.L.", apparatus model 102, "F.P". A beaker filled with 200 ml deionized water (40°C), was placed in the apparatus, under the pipette. It was activated with the beaker. All the components measured were displayed. A note of each milk component, fat (F), protein (P), lactose (L) and solid non-fat (SNF) was made. The activation and a full measurement cycle were repeated three times and the average for each component calculated. This analysis was carried out at Dairybelle in Bloemfontein, 10 km from the University of the Orange Free State.

3.8.3 Teat measurements

Prior the commencement of each milking, the teat measurements were recorded (the teat volume, length and width) for both left and right teat with the aid of a caliper (Plate 3.4). The teat volume was measured (ml) by displacement of water. This was done by inserting the teat into a glass

beaker filled with water (37°C). The water displaced, was recovered and measured and registered as the volume of the teat.

3.8.4 Body weights

All does and their kids were weighed (kg) weekly throughout the experimental period. These bodyweight measurements were recorded on Monday and Tuesday mornings before nursing for the intensive and extensive groups, respectively.

3.8.5 Daily feed intake

The daily feed intake was measured only for does fed intensively. The extensive group, maintained on natural pastures, was offered no supplements (3.5). All the does in the intensively fed group were individually fed 2 kg/day lamb, ram and ewe pelleted diet during the lactation period (Table 3.2), regardless of their intake, milk production and litter size (3 and 2 twins for Boer and Indigenous goat does, respectively, 6 and 7 singles for the Boer and Indigenous goat does, respectively). Feeding was done between 6h30 – 7h30 every day, whilst the diet refusals for each doe was collected prior to daily feeding (6h00). The daily feed intake for each doe was determined by subtracting the weight of individual feed refusal from the total amount of feed offered to the individual. The daily feed intake was recorded for each individual animal throughout the experimental period. Kids were weaned from their dams at 90 days old.

3.8.6 Statistical analysis

The mean daily milk production, feed intake, doe live weight, kid live weight, teat measurements as well as percentage protein, fat, solid non-fat and lactose in the milk were analyzed using the one way ANOVA with treatments in a 2 x 2 factorial design. Data analysis was carried out using the General Linear Models Procedures of the Statistical Analysis Systems Institute (SAS, 1991).



Plate 3.1 Boer and Indigenous goat does used in the extensive feeding regime

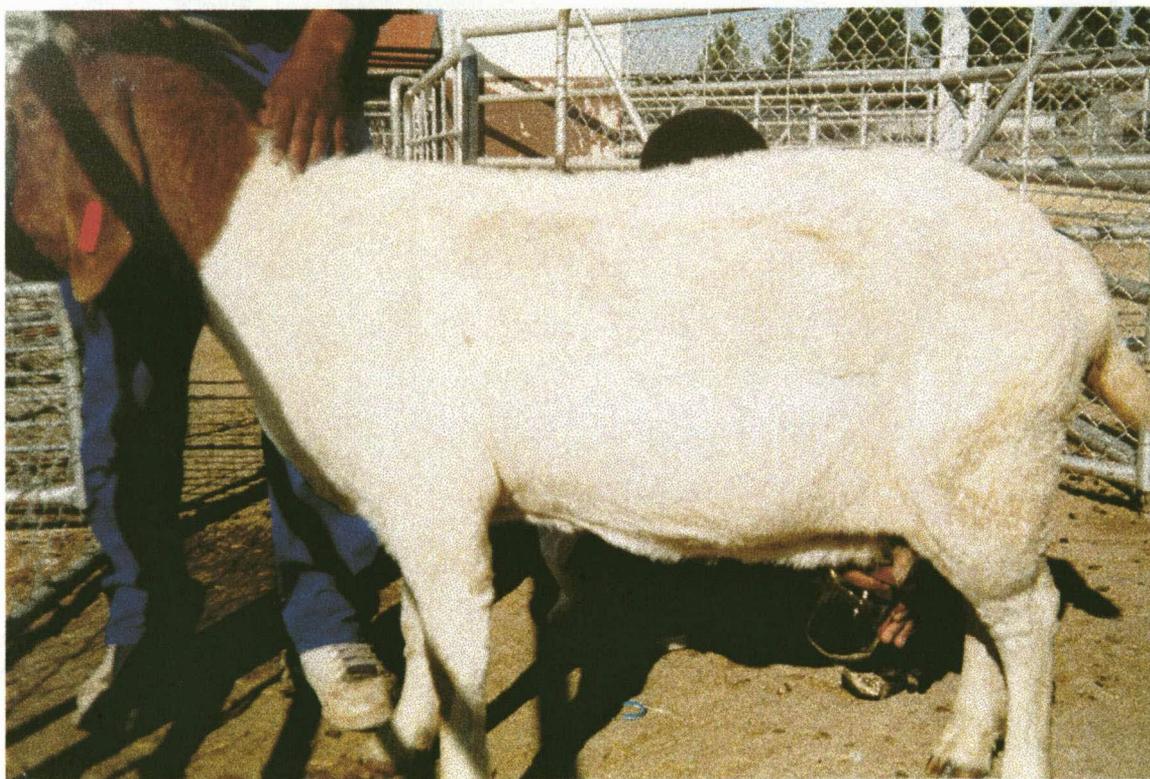


Plate 3.2 Milk production recording of Boer goat in the extensive feeding regime

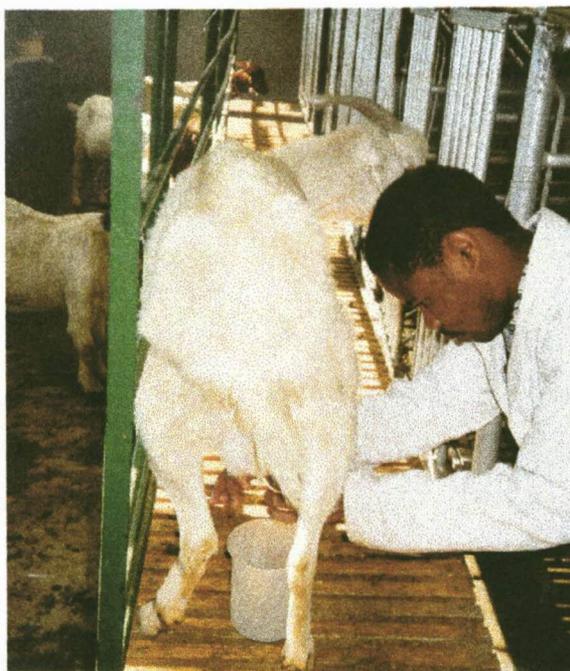


Plate 3.3 Milk production recording of Indigenous goats in the intensive feeding regime

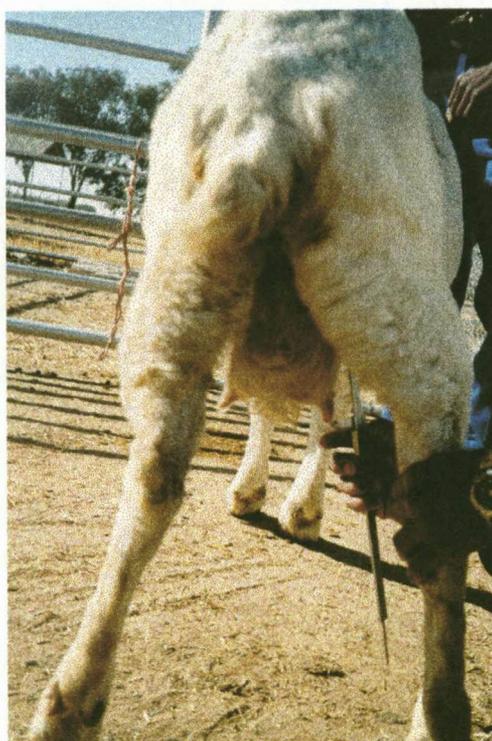


Plate 3.4 Teat measurements with the aid of a caliper in the extensive feeding regime

CHAPTER 4

RESULTS

4.1 MILK PRODUCTION

Table 4.1 summarises the mean daily milk yield (\pm SD) for all the groups for the 12 week period. Figure 4.1 illustrates graphically the mean milk production per week for all the treatment groups throughout the observation period. The intensively fed Boer goat does produced the maximum milk production (mean 3.7 ± 1.4 l/day) during Week 4, whilst the extensively managed Boer goat does produced their maximum milk yield (mean 1.1 ± 0.7 l/day) at Week 8 (Figure 4.2). The intensively fed Indigenous goat does produced their highest and lowest milk yield (mean 1.9 ± 7.0 l/day and mean 1.1 ± 7.1 l/day, respectively) during Weeks 5 and 11. The Indigenous goat does in the extensively managed environment produced their maximum volume of milk (0.8 ± 2.0 l/day) during Week 9 (Figure 4.3). Nutritional feeding regime significantly ($P < 0.05$) influenced the milk production, with the intensively fed animals producing more milk. The Boer goat also produced significantly ($P < 0.05$) more milk than the Indigenous goat under the same managerial environment.

Milk production over the observation period showed a 20% and 13% increase for the Boer goat does under the intensive and extensive management systems, respectively. The Indigenous does showed a 6.5% increase and an 11.9% decrease in milk production for the intensive and extensive groups, respectively (Table 4.1). The Boer goat does in the intensively managed nutritional group produced more milk than the Indigenous goat does managed under the same nutritional management system. Similarly, the Boer goat does (extensive group) yielded more milk from Week 3 to Week 8 and Week 10 to Week 12 than the Indigenous goat does managed under the same nutritional management. The intensively managed does produced more ($P < 0.05$) milk than those kept on the extensive nutritional management

system. Milk production fluctuated in all groups regardless of the breed and nutritional management as can be seen in the large standard deviation (Table 4.1).

Table 4.1 The mean milk production (l/day) for Boer and Indigenous goat does under different nutritional management systems

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	2.18	1.72	0.66	1.27	1.34	0.11	0.52	0.12
2	3.04	0.51	0.63	1.69	1.33	0.62	0.67	0.58
3	2.99	1.57	0.73	0.20	1.38	2.49	0.62	0.64
4	3.66	1.42	0.67	0.35	1.21	3.03	0.57	0.82
5	3.63	1.56	0.52	0.44	1.87	7.04	0.42	0.29
6	3.15	1.26	0.72	0.50	1.51	6.58	0.62	0.31
7	3.11	2.40	1.07	0.68	1.55	4.87	0.65	0.25
8	3.65	1.69	1.15	0.68	1.64	0.09	0.66	0.09
9	3.20	1.21	0.55	0.46	1.69	7.50	0.84	2.01
10	2.77	1.54	1.13	0.83	1.77	5.46	0.56	0.95
11	3.16	1.20	1.09	0.55	1.12	7.12	0.40	0.08
12	2.47	0.97	0.79	0.84	1.43	5.83	0.46	0.12

SD Standard deviation

4.2 MILK COMPOSITION

4.2.1 Fat content of goat milk

The mean milk fat content of does during the observation period is set out in Table 4.2 and illustrated in Figure 4.4 to 4.6.

The intensively managed does had a maximum milk fat yield ($8.79 \pm 2.58\%$ and $8.86 \pm 3.68\%$) in Week 1 and 8 for Boer and Indigenous does, respectively. The extensive group showed a maximum milk fat yield ($8.16 \pm 1.85\%$, $7.48 \pm 4.52\%$) in Weeks 1 and 5 for Boer and Indigenous goat does,

respectively. The intensively managed breeds produced the least milk fat ($4.76 \pm 1.8\%$ and $5.93 \pm 1.55\%$) in Weeks 6 and 1 for the Boer and Indigenous breeds, respectively), whilst the extensively fed breeds produced the least ($5.14 \pm 0.96\%$ and $5.16 \pm 1.0\%$) in Weeks 9 and 8 for the Boer and Indigenous goats, respectively. The intensively managed Indigenous does produced the highest mean overall milk fat ($7.47 \pm 3.23\%$) for the entire observation period, compared to all the treatment groups (Table 4.2). The extensively managed Boer goat group ($6.39 \pm 2.08\%$) was second regarding milk fat content. The interaction between feed and breed had a significant ($P < 0.01$) effect on milk fat, with Indigenous goat does managed intensively yielding more milk fat than the Boer goat does in an intensive nutritional system. In the extensive system, the Boer goat does produced more milk fat than the Indigenous goat does. An overall correlation coefficient (r) of 0.073 was observed between milk yield and milk fat.

Table 4.2 The mean fat (%) for Boer and Indigenous goat does under different nutritional management systems

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	8.79	2.58	8.16	1.85	5.93	1.55	6.80	1.83
2	6.91	2.29	6.72	2.25	6.78	2.66	6.60	1.51
3	6.33	1.93	5.91	1.64	6.78	3.03	6.22	1.51
4	6.85	3.17	6.47	1.96	7.18	3.35	6.42	1.61
5	6.00	1.98	7.23	2.98	7.96	3.34	7.48	4.52
6	4.76	1.80	6.19	1.77	8.81	3.81	5.36	1.57
7	5.11	1.05	5.89	1.51	8.11	3.92	5.56	0.97
8	5.25	0.99	6.16	1.64	8.86	3.68	5.16	1.00
9	6.48	2.11	5.14	0.96	6.16	1.17	5.95	0.43
10	5.34	0.66	6.95	2.47	6.80	3.45	5.29	1.21
11	5.87	2.52	5.51	1.41	6.93	2.35	5.98	2.38
12	6.37	2.82	5.41	2.00	7.72	3.44	5.60	1.83

SD Standard deviation

Figure 4.1 Mean milk production (l/day) for Boer and Indigenous goat does in intensive and extensive feeding regimes

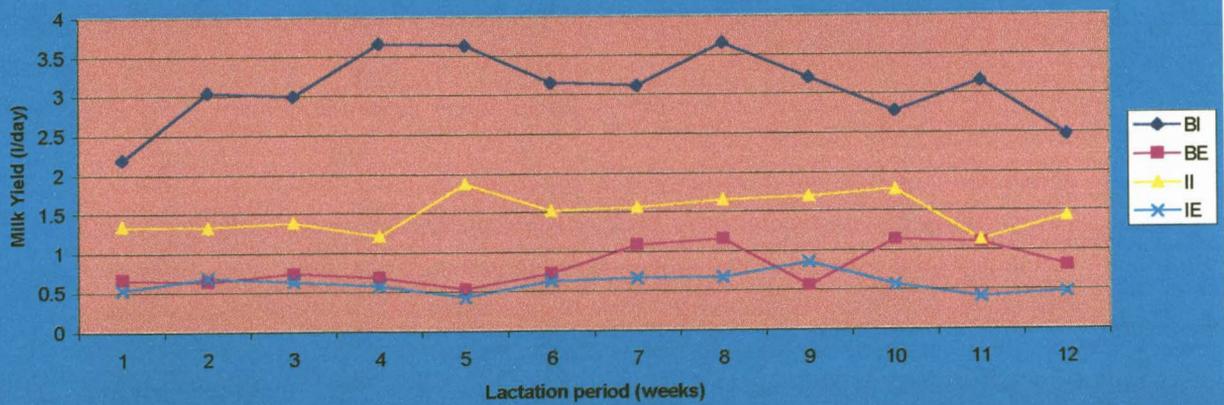
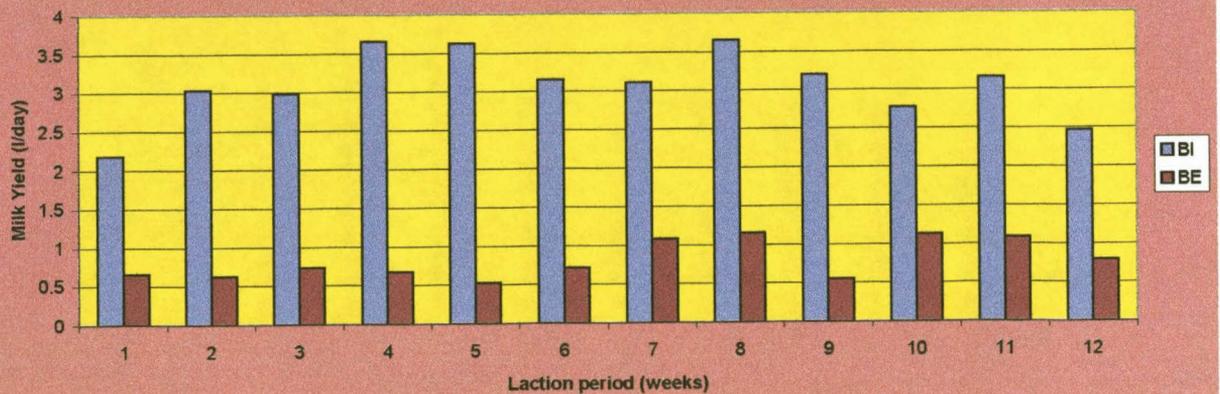


Figure 4.2 Mean milk production (l/day) for Boer goat does in the intensive and extensive feeding systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

Figure 4.3 Mean milk production (l/day) for Indigenous does in intensive and extensive feeding regimes

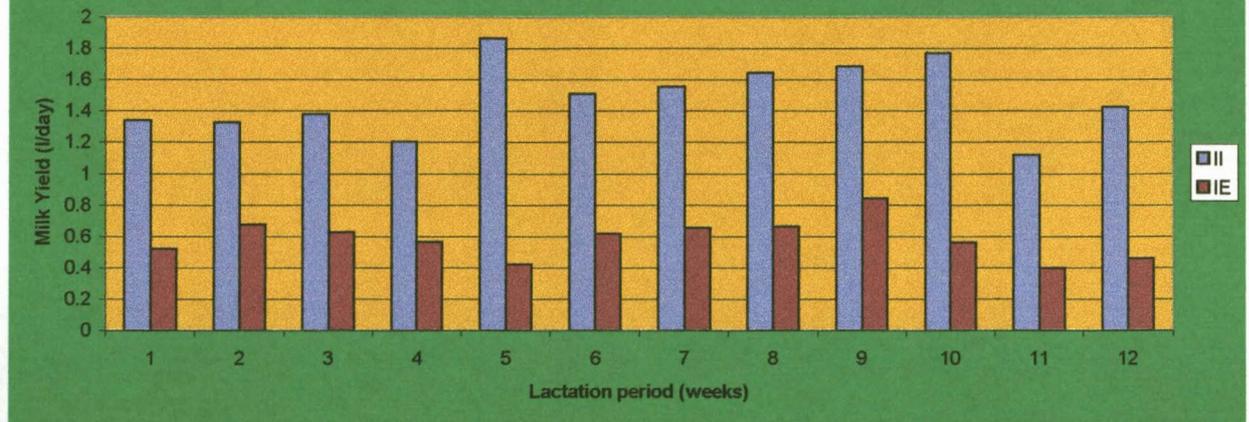
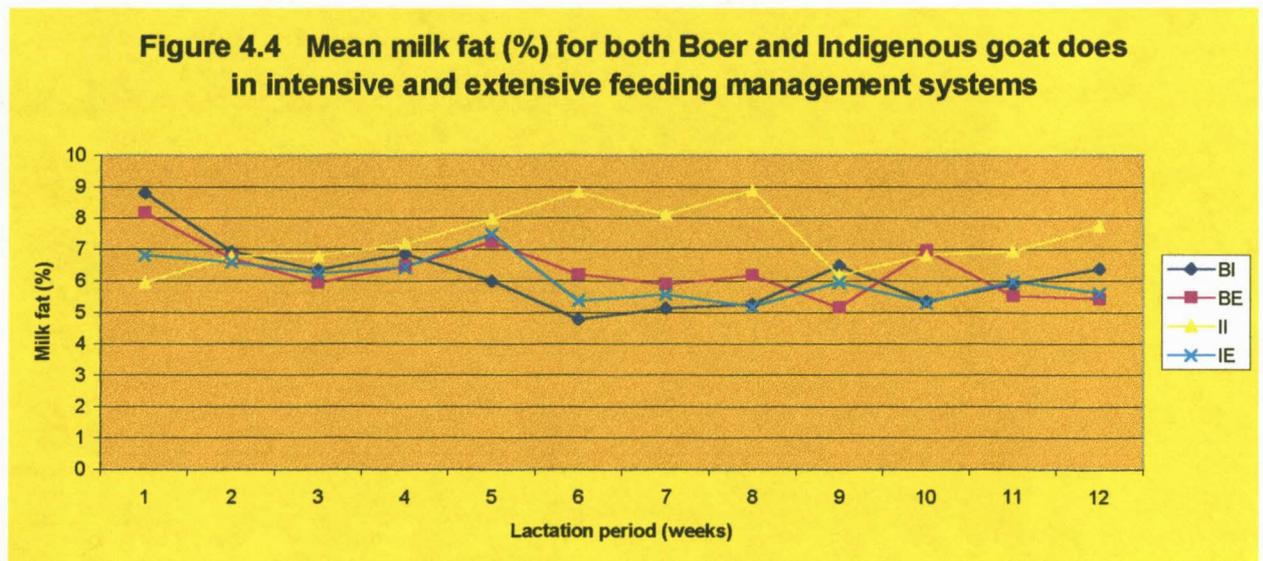


Figure 4.4 Mean milk fat (%) for both Boer and Indigenous goat does in intensive and extensive feeding management systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

Figure 4.5 Mean milk fat (%) for Boer goat does in the intensive and extensive feeding management systems

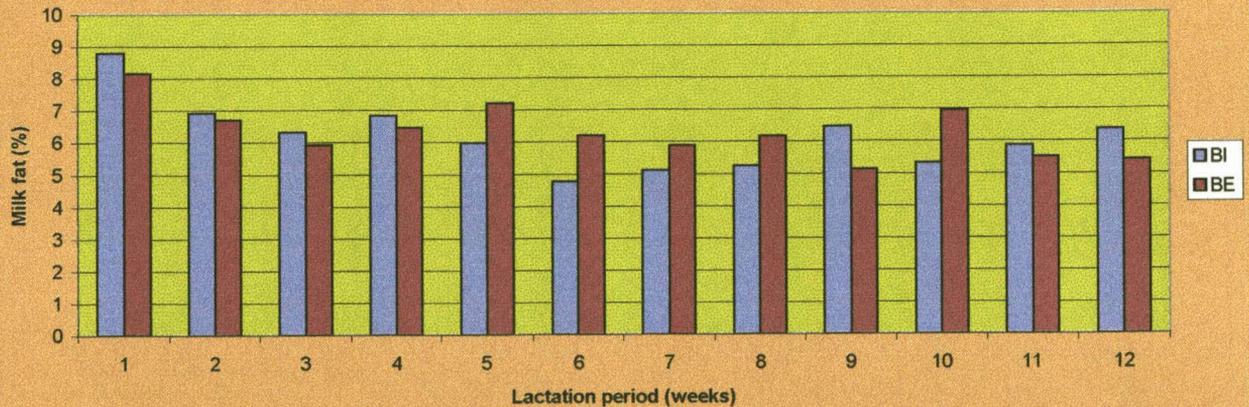
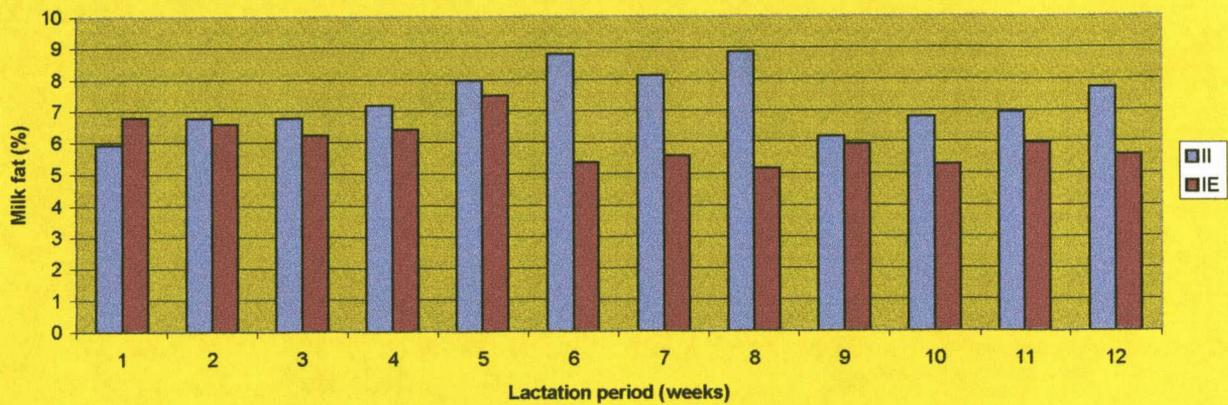


Figure 4.6 Mean fat (%) for Indigenous goat does in the intensive and extensive feeding management systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

4.2.2 Lactose content of goat milk

Mean milk lactose content (%) of both breeds under the different nutritional regimes is set out in Table 4.3. These results are depicted graphically in Figure 4.7, whilst Figure 4.8 and 4.9 illustrate the differences of the breeds which are managed under different environments.

Table 4.3 The mean lactose (%) for Boer and Indigenous goat does under different nutritional management systems

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	4.73	0.47	4.78	1.26	4.93	0.47	4.73	0.37
2	5.13	0.35	4.60	0.38	4.91	0.49	4.69	0.38
3	5.10	0.25	4.74	0.26	4.80	0.31	4.64	0.25
4	5.10	0.52	4.50	0.44	4.61	0.70	4.55	0.22
5	5.27	1.05	4.27	0.56	4.43	0.66	4.32	0.51
6	5.11	0.29	4.37	0.31	4.37	0.79	4.49	0.20
7	4.95	0.38	4.48	0.45	4.41	0.72	4.57	0.30
8	4.90	0.32	4.50	0.53	4.04	0.85	4.45	0.27
9	4.91	0.34	4.43	0.45	3.50	1.02	4.34	0.43
10	4.91	0.24	4.48	0.68	3.79	1.18	4.59	0.32
11	4.89	0.92	4.30	0.53	3.90	1.45	4.36	0.37
12	4.92	1.58	4.27	0.50	3.37	1.09	4.42	0.31

SD Standard deviation

Boer goats in the intensive feeding system yielded a maximum of $5.27 \pm 1.05\%$ lactose in week 5, whilst a maximum of $4.78 \pm 1.26\%$, $4.93 \pm 0.47\%$ and $4.73 \pm 0.37\%$ mean lactose content for Boer goat (extensive) and Indigenous goats (intensive and extensive, respectively) were recorded in Week 1. The minimum mean lactose content ($4.27 \pm 0.56\%$ and $4.32 \pm 0.51\%$) for Boer and Indigenous goat does under extensive conditions were attained in Week 5. In the intensively managed goats, the lowest levels were attained a week after one another (Week 11 and 12) for the Boer and Indigenous does, respectively. The Boer goat does in the intensive feeding

regime recorded the highest mean daily milk lactose content ($4.97 \pm 0.68\%$), compared to the other treatment groups. The feeding regime was found to have a significant ($P < 0.01$) effect on the lactose yield, with the intensively fed animals recording a higher lactose content in the milk. The Boer goat does generally yielded a higher lactose percentage than the Indigenous goat does in the respective nutritional management systems. Consequently, Boer goat does showed a trend of producing a higher milk lactose content throughout the trial. A correlation coefficient of $r = 0.103$ was found between lactose content and the mean daily milk yield for the entire experiment.

4.2.3 Protein content in goat milk

The mean milk protein content (%) per week for Boer and Indigenous goat does under different nutritional management systems is set out in Table 4.4. The difference in protein content between the breeds under the same nutritional regime is illustrated in Figures 4.10 and 4.11.

Boer goat does fed intensively yielded a maximum and minimum mean milk protein content (%) in Weeks 1 and 7, respectively, whilst the same breed under extensive feeding, yielded a maximum and minimum protein content at Weeks 11 and 6, respectively (Table 4.4). The intensively fed Indigenous goat protein yield was highest and lowest in Weeks 10 and 3, respectively. The extensively fed Indigenous goats produced maximum and minimum milk protein % in Weeks 11 and 4, respectively. The Boer goat extensive group yielded the highest mean daily milk protein % ($5.03 \pm 2.96\%$), compared to the other groups. The Indigenous goats in the intensive group produced the second highest mean daily milk protein % ($4.95 \pm 1.96\%$). Feed had a significant ($P < 0.01$) effect on the milk protein content in the Indigenous goat does, with the intensive group having a higher milk protein content than the extensive group. The extensive fed Boer goat does yielded higher milk protein content than the intensive group. The production of protein varied throughout the trial, with one breed exceeding the other at particular stages of lactation and the other breed showing the same trend at other stages of

lactation. A correlation coefficient of $r = 0.125$ was recorded between milk protein content and the mean daily milk yield.

Table 4.4 The mean milk protein content (%) for Boer and Indigenous goat does under different feeding regimes

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	5.56	1.61	5.18	2.10	4.32	1.56	5.01	2.35
2	4.03	0.47	3.93	0.77	4.01	0.87	4.12	0.91
3	4.30	0.61	4.16	0.79	3.75	0.70	4.43	1.05
4	4.16	0.49	3.70	0.71	4.12	0.96	3.81	0.65
5	3.92	0.83	3.82	0.43	3.75	0.46	3.81	0.46
6	3.85	0.70	3.65	0.53	4.95	3.01	5.28	6.95
7	3.78	0.74	6.02	4.47	4.56	1.16	4.32	1.88
8	3.98	0.69	4.65	2.18	4.88	1.66	4.38	2.04
9	3.95	0.68	5.39	3.48	5.86	2.64	4.51	1.89
10	4.10	0.66	5.94	4.02	6.40	2.35	4.46	2.25
11	4.25	0.61	7.21	4.91	5.42	1.99	5.61	3.84
12	4.91	1.25	5.97	2.92	5.98	1.74	4.91	2.07

SD Standard deviation

4.2.4 The solid non-fat (SNF) content of goat milk

Table 4.5 sets out the mean milk SNF content (%) throughout the lactation observation period. These values for the different breeds and nutritional regimes are graphically illustrated in Figure 4.12.

The intensively fed Boer and Indigenous goats showed a peak mean milk SNF content in Weeks 1 and 10, respectively, whilst the extensively fed animals reached their maximum values in week 11 and 6 for Boer and Indigenous goat does, respectively. The minimum mean milk SNF content was observed in Weeks 2, 3 and 11 for Boer and Indigenous goat does in intensive and extensive feeding systems, respectively (Table 4.5).

Figure 4.7 Mean milk lactose content (%) for Boer and Indigenous goat does in intensive and extensive feeding systems

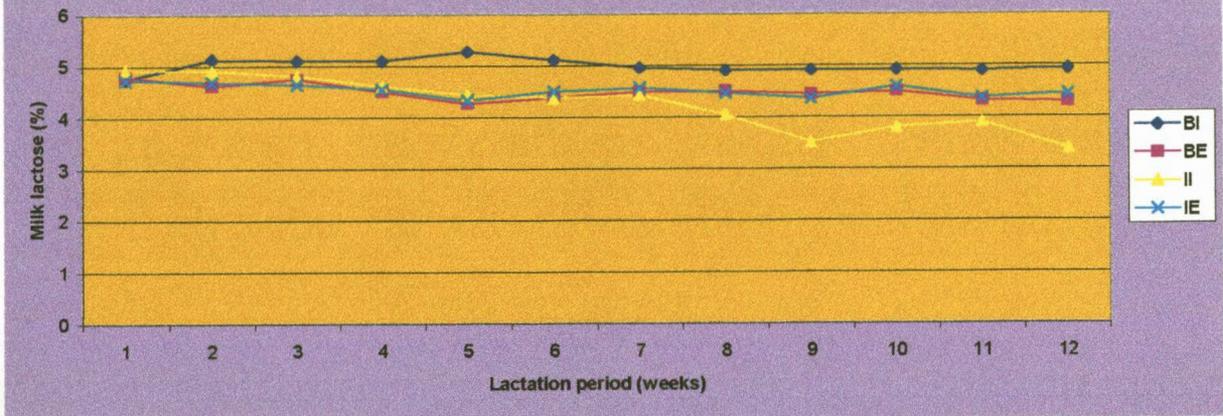
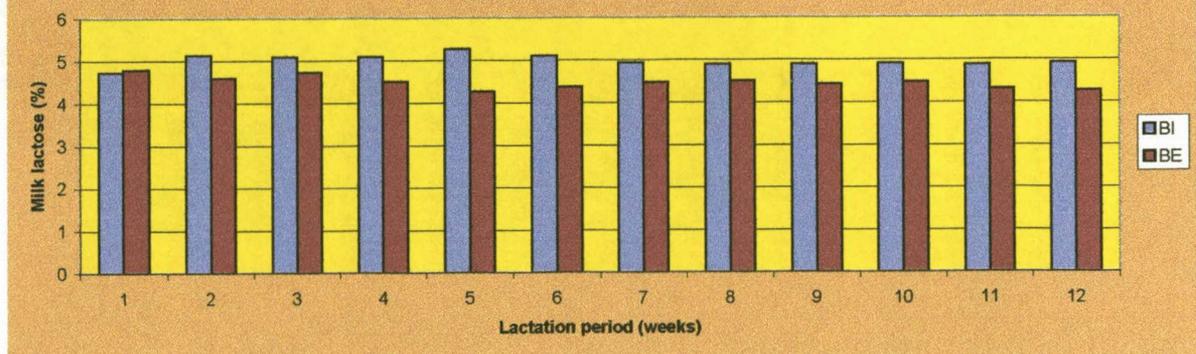


Figure 4.8 Mean milk lactose content (%) for Boer goat does in intensive and extensive feeding systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

Figure 4.9 Mean milk lactose content (%) for Indigenous goat does in intensive and extensive feeding systems

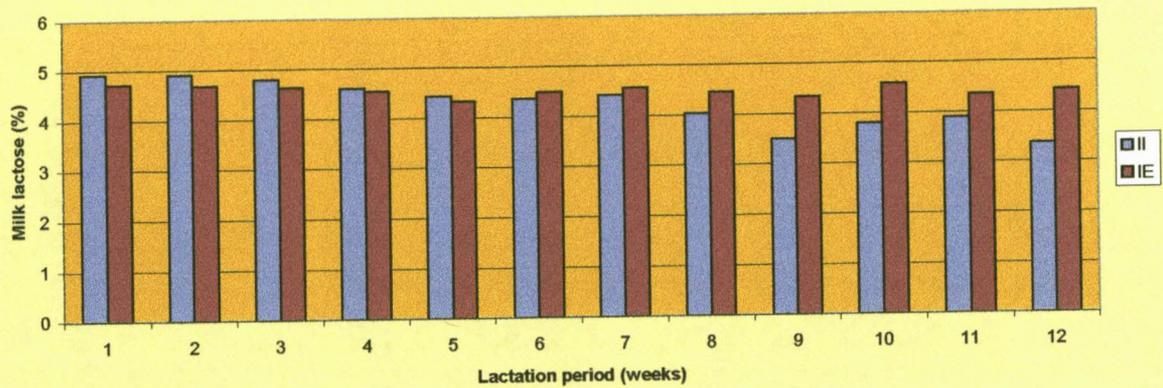
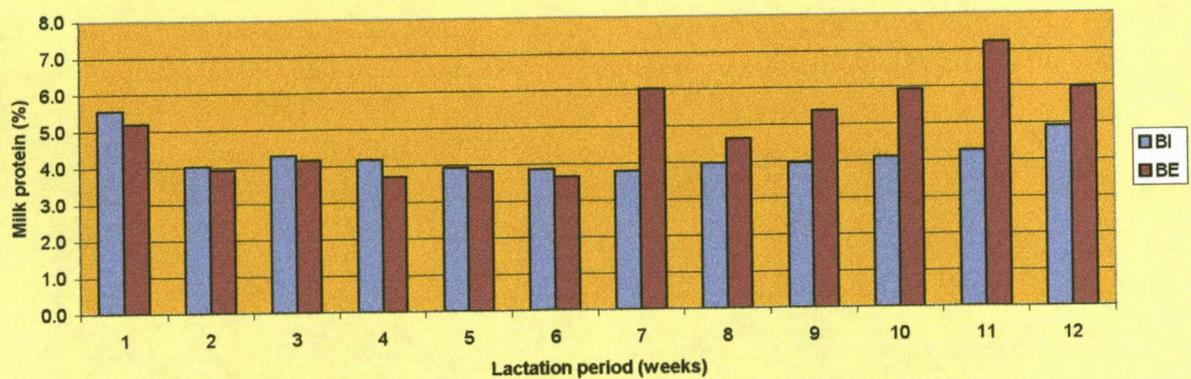


Figure 4.10 Mean milk protein content (%) for Boer goat does in the intensive and extensive feeding regimes



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

Figure 4.11 Mean milk protein content (%) for Indigenous goat does under intensive and extensive feeding regimes

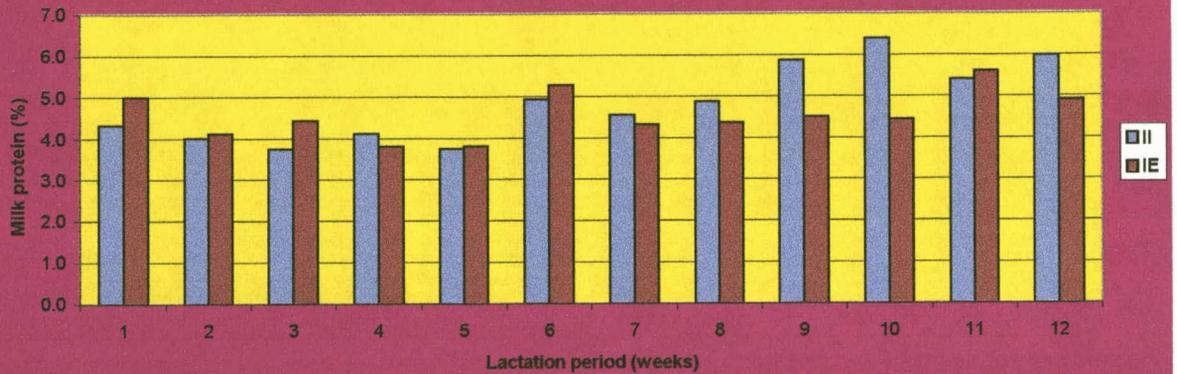
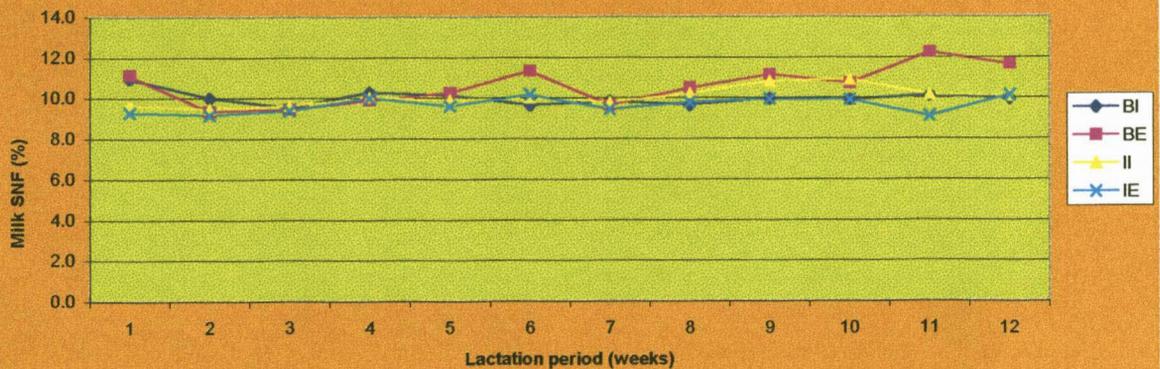


Figure 4.12 Mean milk SNF content (%) for Boer and Indigenous goat does under intensive and extensive feeding systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

Table 4.5 Mean milk SNF content (%) for Boer and Indigenous goat does under different feeding regimes

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	10.92	1.52	11.08	2.63	9.59	1.26	9.27	2.02
2	9.96	0.62	9.31	0.53	9.43	0.60	9.13	0.91
3	9.51	0.70	9.42	1.34	9.59	1.19	9.36	1.42
4	10.24	1.46	9.85	2.92	10.01	1.16	9.96	2.71
5	10.09	1.11	10.21	2.13	9.89	0.99	9.56	1.64
6	9.62	0.80	11.30	4.48	9.99	0.67	10.15	2.59
7	9.80	0.568	9.63	1.98	9.75	0.90	9.41	2.30
8	9.626	0.65	10.45	2.84	10.19	2.38	9.76	1.78
9	9.92	0.64	11.10	3.63	10.79	2.85	9.91	2.34
10	9.87	0.60	10.70	2.99	10.876	2.16	9.87	2.55
11	10.08	0.967	12.19	4.46	10.13	1.99	9.08	1.26
12	9.933	0.44	11.60	3.77	10.04	1.84	10.08	1.94

SNF Solid non-fat

SD Standard deviation

The Boer goats in the extensive group produced the highest mean daily milk SNF content for the entire period ($10.69 \pm 5.13\%$), followed by the Boer goats in the intensive group ($10.42 \pm 6.48\%$). The Indigenous goat does of the extensive group produced the lowest milk solid non-fat content (SNF) with a mean daily content of $9.55 \pm 1.90\%$. These results show that breed plays a significant ($P < 0.01$) role in SNF content, with the Boer goat extensive group having the highest milk SNF content. The production of SNF content (%) varied throughout the observation period for both breeds in the different feeding systems, with Boer goat does (extensive group) producing more than all the groups (Table 4.5) at Weeks 6, 10 and 11. The correlation coefficient between mean daily milk SNF content (%) and mean daily milk yield was $r = 0.271$.

Table 4.6 Mean feed intake (kg/day) for both the Boer and Indigenous goat does in an intensive feeding system

Week	Boer goats		Indigenous goats	
	Intensive feeding		Intensive feeding	
	Mean	SD	Mean	SD
1	1.33	0.59	0.97	0.46
2	1.54	0.49	0.95	0.45
3	1.58	0.54	0.73	0.31
4	1.49	0.68	0.73	0.57
5	1.49	0.64	0.71	0.40
6	1.52	0.75	0.77	0.74
7	1.60	0.55	0.71	0.44
8	0.82	0.50	0.64	0.41
9	0.52	0.51	0.74	0.46
10	0.62	0.48	0.69	0.42
11	0.75	0.55	0.74	0.49
12	0.77	0.43	0.73	0.46

SD Standard deviation

4.3 FEED INTAKE

Mean daily feed intake during the observation period for the does in the intensively fed groups is set out in Table 4.6. The maximum and minimum feed intake (1.6 ± 0.6 and 0.5 ± 0.5 kg/d) for Boer goats were observed during Weeks 7 (49 days) and 9 (63 days), respectively. Similarly, the maximum and minimum feed intakes (0.97 ± 0.46 and 0.64 ± 0.41 kg/d) recorded for the Indigenous goat does in the same nutritional regime were observed during Weeks 1 and 8 (Figure 4.13). Feed intake in the Indigenous goats remained fairly constant (between 0.97 and 0.64 kg/d). The larger Boer goats had a significantly larger ($P < 0.05$) feed intake than the smaller framed Indigenous goats. A correlation coefficient (r) of 0.7 was recorded between feed intake and milk production for Boer goat does, whilst the correlation coefficient (r) was 0.4 between feed intake and milk production for Indigenous goat does. It can be seen that the feed intake decreased

(Table 4.6), as the post partum period increased. There was a relatively large variation in feed intake of the Boer and Indigenous goats throughout the observation period.

4.4 LIVE WEIGHT OF DOES

The mean changes in live weight (\pm SD) of the does under the different nutritional regimes from Week 1 to the end of lactation (Week 12) is set out in Table 4.7. Body weight changes during the observation period are illustrated in Figure 4.14.

Table 4.7 Mean live weight (kg) of Boer and Indigenous goat does under different nutritional management systems

Week	Boer goat doe				Indigenous goat doe			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	49.03	11.03	46.76	8.02	34.16	5.08	32.33	4.36
2	46.37	9.17	43.89	9.45	31.24	5.07	30.31	3.91
3	45.87	9.19	44.13	7.10	32.20	6.06	30.62	3.85
4	45.92	8.55	43.96	6.57	30.36	5.61	29.36	4.41
5	44.86	9.23	42.83	6.62	30.46	6.34	30.51	3.90
6	44.29	8.51	42.58	6.59	31.39	5.95	28.43	4.74
7	44.27	9.06	40.37	7.86	31.93	6.80	26.82	4.13
8	43.11	8.37	39.08	8.46	32.28	6.93	28.00	4.44
9	42.82	8.36	39.77	8.37	33.01	6.30	28.16	4.88
10	43.47	6.65	38.58	7.98	33.50	6.35	28.82	5.06
11	43.08	7.49	40.47	7.62	32.68	7.18	27.88	4.22
12	42.98	6.89	40.42	8.10	33.18	7.86	27.69	4.66

SD Standard deviation

Figure 4.13 Mean feed intake (kg/day) for Boer and Indigenous goat does in an intensive feeding regime

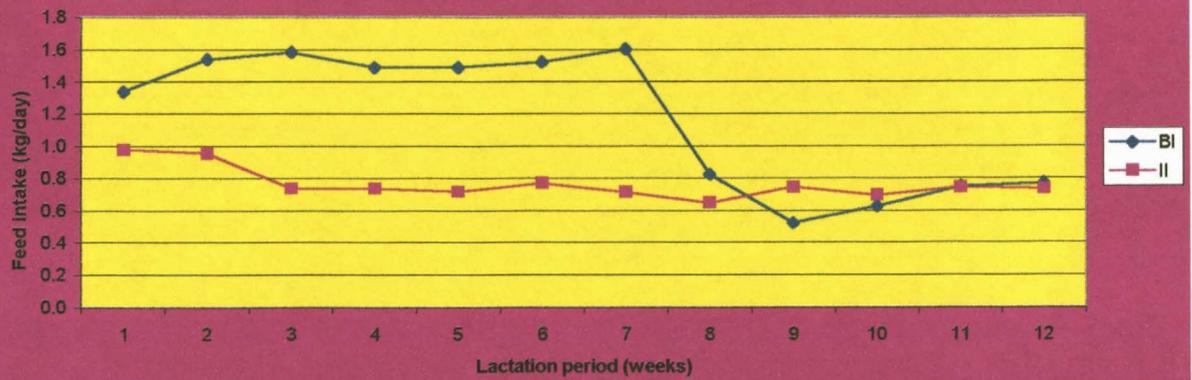
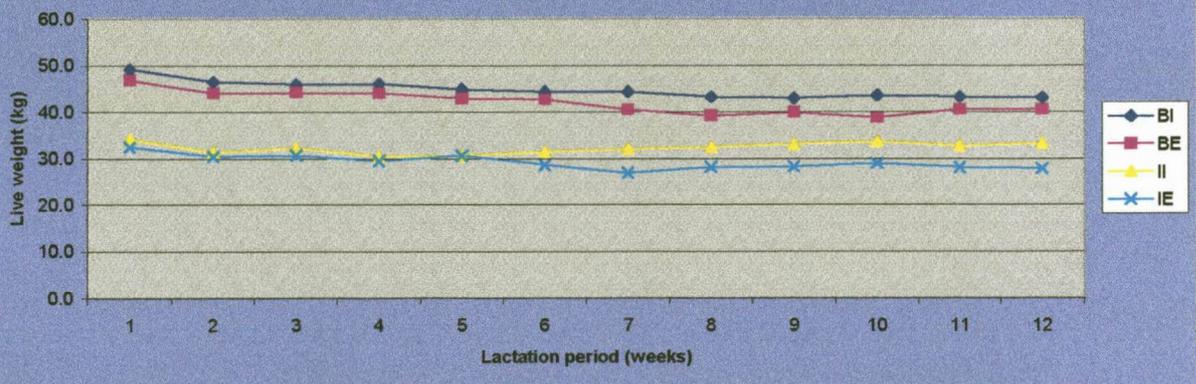


Figure 4.14 Mean live weight (kg) for Boer and Indigenous goat does under intensive and extensive feeding systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

Mean live weight for all animals decreased from the first week to the second week, regardless of the nutritional regime. Boer goat does were significantly ($P < 0.05$) heavier than the Indigenous does, with Boer goat does (intensive group) heavier than Boer goat does (extensive group). Similarly the same tendency was shown by the Indigenous goat does kept in intensive nutritional regime over Indigenous goat does kept under extensive conditions (Table 4.7). Although there were variations (standard deviation) in the live weights within the breeds, the live weights increased in all the treatment groups (except the Boer Intensive group) from Week 2 up until Week 3 of lactation. After Week 3, the Boer and Indigenous (extensive group) does showed a slight (6.9%) decrease in body weight, while the Boer and Indigenous (intensive group) showed a small increase (3.1%) (Week 6).

Mean live weight per breed for the total observation period was 45.0 ± 8.7 kg vs 32.3 ± 6.1 kg for Boer and Indigenous goats kept under the intensive feeding regime, and 42.3 ± 8.0 kg vs 29.3 ± 4.5 kg for those under an extensive feeding regime.

4.5 LIVE WEIGHT OF GOAT KIDS

In Table 4.8 the mean kid body weights for the 12 week period in both breeds under different nutritional regimes is set out. The birth weights (Week 1) did not differ significantly between breeds and nutritional regimes. For the intensive groups, the ADG during the observation period was 158.3 vs 90.4 g for the Boer and Indigenous kids, respectively. Similarly, the ADG for the extensive groups was 75.8 vs 56.4 g (Boer and Indigenous goats, respectively). The mean live weight gain during the observation period was 13.3 kg and 6.4 kg for the intensive and extensive Boer goat kids, respectively, and 7.6 kg and 4.7 kg for the intensive and extensive Indigenous goat kids, respectively. Kids maintained under intensive feeding conditions grew faster than those in the extensive group, with Boer goat kids showing faster growth rate in all the respective nutritional regimes, compared to the Indigenous goat kids. From Week 10 the Indigenous goat kids

(intensive group) grew faster than both the Boer and Indigenous goat kids in an extensive group.

Table 4.8 Mean live weight (kg) for Boer and Indigenous goat kids under intensive and extensive feeding regimes

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	3.35	0.72	3.81	0.99	2.97	0.76	3.60	0.70
2	4.16	0.85	4.43	1.29	3.96	0.63	3.50	0.88
3	5.17	1.04	4.25	2.05	4.48	0.79	3.60	1.04
4	6.13	1.24	5.58	1.75	4.79	0.99	4.70	0.72
5	7.16	1.27	6.44	1.82	5.66	1.74	5.10	1.00
6	7.99	1.62	6.60	1.92	6.03	2.25	5.63	1.13
7	9.04	1.68	7.67	2.04	6.76	2.41	5.71	1.59
8	10.61	2.06	7.80	2.10	7.70	2.24	6.61	1.50
9	11.59	1.90	7.73	2.50	7.92	2.22	7.11	1.46
10	13.55	2.95	7.80	2.60	8.08	2.80	7.07	1.46
11	14.04	4.22	7.10	2.74	8.92	2.02	7.43	1.62
12	16.65	6.57	10.18	2.19	10.57	4.82	8.34	2.41

SD Standard deviation

4.6 GOAT TEAT MEASUREMENTS

The mean teat lengths for the left and right teats in the Boer goat (intensive) group were 55.8 ± 15.6 and 56.4 ± 15.4 mm, respectively. The mean teat lengths for the same breed under extensive conditions were 37.9 ± 8.3 and 40.3 ± 9.1 mm for the left and right teats, respectively. Similarly, the mean teat lengths of the Indigenous does in the intensive feeding group were recorded as 42.7 ± 7.7 and 42.1 ± 10.3 mm for the left and right teats, respectively. The mean teat lengths for the Indigenous does in the extensive group were 34.2 ± 7.9 and 35.6 ± 8.3 mm for left and right teats, respectively (Table 4.9). Considerable variation in teat length was recorded throughout the observation period as can be seen in the standard deviation.

Table 4.9 Mean teat length (mm), teat volume (ml) and teat width (mm) for Boer and Indigenous goat does under intensive and extensive feeding regimes for the 12-week observation period.

	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Teat length – L	55.8	15.6	37.9	8.3	42.7	7.7	34.2	7.9
Teat length – R	56.4	15.4	40.3	9.1	42.1	10.3	35.6	8.3
Teat volume – L	12.7	5.5	11.7	3.8	11.4	2.9	10.8	4.1
Teat volume – R	13.7	5.4	12.7	4.6	11.4	2.7	11.7	4.4
Teat width – L	14.7	5.2	12.3	2.9	9.0	2.1	11.1	3.3
Teat width – R	14.6	4.8	13.5	3.7	9.1	2.1	11.1	3.1

SD Standard deviation

The mean teat width recorded for the entire observation (left and right teats, respectively) for both breeds (irrespective of the feeding regime) was 13.6 ± 4.4 mm and 14.0 ± 4.3 mm for the Boer goat and 10.0 ± 3.0 mm and 10.1 ± 2.8 mm for the Indigenous goat. As expected, Boer goats tended to have larger teats, but a relatively large variation in width was recorded. The mean teat volume (left and right teats, respectively) for both breeds (irrespective of nutrition level) was 12.2 ± 4.8 ml and 13.0 ± 5.0 ml, and 11.1 ± 3.5 ml and 11.6 ± 3.6 ml for the Boer and Indigenous goats, respectively. Boer goats tended to have larger teats. Due to the variation between and within breeds and treatment groups, no significant differences for teat length, width or volume was recorded.

4.7 SERUM PROGESTERONE PROFILE

The ovarian activity of individual goats was assessed according to the serum progesterone profiles of each doe during the observation period. Table 4.10 and Figure 4.15 shows the mean weekly serum progesterone concentration during the observation period. The peak concentration of serum

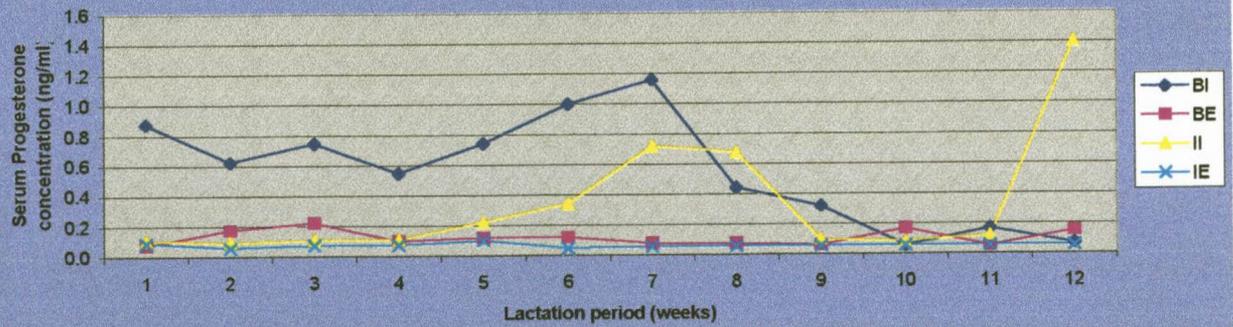
progesterone was recorded during Week 7 (49 days) for the Boer goats (intensive group) and Week 12 (84 days) for the Indigenous goats (intensive group). The mean peak serum progesterone value recorded did not even measure 0.2 ng/ml for the extensive groups (irrespective of breed). Large variation was recorded within and between breeds and nutritional regimes. The ovarian activity (as measured by the serum progesterone concentration) remained low in the extensive groups throughout the observation period (Figure 4.15).

Table 4.10 Mean serum progesterone level (ng/ml) for Boer and Indigenous goat does under different nutritional management systems

Week	Boer goats				Indigenous goats			
	Intensive feeding		Extensive feeding		Intensive feeding		Extensive feeding	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	0.87	2.36	0.07	0.06	0.10	0.11	0.09	0.11
2	0.62	1.51	0.17	0.17	0.09	0.08	0.05	1.09
3	0.74	2.00	0.22	0.43	0.11	0.08	0.07	0.06
4	0.55	1.34	0.09	0.10	0.11	0.14	0.07	0.06
5	0.74	1.75	0.11	0.15	0.22	0.48	0.10	0.09
6	1.00	1.88	0.12	0.15	0.34	0.78	0.05	0.01
7	1.16	2.99	0.07	0.07	0.72	2.03	0.05	1.09
8	0.44	1.10	0.07	0.08	0.67	1.79	0.05	1.09
9	0.31	0.69	0.06	0.04	0.10	0.09	0.05	1.09
10	0.05	1.08	0.16	0.28	0.08	0.06	0.05	1.09
11	0.16	0.31	0.05	0.02	0.12	0.14	0.05	1.09
12	0.07	0.04	0.15	0.29	1.40	4.04	0.05	1.09

SD Standard deviation

Figure 4.15 Mean serum progesterone concentration (ng/ml) for Boer and Indigenous goat does in intensive and extensive feeding systems



BI = Boer intensive
 BE = Boer extensive
 II = Indigenous intensive
 IE = Indigenous extensive

CHAPTER 5

DISCUSSION

5.1 MILK PRODUCTION

According to Devendra and Burns (1970) milk yield is largely affected by a combination of factors, namely, the use of improved breeds selected for high milk production, a more favourable nutrition environment and improved managerial practices. The high milk yields observed in the present study serve to demonstrate the potential of goats, given the best possible environment, to allow the maximum expression of genes for milk production. The present results show that feed has a significant ($P < 0.01$) effect on milk production, with the intensively fed does producing much more milk than the extensively managed does. The Boer goat demonstrated a high mean milk production potential (3.12 ± 1.48 l/day) in an improved nutritional regime, whilst the contrary was recorded for those subjected to the poor nutritional conditions of natural pastures (mean 0.78 ± 0.67 l/day). The Indigenous does also showed the same milk production trend, but with lower mean daily milk production for the intensively fed goats (1.42 ± 1.37 l/day), compared to the Boer goats. This is in agreement with other researchers, who found milk yield of Indigenous feral goats in the tropics to be generally low (Akinsoyinu *et al.*, 1977). Jamnapari, Beetal and Barbari breeds in India produced 0.75, 1.0 and 0.6 kg/day per animal, respectively. This is consistent with the findings of this trial (mean of 1.42 ± 1.37 and 0.65 ± 0.64 l/day for intensively and extensively maintained Indigenous feral does, respectively). Akinsoyinu *et al.* (1977) reported that the main reason for lower milk production was that most Indigenous goats in the tropics were meat or dual purpose animals, and were not selected for milk production. As would be expected, the does fed a balanced diet, produced more milk per day, compared to those maintained on natural pastures (3.12 ± 1.48 and 1.42 ± 1.37 l/day for Boer and Indigenous does under intensive conditions, compared to 0.78 ± 0.67 and 0.65 ± 0.64 l/day for the Boer and Indigenous does under extensive conditions). This

observation is also in agreement with Sachdeva *et al.* (1974), who found that milk production is influenced by pre- and post partum nutrition of the doe, and Mavrogenis and Narjisse (1992) and Olsson *et al.* (1997), who stated that better feeding promoted higher milk yield in both local and exotic goat breeds. The quality of the forage part of the diet determines to a large extent the amplitude of the lactation curve (milk production).

Both the Boer and Indigenous goat does reached their peak lactation (3.6 ± 1.4 l/day and 1.9 ± 7.0 l/day, respectively), earlier (Week 5) compared to their counterparts under extensive natural conditions (1.1 ± 0.7 and 0.8 ± 2.0 l/day respectively). This peak production was only achieved in Weeks 8 and 9, respectively for the extensive group. Working with Indigenous goats (*Capra Prisca*) in Greece, Zygoiannis and Katsaounis (1986) found peak milk production to be reached at Weeks 10 and 11 of lactation. Both breeds managed extensively reached their peak lactation at a time similar to the period reported by Zygoiannis and Katsaounis (1986). The difference in peak milk yield obtained for both the Boer and the Indigenous goat does can be attributed to the genotype and nutritional environment (Hayden *et al.*, 1979; Morand-Fehr & Sauvant, 1980; Gall, 1981). This is evident in the results of this study, where the genetically superior Boer goat produced significantly ($P < 0.01$) more milk than the local Indigenous feral goat. Nutrition promoted a higher milk production – irrespective of the breed.

5.2 MILK COMPOSITION

The composition of goat milk has been researched and compared with milk from other species by several researchers (Parkash & Jenness, 1968; Jenness, 1980). Fat, protein, SNF and lactose content in milk depends largely on the volume of milk produced (Zygoiannis, 1988b). These constituents of milk determine the value of milk. The production of goat milk has traditionally been of major importance in several countries where climatic conditions are not favourable for cattle production and dairy farming. In addition, in recent years, an increasingly important health role in the diet of

man has been linked to goat milk. It may be tolerated by children and infants suffering from hypersensitivity (allergy) to cow milk. This is due to the fact that the average globule size of fat in the goat milk ($3.5 \mu\text{m}$) is considerably smaller than that of cow milk ($4.5 \mu\text{m}$). Merin *et al.* (1988) indicated that the composition of goat milk varies somewhat and it is a function of several factors, such as breed, stage of lactation, climatic conditions, diet and the season of the year.

5.2.1 Fat content of goat milk

The Indigenous feral goat does produced the highest mean fat content ($7.5 \pm 3.2\%$) with a mean milk yield of 1.42 ± 1.37 l/day. The Boer goat doe on the other hand produced a mean fat content of $6.1 \pm 2.2\%$, with a higher mean milk production of 3.1 ± 1.5 l/day. This observation is in agreement with Flamant and Morand-Fehr (1982), who indicated high levels of milk production to be associated with a lower fat content of the milk. Zygoiannis and Katsaounis (1986) also found the trend towards a lower milk fat content in high milk producing goats to be associated with the higher total milk yield. Similarly, Simos *et al.* (1996) found a negative correlation between higher milk yield and fat content. Working with Indigenous goats in Germany, it was found that the overall values of the measured milk constituents, especially fat, were relative to the yield of milk in the goats. Furthermore it was indicated that the amount of milk fat could be related to both the genetic potential of the goats, and to the comparatively low milk yield associated with the nutritional environment (Gall, 1981).

The $7.5 \pm 3.2\%$ fat content for the intensively housed Indigenous goats was lower than the 12% mean daily fat content of Indigenous goats (*Capra Prisca*) quoted by Zygoiannis (1987), but higher than 4.75% and 3.37% reported by Echoche and Buvanendran (1983) and Muggli (1981), respectively. Whilst the value of $6.1 \pm 2.2\%$ mean fat content recorded for Boer goat does was lower than the $6.9 \pm 0.1\%$ mean daily milk fat content quoted by Akinsoyinu *et al.* (1977). This value ($6.9 \pm 0.1\%$) was also higher than the fat content

reported by Lythgoe (1940) and Mitchell (1962) for goats and for White Fulani cows (Adeneye *et al.*, 1970), and lower than the 7.5% reported for ewe's milk (Ling *et al.*, 1961). These values are again lower than the $7.5 \pm 3.2\%$ for the Indigenous goat does in the intensively fed group reported in this trial. The decrease in goat milk fat content is attributed to a decrease in the molar proportion of acetic acid in the rumen and an increase in the molar proportion of propionic acid (Armstrong & Blaxter, 1964; Mba *et al.*, 1975; Morand-Fehr & Sauvant, 1980).

5.2.2 Lactose content of goat milk

The major carbohydrate in goat milk is lactose (Chandan *et al.*, 1992). In this study the highest mean lactose content of $5.0 \pm 0.7\%$ was produced by Boer goat does which were managed intensively. This value is higher than the values of 4.45% and 4.66% reported by Chandan *et al.* (1992), but lower than the 5.83% in Native Greek goats reported by Simos *et al.* (1991). Boer goats maintained under intensive conditions attained a maximum and minimum mean milk lactose contents in Weeks 5 and 1 of the lactation period, respectively. This is in agreement with Singh and Sengar (1990) who stated that milk lactose content declined with a decrease in milk yield, as the lactation period progressed. In their study all the breeds showed a tendency for a decline in milk lactose content as the lactation period progressed. In the same study, milk lactose content exhibited variations between the 7th week and the end of lactation (Simos *et al.*, 1996). In the present study such variations were observed one week earlier. This confirms the fact that milk lactose is positively correlated to milk yield, which is found to be significantly ($P < 0.05$) influenced by the feed status of the animal.

5.2.3 Protein content of goat milk

Interest in the protein content of milk is becoming more important. Human health concerns regarding animal fats, resulted in the development of a milk processing system that places less economic emphasis on milk fat, and more emphasis on milk protein (De Peters & Fergurson, 1992; Hadjipanayiotou,

1995). The Indigenous goats showed very high levels of milk fat and protein compared to the Saanen goat (Donkin, 1998). The mean concentration of protein in goat milk is 4.5% (Zerfas *et al.*, 1992). In this trial, the Boer goats maintained extensively yielded a maximum and minimum mean milk protein content ($7.21 \pm 4.91\%$ and $3.75 \pm 0.7\%$) in Weeks 11 and 4, respectively. The Indigenous does (extensive group) also attained a maximum and minimum level ($5.61 \pm 3.84\%$ and $3.81 \pm 0.65\%$) during the same period. Table 4.6 shows the intensively managed breeds, achieving a maximum and minimum mean milk protein content at different periods in lactation. Milk protein content together with the other milk constituents (except lactose), increase with advancement of the lactation period (Singh & Sengar, 1990). This confirms the findings by Agnihotri and Prasad (1992) who state that protein, fat and total solid content in Jamanapari and Barbari goats to be more than in the milk of the European goat breeds. This could be the case, as the breeds are low milk producers (0.75 and 0.6 kg/day, respectively), compared to the European goats (Akinsoyinu *et al.*, 1977). These researchers also report a mean daily protein content of $3.91 \pm 0.01\%$, which is less than the findings of this study ($4.20 \pm 0.97\%$, $5.03 \pm 2.96\%$, $4.95 \pm 1.96\%$ and $4.54 \pm 2.79\%$ for Boer and Indigenous goats in an intensive and extensive environment, respectively). These differences were, however, not significant between the different breeds and feeding regimes.

5.2.4 Solid non-fat (SNF) content of goat milk

The composition and the characteristics of goat milk from different breeds and countries have been reported by many authors (Haenlein, 1980; Jenness, 1980). Most of these reports do not place much emphasis on the SNF content of the milk. Simos *et al.* (1991), working with Native Greek goats, recorded a mean SNF content of 14.12%, which is higher than the values recorded in this study. With the highest mean SNF content ($10.69 \pm 5.13\%$) produced by Boer goats which grazed on natural pasture for the entire experiment, it is possible that the SNF content of milk is determined by genetic factors in the breed, rather than the energy intake of the animal. In

this study the Boer goat group, under extensive feeding conditions, produced a mean daily milk production of 0.78 ± 0.67 . This quantity was the second lowest when compared with other groups, but this breed yielded the highest SNF content in the study. This confirms the finding of Simos *et al.* (1996) that SNF together with fat and protein content are negatively correlated to milk yield. In the present trial it was found that breed has a significant ($P < 0.01$) influence on SNF content, with Boer goat does yielding a higher SNF content than the Indigenous goat does under their respective feeding systems.

5.3 FEED INTAKE

The most important causes of the variation in milk yield between ewes are feed intake, genotype of the ewes (Moore, 1966) and the plane of nutrition of the ewes (Forbes, 1969). Concentrates are the most expensive nutrient component of dairy rations and are important. Any variation in concentrate level has a big impact on feed intake (Burt, 1957). Sanz *et al.* (1999) reported that milk production of goats fed diets, practically equal in energy and N content, is known to be dependent on the intake level of the diet. In this study, the Boer goat does had the highest mean feed intake and milk production (1.6 ± 0.55 kg/d vs 3.62 ± 1.42 l/d), whilst the Indigenous does had a maximum mean feed intake and milk production of 0.97 ± 0.46 kg/d vs 1.87 ± 7.04 l/d. Hadjipanayiotou (1995), reported that feed intake is the main factor that determines milk production in goats. These researchers furthermore, reported the correlation between the energy intake and milk production halfway through lactation to be as high as $r = 0.83$. However, in the present trial the correlation between milk yield and the feed intake was found to be slightly lower ($r = 0.7$) for the higher milk producing goats (Boer goat does in the intensive group). Those producing less milk were found to have a lower correlation coefficient ($r = 0.4$) between feed intake and milk production. In the present study, it has been found that feed intake is significantly ($P < 0.01$) correlated to milk production, irrespective of the breed. Thus, the higher the production, the higher the feed intake.

5.4 LIVE WEIGHT OF THE DOES

The highest mean live weight for the Boer goat does was found to be 45.0 ± 8.7 kg in the intensive feeding group, having the highest mean daily milk yield (3.12 ± 1.48 l/day). The highest mean live weight for the Indigenous does in the intensive feeding system was 32.3 ± 6.1 kg with the highest mean daily milk yield being 1.42 ± 1.37 l/day. This observation is consistent with other researchers who reported a general positive relationship between milk yield and live weight. Variations in body weight accounts for only about 10% of the variation in milk yield (Gall, 1981). Furthermore, Echoche and Buvanendran (1983) showed that doe live weight is the most important trait influencing milk yield in Red Sokoto goats (mean live weight of 22.3 kg) and suggested it to be responsible for proportionately 0.46 of the variation in milk yield.

In both groups and breeds (Table 4.7) live weight decreased during early lactation (Weeks 1 and 2). This was followed by relative maintenance of body weight (low nutritional maintenance) in the intensively fed animals. The Indigenous does in the extensive group struggled to maintain their live weight and actually lost weight during the observation period. Fehr and Sauvart (1975) found that weight loss in adult goats at the onset of lactation was related to milk yield during the first week of lactation only. The weight loss at the beginning of the lactation period is attributed to the mobilization of body fat, which is stored during the dry period. Researchers found mobilization of fatty tissue to begin during the last third of the pregnancy (Chilliard *et al.*, 1978).

In sheep, reports on the effect of live weight on quantity of milk produced are not consistent. Thus, while Coombe *et al.* (1960) and Krizek *et al.* (1981) found live weight not to be significantly correlated with milk yield, Owen (1957) recorded live weight to significantly influence the milk yield. In this trial all the breeds kept intensively tended to show a slight decrease in body

weight, whilst the extensive groups, regardless of the breed, showed a greater decrease in live weight. This was because the extensive group was additionally subjected to poorer nutritional environmental conditions, compared to those in the intensive groups. Thus, the nutrient demand for milk production was met by a higher nutrient mobilisation from the body reserves in the extensive groups compared to the intensive group.

5.5 LIVE WEIGHT OF GOAT KIDS

Milk produced by the doe is the main source of nutrients for young goat kids during the first few weeks of life. If milk production by the doe is inadequate, then growth, development and health of the goat kid can be hindered (Godfrey *et al.*, 1997). The present study found that kids maintained intensively, where the does were fed a complete diet, had a higher ADG and weaning weights compared to the does that were extensively managed. The higher growth rate was due to adequate milk production produced by does. This was due to the intensively fed does, regardless of the breed (genotype) ability to meet the nutritional demand for milk production. The Boer goat kids (intensive group) had the highest mean weaning (12 weeks) weight (16.6 ± 6.6 kg). The higher weaning weights were as a result of the higher feed intake and milk production of the does, even though this breed generally gave birth to twins. Ramsay *et al.* (1994) demonstrated that Targhee ewes nursing twin lambs had higher dry matter intake and higher milk yield than ewes nursing singles. This aspect of number of offspring is confirmed by the fact that the Boer goat does in the intensive group had a higher feed intake than the Indigenous goat does (1.26 ± 0.71 vs 0.75 ± 0.47 kg/day) and at the same time also had a higher milk yield (Barnicoat *et al.* 1949; Alexander & Davies, 1959; Ricordeau *et al.*, 1960; Lai *et al.*, 1993). Other workers found milk yield to be affected by the number of lambs suckled and not by the number of lambs born (Doney & Munro, 1962; Peart, 1967; Corbett, 1968; Davis *et al.*, 1989). The increase in milk yield observed in the group rearing twins was obviously due to the increased stimulation of the udder (Karam *et al.*, 1971). However, Knights and Bencin (1993) reported no

difference between ewes suckling twins and singles in terms of milk production. Steine (1975), Gall (1981) and Montaldo *et al.* (1995) furthermore reported that the greater milk production observed in goats with two or more kids can be explained by increased levels of placental lactogen in the does.

5.6 TEAT MEASUREMENTS

Good udder formation, particularly the position and size of the teat ensures proper lamb rearing and milking efficiency (Montaldo & Martinez-Lozano, 1993). Thus, a prediction of milk production from the external measures of the udder can be based on the udder and teat perimeters (Montaldo *et al.*, 1988). Traditionally, the production capacity of dairy animals is judged, to a large extent, by the physical appearance and the size of the udder. Sometimes the large size of the udder is due to excessive deposition of connective tissues, which frequently obscure the granular or secretory content of the udder. A big udder is, therefore, no indication of animal's capacity for producing milk (Naraim *et al.*, 1988). Montaldo and Martinez-Lozano (1993) found milk production to be correlated significantly with teat parameters ($r = 0.45$). In this trial, the left and right teat measurements were found to be positively correlated ($r = 0.21$ vs $r = 0.23$; $r = 0.46$ vs $r = 0.36$; $r = 0.55$ vs $r = 0.52$ for teat volume, width and length, respectively) with milk output. It was also found that both milk production and teat parameters were influenced significantly ($P < 0.01$) by the nutritional regime. Teat measurements were found to be unreliable indicators of milk production and much variation in size existed between and within the breeds measured.

5.7 SERUM PROGESTERONE CONCENTRATION

The determination of the serum progesterone concentrations in the lactational goat revealed the mean progesterone concentration to vary according to the breed and nutritional environment. The serum progesterone concentration of the Boer goat does (intensive group) was higher than for that of all the other treatment groups during early lactation (Week 3) and mid-lactation period

(Week 7). The serum progesterone concentration for the Boer goat does intensively fed, was found to increase after the peak of lactation which could be indicative of sexual activity. It was also found that the serum progesterone concentration for this group declined with a decrease in feed intake. These results confirm the findings of Peart (1967; 1968) and Barnicoat *et al.* (1949) that nutrition during lactation is the primary factor influencing milk production of the ewes. It can be stated that ovarian activity of the Boer goat does (intensive group), was suppressed by high milk production until 2 weeks after the peak of lactation. This means that at this time energy is in abundance for both lactational and oestrus activity. This is confirmed by the fact that all the breeds in the extensive environment, where energy intake was limited, exhibited low levels of serum progesterone concentrations and consequently maintained high levels of anoestrus. The Indigenous goats (intensive group) showed the most elevated serum progesterone concentration, one week before the end of the observation period (Week 11). This elevation in the serum progesterone level was found to occur during the same week as the occurrence of minimum milk yield. This implies that during the period when milk yield increased, more energy was partitioned for milk production than for ovarian activities. This is in agreement with findings by Bauman *et al.* (1980), who indicated that marked alterations in the general partitioning of nutrients took place to accommodate the demands of the mammary gland during the initiation of lactation.

CHAPTER 6

GENERAL CONCLUSIONS

This study was carried out to investigate the milk production potential (quantity and quality) of both Boer and Indigenous goat does under intensive or extensive feeding regimes. The milk yield in both breeds was found to be significantly ($P < 0.01$) related to the nutritional regime. The breed and the interaction between the feed and breed were not significant. The animals on an intensive feeding regime produced the most milk during the same week, whilst those kept under extensive conditions had their maximum milk yield at different weeks of the lactation period. The Boer goat doe produced its maximum milk one-week earlier than the Indigenous goat doe (Week 8 vs Week 9). It was observed that the Boer goat doe produced more milk per day than the Indigenous goat doe in the intensive and extensive group (3.12 ± 1.48 vs 1.42 ± 1.37 l/day; 0.78 ± 0.67 vs 0.65 ± 0.64 l/day, respectively), regardless of the feeding regime. It can be concluded that the Boer goat doe had better genetic potential for milk production than the Indigenous doe.

The two breeds proved clearly that the milk produced is of equal quality to that of the dairy goat, although the quantity of the milk produced is relatively low. All the milk constituents (lactose, fat, protein and SNF) were found to be significantly ($P < 0.01$) influenced by both nutrition and breed of the goat. Milk fat content differed significantly ($P < 0.01$) between breeds, with the Indigenous goats having a higher fat content than the Boer goats. Milk protein and lactose were significantly ($P < 0.01$) influenced by the nutritional management, whereas SNF was significantly influenced by both (nutritional management and breed), Boer goat under extensive feeding conditions having the higher SNF content. The live weight of the doe was positively correlated with milk production. In this study it was found that does which possess the highest live weight (45.0 ± 8.7 kg vs 42.3 ± 8.0 kg; 32.3 ± 6.1 vs 29.3 ± 4.5 kg for the Boer goat intensive and extensive groups and the

Indigenous goat intensive and extensive groups, respectively) produced more milk. Similarly, the does with higher milk production had kids with higher weaning weights (Week 12), compared to those with less milk production. This confirms that milk production plays an important role in the daily weight gain of the kids.

The teat measurements (volume, width and length) were found to be positively correlated (although not significant) with milk production. These measurements can possibly be used as a tool to predict the milk production of does, compared to evaluating the physical appearance and the size of the udder. The large size of the udder is due to excessive deposition of connective tissues, which frequently camouflage the secretory content of the udder.

The level of reproductive performance depends on the interaction of genetic and environmental factors, but it is especially susceptible to the influence of the latter. The serum progesterone level was found to be 1.26 ± 8.93 , 0.11 ± 0.19 , 0.40 ± 1.6 and 0.06 ± 0.05 ng/ml for Boer and Indigenous goat does fed intensively and extensively, respectively. The higher mean serum progesterone levels in the Boer goat doe indicate an earlier and higher oestrous activity compared to the Indigenous does.

Animals need good nutritional management to produce the maximum quantity of milk. The higher milk yield does not necessarily affect the milk composition. Boer goats produced more milk than the Indigenous goats. Boer goats can, thus, fulfil the function of providing milk to the rural communities. Given the abundance and adaptability of this breed in the harsh conditions of the rural areas, the breed can be used to alleviate malnutrition among the rural communities. Goats have the advantage that they can be maintained cheaper than dairy cows. It is recommended that Boer goats be used for milk production in the poor communities who cannot manage to purchase dairy goats or dairy cows. In addition, goat milk has medicinal properties, particularly for children susceptible to cow milk allergies.

and child epilepsy. Goat milk is believed to be able to improve the conditions for those people suffering from asthma, osteoporosis and stomach ulcers. Furthermore, the rural communities should be enlightened about these advantages from goat milk, so that they must not be deceived by the belief that goat milk is an inferior product. It is suggested that further studies be done to evaluate the suitability of goat milk for processing into cream, yoghurt, ice cream and cheeses.

ABSTRACT

MILK PRODUCTION OF SOUTH AFRICAN BOER AND INDIGENOUS FERAL GOATS UNDER INTENSIVE AND EXTENSIVE FEEDING SYSTEMS

by

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The primary aim of this study was to investigate the milk production potential (quantity and quality) of Indigenous feral and Boer goat does under intensive and extensive nutritional regimes. The study was carried out at two different locations to accommodate the nutritional regimes. The extensive group was maintained at the Paradys experimental farm of the Department of Animal Science (Faculty of Agriculture), which is situated 20 km south of Bloemfontein. Whilst the intensive group was maintained on campus, at the Faculty of Agriculture, Bloemfontein. The animals used were 36 multiparous goat does, out of which 18 were Boer and 18 were Indigenous feral goats. Half ($n = 9$) of the Boer goats and half ($n = 9$) of the Indigenous goats were each randomly allocated to an extensive and intensive group.

The intensively fed group received a complete diet. Each doe was given 2 kg/d and daily feed intake was recorded. In the extensive group, does were maintained on natural pastures with no feed supplementation. All does were milked twice a week. During each milking does were subjected to two milking

periods. The first milking was done to empty the udder, and no records of milk production were taken. The second milking was undertaken two hours after the first milking, and the milk output from each teat was recorded and milk samples collected. The percentage milk fat, solids non-fat, lactose and protein in the samples were determined. Blood samples were taken once a week, to determine the serum progesterone concentrations, as an indicator of oestrous activity. All animals (does and kids) were weighed weekly to determine live weight changes during the post partum lactation period. Weekly teat measurements were also done.

The Boer goat does produced more milk than Indigenous goats ($P < 0.05$). The intensively fed Boer goat does produced their maximum quantity of milk (3.7 ± 1.4 l/day) during Week 4, compared to the extensive group that peaked (1.1 ± 0.7 l/day) at Week 8. Similarly, the intensively fed Indigenous goats had their highest milk yield (1.9 ± 0.7 l/day) during Week 5, compared to the extensive group (1.1 ± 0.7 l/day) at Week 11. The intensively managed does had a maximum milk fat yield ($8.79 \pm 2.58\%$ and $8.86 \pm 3.68\%$) in Weeks 1 and 8 for Boer and Indigenous does, respectively. This maximum yield (not significantly different) was achieved in Weeks 1 and 5 for the same respective breeds in the extensive group. A correlation coefficient (r) of 0.073 between milk production and milk fat content was observed. Boer goats showed a trend of producing a higher milk lactose content throughout the trial. Boer goats fed intensively yielded maximum ($5.6 \pm 1.6\%$) and minimum ($3.8 \pm 0.7\%$) milk protein contents in Weeks 1 and 7, respectively, while for the extensive group these values were attained during Weeks 11 ($7.2 \pm 4.9\%$) and 6 ($3.6 \pm 0.5\%$), respectively. A correlation coefficient of 0.125 was recorded between milk protein content and the daily milk yield. The Boer goats in the extensive group produced the highest mean daily SNF content ($10.7 \pm 5.1\%$). The larger Boer goats had a significant ($P < 0.05$) higher feed intake. The correlation coefficient between feed intake and milk production was 0.7 for the Boer goat and $r = 0.4$ for the Indigenous goat. The mean body weight was 45.0 ± 8.7 kg vs 32.3 ± 6.1 kg for Boer and Indigenous goats under the intensive feeding regime, and 42.3 ± 8.0 kg vs 29.3 ± 4.5 kg for those under an extensive feeding regime. Considerable variation in teat

lengths was recorded. Peak serum progesterone concentration was recorded during Week 7 for the Boer goats (intensive group) and Week 12 for the Indigenous goats (intensive group). Ovarian activity (progesterone levels) remained low in the extensive groups throughout the observation period. Milk yield was significantly related to the nutritional status and the breed of the goat. The Boer goat produced more milk than the Indigenous goat. It is, thus, suggested that it can be used for milk production in the rural areas of South Africa. This may improve the nutrient intake of the rural communities.

OPSOMMING

MELKPRODUKSIE VAN DIE SUID-AFRIKAANSE BOER- EN INHEEMSE WILDSBOKKE ONDER INTENSIEWE EN EKSTENSIEWE VOEDINGSISTEME

deur

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Die doel van hierdie studie was om die melkproduksie potensiaal (kwantiteit en kwaliteit) van Inheemse en Boerbokooie, onder intensiewe en ekstensiewe voedingstoestande, te evalueer. Die ekstensiewe studie is uitgevoer by Paradys, die proefplaas van die Departement Veekunde (Fakulteit Landbou), geleë 20 km suid van Bloemfontein. Die intensiewe diere is gehuisves op die kampus by die Fakulteit Landbou, Bloemfontein. Ses-en-dertig volwasse bokooie, waarvan 18 Boerbok en 18 Inheemse bokooie is, is in die proef gebruik. Die helfte ($n = 9$) van die Boerbokke en helfte ($n = 9$) van die Inheemse bokke is ewekansig aan die ekstensiewe en intensiewe behandelingsgroepe geallokeer.

Die intensiewe groep het 'n volledige gebalanseerde dieet ontvang en die daaglikse voerinnome is gemonitor. Elk van hierdie ooie is 2 kg/dag gevoer en die reste gemeet. In die ekstensiewe groep is ooie onderhou op natuurlike weiding met geen byvoeding. Alle ooie is twee maal per week gemelk. Tydens elke melk is die ooie blootgestel aan twee melksessies.

Die eerste melking is gedoen om die niere te ledig en geen produksierekords is geneem. Die tweede melking is twee uur later gedoen en die melkproduksie van elke speen is geneem en melkmonsters is geneem. Die melkvet, nie-vet vaste stowwe (SNF) laktose en proteïnehoud is bepaal. Bloedmonsters is een maal per week geneem vir serum progesteron konsentrasie bepaling – as 'n aanduiding van oestrus aktiwiteit. Alle diere (ooie en lammers) is weekliks geweeg om liggaamsgewig verandering te monitor, tydens die post partum laktasie periode. Speenmates is ook weekliks gedoen.

Die Boerbok het meer ($P < 0.05$) melk geproduseer tydens die observasie periode. Die intensief gevoerde Boerbokke het hul maksimum melk geproduseer (3.7 ± 1.4 l/dag) tydens Week 4, vergeleke met die ekstensiewe groep wat gepiek het (1.1 ± 0.7 l/dag) by Week 8. Soortgelyk het die intensief gevoerde Inheemse bokke hul maksimum melk geproduseer (1.9 ± 7.0 l/dag) tydens Week 5, terwyl die ekstensiewe groep (1.1 ± 7.1 l/dag) hul hoogste produksie by Week 11 behaal het. Die intensiewe ooie het hul maksimum melkvet inhoud ($8.79 \pm 2.58\%$ en $8.86 \pm 3.68\%$) tydens Week 1 en 8 vir die Boer en Inheemse bokke respektiewelik gehad. Die ooreenstemmende melkvet inhoud (nie betekenisvol verskillend) is gekry in Week 1 en 5 vir die twee rasse respektiewelik in die ekstensiewe groepe. 'n Korrelasie van $r = 0.073$ is gemeet tussen melkproduksie en melkvet inhoud. Boerbokke het 'n tendens getoon om 'n hoër melk laktose inhoud deurgaans te handhaaf. Boerbokooie in die intensiewe groep het 'n maksimum ($5.6 \pm 1.6\%$) en minimum ($3.8 \pm 0.7\%$) melk proteïen inhoud in Week 1 en 7 respektiewelik gehandhaaf – terwyl in die ekstensiewe groep die respektiewelike waardes verkry is in Week 11 ($7.2 \pm 4.9\%$) en Week 6 ($3.6 \pm 0.5\%$). 'n Korrelasie van $r = 0.125$ is verkry tussen melk proteïen inhoud en melkproduksie. Die ekstensiewe Boerbokgroep het die hoogste SNF inhoud getoon ($10.7 \pm 5.1\%$) oor die totale periode. Die groter Boerbokke het 'n betekenisvolle ($P < 0.05$) hoër voerinnome gehad. Die korrelasie tussen voerinnome en melkproduksie was $r = 0.7$ vir die Boerbok en $r = 0.4$ vir die Inheemse bok. Die gemiddelde liggaamsgewig vir die Boer en Inheemse bokke onder intensiewe toestande was 45.0 ± 8.7 kg en 32.3 ± 6.1 kg en 42.3

± 8.0 kg vs 29.3 ± 4.5 kg vir die ekstensiewe groep. Heelwat variasie in speenmates is gevind. Piek serum progesteron konsentrasie is bepaal tydens Week 7 vir die Boerbokke (intensief) en Week 12 vir die Inheemse bokke (intensief). Ovarium aktiwiteit (progesteron waardes) het laag gebly in die ekstensiewe groepe deur die observasie periode.

Melkproduksie is betekenisvol verwant met die voedingstatus en genotipe van die bok. Die kwaliteit van die melk is dieselfde as die van die melkbok. Die boerbok is bewys om meerderwaardig te wees as melkproduseerder en gegee die regte voedingsomstandighede, kan bydra om die voedingsbehoefte van die arm plattelandse gemeenskappe te help bevredig.

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