“EFFECT OF MOLASSES AT DIFFERENT LEVELS IN THE CONCENTRATE SUPPLEMENT ON THE MILK YIELD OF DAIRY COWS GRAZING SETARIA GRASS (*Setaria sphacelata*) PASTURE IN THE CENTRAL DIVISION, FIJI”.

by

ERONI. V. TAMANI (S88II4820)

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Animal Science

DEPARTMENT OF ANIMAL SCIENCE
SCHOOL OF AGRICULTURE
THE UNIVERSITY OF THE SOUTH PACIFIC
JULY 2004

ERONI. V. TAMANI (S88114820)

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I, Eroni. V. Tamani (S88114820) declare that this thesis is my own work and that, to the best of my knowledge, it contains no material previously published, or substantially overlapping with material submitted for the award of any other degree at any institution, except where acknowledgement is made in the text.

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Dr. E.M. Aregheore

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ERONI. V. TAMANI (S88II4820)

We certify that this thesis has been approved by the Postgraduate Committee of the School of Agriculture of the University of the South Pacific for the award of Master of Science in Animal Science degree.

________________________ **Date:** ________________________

Professor Alfred. C. Ebenebe
Chairman – Postgraduate Committee
PRO Vice –Chancellor and Head of School of Agriculture

________________________ **Date:** ________________________

Dr Asifo Ajuya
Member – Postgraduate Committee
Head of Department – Animal Science

________________________ **Date:** ________________________

Mr Aca Nagatalevu
Secretary - School of Agriculture

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DEDICATION

I dedicate this thesis to my loving wife Stephanie and children Savenaca, Loimelei and Liuanne Tamani.

And to the beloved memory of my mother who passed away during the course of this study.

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"Vinaka vakalevu"

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Abstract

Farm born thirty milking cows (Friesian) with mean pre-experimental body weight of 428 ± 6.48 kg, 6 - 7 years old, 3 – 4 lactations with an average of 92 days in lactation on 19 August 2002, were randomly allotted to five diets in a completely randomized design experiment to investigate the effect of supplementary concentrate diets with varying levels of molasses on milk yield of cows grazing *Setaria* grass pastures. Treatments were forage alone and forage + concentrate diets with molasses included at 0, 5, 10 or 15 % levels. These treatments were designated as T_1, T_2, T_3, T_4 and T_5, respectively. Voluntary dry matter (DM) intake, average daily gain (ADG), milk yield, body condition score (BCS), blood glucose and urea-N, milk fat and protein and apparent nutrient digestibility coefficients were studied. DM and energy contents of *Setaria* were low compared to the concentrate diets. Concentrate diets had mean crude protein (CP) content of 18.1 %. Fibre fractions neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), hemicellulose and cellulose) and gross energy were higher in concentrate diets than in the forage. Total DM intakes (forage + concentrate diets) were significantly higher (P<0.001) for cows on concentrate diets. ADG was not different among cows. Average milk yield among cows in the treatments were significantly different ((P<0.05) from each other. Fat corrected milk (FCM) was similar among treatments. BCS was better (P<0.001) in cows on concentrate diets. Blood urea-N peaked at 18 d with a significant (P<0.05) difference between cows in T_2, T_3, T_4, and T_5 on one hand and T_1 on the other. Differences between the former were not significant. Mean blood urea-N (BUN) concentration was 3.2±0.18, 4.4±0.33, 4.0±0.30, 3.9±0.23 and 4.0±0.43 mmol/l for T_1, T_2, T_3, T_4, and T_5, respectively. Blood glucose peaked at 18 d and cows on concentrate diets had significantly higher (P<0.05) concentration.

Mean blood glucose concentrations were 2.37±0.29, 2.63±0.32, 2.80±0.29, 2.80±0.40 and 3.00±0.33 mmol/l for T_1, T_2, T_3, T_4, and T_5, respectively. Milk protein increased with time and reached the highest level between 60 and 70 days for all diets ($P<0.05$; $P<0.001$). Milk fat of cows on all treatments followed the same trend as milk protein ($P<0.05$). Digestibility of all components (DM, CP, NDF, ADF, ADL, OM, and energy) measured was significantly higher ($P<0.001$) in cows in T_2, T_3, T_4 and T_5 than those in T_1. For cows on concentrate there were no differences in the digestibility of DM, CP, NDF, ADF and ADL ($P>0.001$). Based on production parameters, molasses levels that range between 5 - 10 % are recommended. Finally, molasses at the 10 % level is recommended in the concentrate diets for optimum milk yield, fat corrected milk, body condition score, milk and blood constituents and apparent nutrient digestibility coefficients of lactating dairy cows on a basal diet of *Setaria sphacelata* in Fiji.

CHAPTER ONE

INTRODUCTION

The Republic of Fiji, an archipelago with a land area of 18 333 km^2, supports a population of 792 000 (SPC, 1998) on its 105 inhabited islands. The landscape has a steeply dissected topography with several peaks greater than 1000m, with a physiography cover of 62% of the total area on larger islands and slopes of 14 degrees less occur only on alluvial terraces of the coastal plains.

The climate is of the tropical oceanic type. Temperature ranges from 29 - 32^{0}C in the wetter months when the humidity is high (October -March) and from 18 - 25^{0}C in cooler drier months (April-September). Mean rainfall ranges from 1700mm to over 4000mm.

Sixty percent of the population is rural and agriculture provides nearly 50% of the nation's employment (MAFF Annual Research Report, 1996). An estimated 95 000 rural households support 500 000 people. Of these, 15 000 raise pigs (average 15 per household), 65 000 raise chickens (average 30), 24 000 raise goats, 100 raise sheep and 43 000 raise cattle. Among the cattle, there are 39 000 multi-purpose draught/meat/milk, 1 800 commercial beef, 2 200 dairy - 215 registered commercial dairies.

The dairy industry in Fiji is well established with the existence of the Rewa Co-operative Dairy Company milk processing facilities and a number of registered farmers. In 1996 the dairy industry was 27.4% self-sufficient in total milk fat equivalents. There were 215 registered dairy farms (179 supplied 11 900 000 litres of fresh milk to Rewa Co-operative Dairy Company in 1996). The competition amongst the producers for necessary resources and infrastructure is very critical for the survival of the dairy industry. The deregulation of the dairy industry has therefore put pressure on farmers to increase production efficiency through supplementation to improve the poor nutritive value of local pastures.

To improve growth, reproduction rate and lactation of the dairy cow within the diverse systems of the Southwest Pacific, is largely a function of the quantity and nutritive quality of daily forage intake. For a target level of animal production from forages, daily ingested young forage leaf and stem DM must have specified levels of protein (nitrogen), (ME), phosphorus, calcium, potassium, magnesium, sulfur, sodium and trace elements (FAO, 1998).

Lactating cows have higher requirements for protein, ME, phosphorus, calcium and sodium than growing animals. Dairy cows need better quality pastures and more supplementary feeding in order to achieve high milk production potential in the Southwest Pacific environments.

Improved nutrition of the lactating dairy animal through supplementation is very crucial because of the low nutritive value of tropical pastures that cannot sustain high levels of production. There is need to match livestock production with available feed resources, this therefore requires the supplementation of low quality pastures with cheap concentrate diets that can be locally produced using available feed stuffs.

To date the dairy industry has been based largely on local pastures however, the poor nutritive value and the tropical environment contribute to low levels of efficiency in production. In order to increase production it is necessary to offer a dairy animal sufficient amount of the right quality feed throughout the year. During the rainy season pasture supplies are normally adequate however, pasture availability and quality decreases during the dry season.

Dairy cow nutrition is mostly affected by the inappropriate use of available energy supplements in Fiji (eg. molasses). Fiji is the only small island in the South Pacific that has an established dairy industry, however, the efficiency of milk production from existing lactating cows is not optimized due to many associated factors especially nutrition.

The existing forage resources have key limitation resulting in the use of supplementary feeds to complement the diet of farm animals. The potential of local forages is limited by long dry periods of overgrazing leading to permanent weed ingress and loss of productive pasture composition.

Mineral deficiencies such as nitrogen, sodium, copper and sulfur reduces forage quality and result in low digestibility and nutritive value of Setaria and other native pastures. Also low legume content of most pastures, lack of locally produced seeds and vegetative planting materials; and inadequate use of protein and energy supplements during the May-November dry season are some factors that affects the milk yield of dairy cows in Fiji.

This research aims at increasing milk production by ensuring that the nutritional needs for maintenance are fully met first so that further physiological activities of producing cows are maximized. Nutritional requirement has always been highlighted as the prominent drawback to why milking cows in Fiji produce well below average compared to cows in New Zealand and Australia. Australia and New Zealand dairy farmers use other sources of supplement to complement the basal diet of forage that lactating cows consume on a daily basis. The aim of this study is to investigate the effect of inclusion of molasses at different levels in concentrate supplement on milk yield of cows grazing Setaria grass pastures in the Central Division of Fiji. Furthermore, the study aims at determining the effects of supplementary feeding on voluntary DMI, milk constituents, blood glucose and BUN concentrations, growth rate, body condition score and apparent nutrient digestibility coefficients.

CHAPTER TWO

LITERATURE REVIEW

2.1 The Dairy Industry in Fiji

Fiji's dairy industry is over 71 years old and it is the only country in the Southwest Pacific where dairy farming is carried out commercially (FAO, 1991). The average milk production from dairy farms in Fiji is about 1,130 kg per cow per year (Samson, 1993). Large quantities of dairy products, mainly butter, are imported each year to meet local demands. This low rate of milk production is probably due in part to under-nutrition, because it has been shown that with adequate feeding the rate of milk production of dairy cows in the tropics can be comparable with production in some temperate countries (McIntyre, 1971).

In the first 35 years of the establishment of the dairy industry in Fiji the predominant pasture species grazed by cows was Para grass (*Brachiaria mutica*) planted on river flats and sub-divided into paddocks of approximately two acres (0.8 hectares). The average production/acre (0.4 hectares) was 92-kg butter fat. The herds were made up of Jersey, Friesian, Short Horn and their reciprocal crosses. During the war years of 1939-45 Fiji exported butter to the United Kingdom. With an increasing demand for milk products at home and limited land for expansion, the advisory officers of the Department of Agriculture recommended that farmers increase the stocking rates and feed a supplement made of coconut meal, rice bran and molasses. As a result of the increase in stocking rate available pastures were gradually infested with weeds, the main one being Navua sedge (*Cyperus aramaticus*). To maintain production levels, supplements were used at a higher rate and this encouraged the invasion of paddocks with weeds due to their neglect by farmers (Roberts, 1970).

The first manufacture of commercial butter was recorded in 1910 in the island of Taveuni. However, it was not until after the 1st World War when organized dairy industry properly commenced with its concentration being in Tailevu, Rewa and Navua. In the early 1930's, butter production from these small factories exceeded local demand, however due to the worldwide depression on export market it became unprofitable resulting in the closure of the Tailevu factory. Diversion from the production of cream for butter to whole milk occurred early in the 1940's and later in 1949, 12,300 cows were recorded on 132 registered herds (MAFF Dairy Profile, 1984).

The present dairy industry is confined to its original areas of the Central Division. There has not been any comprehensive policy to tackle the fundamental constraints of both production and processing; however, the only assistance from Government is through advisory service and subsidies on essential farm inputs to expand production (MAFF Dairy Profile, 1984).

At present the dominant pasture species in these areas are Para grass (*Brachiaria mutica*) on the flats, Batiki blue grasses (*Ischaemum indicum* and *I. timorense*), and Navua Sedge (*Cyperus aramaticus*) (MAFF Research Report, 1970). In the late seventies, further work on dairy pasture improvement resulted in the introduction of Setaria cultivars (Chand, personal comm, 2000).

Milk production over the years has risen but not to the capacity of the processing factory. In an attempt to improve the efficiency of local producers, opportunities were explored on the utilization of sugarcane by-products. Molasses a typical by-product of the sugar industry is available in large quantities for feeding to livestock. Other available byproducts besides molasses which provide useful constituents in dairy ration includes copra meal (coconut) while brewers' grain has not been widely used though it is a potential protein and energy source for ruminant animal (FAO, 1991). Supplementary feeding is very important because most tropical pastures cannot sustain the production of high lactating cows (MAFF Dairy Profile, 1984).

Farmers can significantly manipulate the quantity and quality of nutrients consumed by using a range of pasture types and supplementation. The only means to increase milk yields in Fiji is by improved nutrition and better feeding practices (Samson, 1993). The high imports of dairy products therefore makes it imperative to increase production of local dairy products four folds since market for dairy products within Fiji is a viable one (MAFF Dairy Profile, 1984).

Compared to other developing countries the dairy industry in Fiji is developed. Comparatively production per cow is higher than average for developing countries such Brazil, India, Pakistan, Mexico and Peru to mention six (Samson, 1993). Fiji has a number of large and small dairy farms operated by farmers with long experience in dairying. Also she has a milk factory with a milk collecting, manufacturing and marketing infrastructure, and a population consuming a considerable amount of milk (Samson, 1993).

2.2 Effect of feed on milk yield in Fiji.

The efficient use of feed resources for animal production has become an important issue due to the high costs of production on-farm and worldwide competitions between livestock and humans for cereal. This dictates the efficient use of available concentrate feeds for lactating cows, commensurate with utilization of available forages.

Large quantities of by-products are usually available in the tropics and these can be used to supplement the dairy cattle during the dry season. The use of by-products and crop residues has not been fully explored and in most areas they are discarded or only partially used; therefore valuable sources of potential feed are lost. With proper treatment and storage of by-products and crop residues they could supplement rations for dry season feeding (O'Donovan *et al*. 1972). If available crop residues and byproducts are well stored, they could provide a satisfactory source of nutrients for livestock, however, it is usually difficult to maintain a continuous supply for the entire year (Aregheore, 2000).

The accurate assessment of the energy content and other nutrients in available feedstuffs and a thorough knowledge of factors influencing their use are essential to ensure their efficient utilization by the dairy cow. Information on many tropical feeds and pasture species are not readily available and this has hindered efforts to design appropriate livestock feeding standards in the tropics using locally available feed resources (Harris and Kearl, 1978; Aregheore, 2001).

Energy intake is the most limiting nutritional factor affecting reproduction and production of the dairy cow in Fiji. In a number of studies carried out in Fiji in the 1940's to the early years of 1970's, it was reported that the inclusion of coconut meal in the production ration of dairy cows produced a linear increase in milk production in Jersey and Friesian cows (McIntyre, 1965). For Friesian cows it was observed that for each extra kilogram of coconut meal given per day up to 3.62 kg gave an approximate increase of 0.95kg of milk and 0.036 kg of fat. For the Jersey the same amount of extra feed gave daily increase of 0.589 kg for milk and 0.03 kg of fat. In the study of Parker and Krishna (1970) on rotational grazing of Para grass at two stocking rates (Low = 2.5 cows/hectare and High = 3.75 cows/hectare) they reported an average of 12.9 kg and 11.3 kg yield respectively.

If increased output of milk from cows were desired, it would be necessary to feed concentrate supplements, although careful consideration of the economics of such feeding will be necessary. Energy supplements are mainly required, however in some instances protein supplements may be necessary. Therefore there is the tendency to say that a cow must have a certain amount of feed/day due to her milk production. Since cows are continually building up body reserves or are milking off condition it is suggested that suitable rations for dairy cows should be developed for efficient utilisation of locally available feedstuffs.

Feeding should be considered over the whole lactation because there are periods when high quality feed is required and others when lower quality feed might be adequate. There is no doubt that early lactation is the most important phase of the whole cycle because the cow's potential is being established and every attempt should be made to obtain a high peak milk yield. Tropical pastures are not sufficiently nutritious to meet the cow's energy requirements therefore it is highly desirable to feed concentrate supplements at this time. The cow's ability to respond to extra feed by giving extra milk falls gradually as the lactation proceeds.

2.3 Locally available feed resources in Fiji

Pasture is the foundation of Fiji's feeding system. Better species of grasses like Para-grass or Sateria have been planted on a large scale. Even the best pasture is inclined to seasonal and daily fluctuations in yields and cannot carry an even continuous flow of nutrients for cattle. In the tropics generally, because of the rapid growth of pasture its quality deteriorates fast and therefore cannot effectively support cows to produce more than the existing level of six to ten litres per cow per day (Samson, 1993).

The large and small ruminant populations are dependent predominantly on pastures as the main feed resource for maintenance, growth, meat and milk production, draught (work) and reproductive performances. However increasing amounts of fully compounded feeds and feeds supplement support livestock production in Fiji (Cegumalua *et al*. 1990). Fiji's wet zone has plentiful year round supply of grass and yet very poor dairy production. To improve production levels efforts should be concerted towards making better use of available pastures (Parker, 1977).

There are a number of feed resources available for dairy animals in Fiji, however, the main feed is forage, an extremely valuable asset in the South Pacific region. From nutritional point of view, tropical pastures are regarded as inferior in quality, however, what they lack in quality is made up in quantity. Comparatively tropical pasture produces forages of less variable quality throughout the year than temperate pastures (FAO, 1991).

By-products commonly used as feeds include coconut meal which is the only locally produced concentrate source available in adequate quantities. There are also some animal proteins sources in Fiji namely meat meal, fishmeal, poultry offal meal and tallow that could be used for dairy rations.

A common ingredient that has been used for dairy animals for the past decades is a wheat by-product. This by-product from the Flour Mills commonly known as bran and pollard – mill mix or mill-run is a useful source of animal feed. Its' usage is very wide and well accepted in Fiji and dairy farmers are the biggest users followed by pigs and poultry farmers. In the commercial dairy sector mill mix is used in combination with coconut meal and molasses, generally in the proportion of 40 % coconut meal, 45 % mill mix and 15 % molasses. Dairy cattle eat a mixture of coconut meal and bran better than coconut meal in itself. Bran is one of the cheapest concentrates available (FAO, 1991). There are however, other non-conventional feed resources in Fiji that are not explored as feed for dairy animals. These include sugar cane tops, rice straws, cocoa wastes and brewer's grains (dry or wet).

2.4 Molasses

In tropical areas, sugarcane (*Saccharinn officinarum* L.) produces more energy/area than any other crop. Warnaars (1973) reported that exceptional yields of over 100 years of whole plant sugarcane/acre/year (250 metric tons/hectare/year) can be obtained and high yields of 75 tons are not uncommon.

Sugar cane should be an obvious choice for development, in view of the fact that in many tropical countries it is grown both to satisfy national requirements for sugar and also to serve as the principal earner of foreign exchange from exports. One of its by-products, molasses is a valuable source of energy, and is often either under utilized or exported at a low price. When used in livestock rations, frequently much less than it's maximum value is obtained because it is fed with unsuitable ingredients and in unbalanced diets especially at the on-farm situation.

Molasses is an energy feed, free of fat and fibre and it contains little protein. It is mainly used to improve appetite of animals or add extra energy when prices of molasses are lower than that of other energy sources. It also forms the usual basic ingredient of the growing number of liquid feeds and supplements, used for ruminant livestock (Patton *et al*. 1977; Perez, 2000).

Nitrogen free extract (NFE), the main fraction that represents between 85 – 90% of the DM is composed of a mixture of simple sugars and a non-sugar fraction (Perez, 2000). The non-sugar fraction is poorly digested and fermented in the gastrointestinal tract (GIT).

2.4.1 Effect of molasses on feed intake and milk yield

Supplementary feeding of milking cows is one way to have higher production out of the existing national herd in Fiji. Fiji has an unlimited supply of molasses and every cow in milk should get two or three kilogram of molasses/day. A mixture of molasses and urea is an ideal supplementary feed. The mixture can contribute immensely to higher milk production (Samson, 1993).

Haryanto (1991) in Indonesia reported the benefits of supplementation using molasses for milk production and agreed with the work of (Hendratno *et al*. 1989) that urea mineral molasses block fed to goats and dairy cows ensured continuous supply of nutrients for rumen microbes. Supplementation with molasses blocks for 8 hours per day resulted in a 2.8 fold increase in rumen microbial cell production and in a faster growth rate (Hendratno *et al*. 1989).

Johnson (1969) compared three supplementary rations a] coconut meal and molasses: coconut meal mix: 54 – 64kg coconut meal + 18 litre molasses/water; b] Dairy meal (Crest) and; c] molasses + Morea (Urea + Mineral mix). He found that net return from (a) and (c) was significantly higher than (b). Supplementation with 3kg coconut meal/molasses per cow/day has been shown to double daily milk production (Singh *et al*. 1981 and 1985).

Stobbs and Thompson (1978) indicated that while pasture improvement may be the cheaper long-term measure than supplementary feeding to improve the milk production of dairy cows, the rate of improvement however has been very slow. As an interim measure, the feeding of molasses and coconut meal in addition to other agro-industrial by-products may prove to be economical at improving local dairy production, thus saving foreign exchange. The addition of molasses to forage and urea treated whole crop wheat increased total DM intake in lactating cows however this was not the case with concentrate (Sutton *et al*. 2001).

Inclusion of a small percentage of molasses improves the palatability of the diet and it is particularly valuable when incorporated with coarse unpalatable roughages. While molasses have been used successfully in developed countries for feeding livestock, the recommendation has been that it should not form more than ten percent of the ration. Lofgreen and Otagaki (1960a, b) found that diets containing more than 10 – 15 percent molasses have less net energy although this varied with total feed ration composition. Also Morrison (1967) suggested that the maximum limit of molasses in the diet should be 10 percent, since at higher levels of 30 – 40 percent its feeding value could decline by almost 50 percent.

Contrary to the reports of Lofgreen and Otagaki (1960a, b) and Morrison (1967), Hatch and Beeson (1972) reported that replacing 10 and 15 percent molasses increased nitrogen retention, energy and DM digestibility, and level of butyric acid in the rumen was significantly increased by higher percentages of molasses. Large quantities of cane molasses are produced in tropical areas therefore it is important to explore the possibility of using higher than conventional levels. Preston *et al*. (1967) and Elias *et al*. (1968) reported that molasses could compromise up to 80 percent of the metabolizable energy for beef cattle under specific conditions.

O'Donovan *et al*. (1972) fed dairy heifers at different stages of growth on diets in which cane molasses accounted for 25, 33 and 45 percent of the total weight of feed. The animals gained weight satisfactorily on the first two levels but at the 45 percent level, that contained only 10 percent soybean meal, rate of gain was significantly depressed. This indicated that growing heifers could initially be fed 25 percent molasses and the level could later be increased to 33 percent.

Although the use of molasses alone as a supplement for dairy cows in tropical sugar producing countries has not been reported, it has been tested successfully for grazing beef animals in Brazil (Mott *et al*. 1967) and for feedlot beef production in Cuba (Preston and Willis, 1971).

2.5 Available pasture grass species for dairy cattle in Fiji

The Department of Agriculture in the late 1940's initiated forage evaluation and by the 1970's a number of improved grasses and legumes were introduced and evaluated for different soil types and climatic conditions. It was concluded that species which adapted well to wet areas included:- *Brachiaria decumbens, Brachiaria humidicola, Brachiara mutica, Ischaemum indicum, Panicum maximum*, *Paspalum plicatalum* cv Rodds Bay and *Setaria sphacelata* cv Kazangula and Splendida, and the legumes *Centrosema Pubescens*, *Leucaena leucoc*ephala and *Macroptilium atropurpureum* (Cegumalua *et al*. 1990).

Herbage maturity influences quality more than any other single factor, but plant environment and agronomic factors modify the impact of herbage maturity on forage quality and cause year-to year, seasonal and geographic location effects on forage quality even when harvested at the same stage of development. Year-to-year seasonal variations in environment alter forage quality when harvested at similar maturity stages. This can alter the optimal maturity stage for harvesting forage of a given quality (Buxton, 1996). The importance of seasonal fluctuations in forage supply between dry and rainy seasons will remain a constraint for a long time in the tropics. However, forage will continue to be the major, if not the only source of essential nutrients for grazing dairy cattle. During the long dry season, forages are almost always low in protein and digestible energy and high in fibre and lignin and at this period animal performance is very poor (Henrique and Ilto, 1992).

Tropical pastures generally have lower digestibility than temperate pasture due to early lignification. Since digestibility can drop considerably in the warmer months, it is important where rotational grazing is practiced to keep the spell interval as short as possible (MAFF Training notes, 1997).

Setaria splenda, *S. splendida* and *S. Kazangula* cultivars are widely grown in Fiji's dairy farms due to palatability and high preference by dairy animals. *Setaria sphacelata*, a newly introduced grass has been observed to grow well in alluvial soils where fertilizers are applied (Ranacou, 1985). It is more aggressive than Para grass against Navua Sedge. Cows grazing on Setaria gave equal or higher milk production compared to cows on Para grass.

Setaria is an annual plant with stems that branched little. It generally forms a dense tussock and spreads by short rhizomes. Leaves can be up to 40 cm long and 8 – 20 mm wide but considerable variations in the leaf width and plant height occur. It has a well-developed root system. The tubular stalk is filled with a loose tissue. The leaf blade is widely lanceolate, long acuminate, dense scabrous, and may have a brightly coloured midrib; leaf edges serrate. Leaf sheaths longer than the nodes; collar indistinct, ligule, short and thick. Inflorescence has the main stalk with shortened branching bearing spikes and bristles. Flower two spikelets, the upper bisexual (Ranacou, 1985).

Setaria splendida is a perennial. Leaves are long and narrow with new tillers growing off the main tillers from the base at ground level. New shoots also develop at nodes of mature stems and these may take roots if they touch the ground. New tillers are fan shaped.

Another species, *S. kazangula* is adapted to the wet zone. It has narrower and lighter coloured leaves than *S. splendida*. Studies at Koronivia indicated that *S. splendida* is more productive than *S. kazangula* however *S. kazangula* flowers 3-4 weeks earlier than *S. splendida* from October. Flowers are borne at the end of elongated stems, are cylindrical in shape, brownish in colour and about 45 cm long. *S. splendida* has bigger and greener leaves and is more robust in growth than kazangula. The viability of seeds of *S. splendida* is very low, however it can be propagated vegetatively (by rooted splits) (Ranacou, 1985).

S. sphacelata has received a high attention as a more suitable grass for dairy pastures. At Koronivia Research Station the advantages of Setaria over other prevailing pastures have been reported (Ranacou, 1986 a,b,c). Its comparative advantages are higher DM yield than para grass; higher yield during cold season; keeps growing in cold when para grass stops growing during flowering. It is more aggressive against Navua sedge than Para grass. Also it is palatable to livestock; responds well to fertilizer application and persists well if managed properly (Ranacou, 1985). Proper grazing management is very critical for the persistence and high productivity of the established pasture. Grazing must be rotational and subdivision of paddocks is essential to enable stock control (Ranacou, 1985).

On flat and hill land soils *Setaria splendida* and kazangula gave more DM yields than para grass. Also *Setaria splendida* and Koronivia grasses have been observed to give more DM yields than Batiki blue under cutting regime, respectively (MAFF Annual Research Report, 1985). Rotational grazing of Setaria would normally ranges from 2-3 weeks in wet season and 3-4 weeks in dry season (MAFF Training Notes, 1997).

In a plot cutting trial on hill soils at the Koronivia Research Station yields average in the dry and wet months for Setaria and Batiki blue were 438.3 and 720 kg/ha; and 350 and 500kg/ha, respectively (Ranacou, 1985). The DM yield, CP, CF and energy of Setaria in a study at Koronivia for dry and wet seasons were 96.3 %, 14.2 and 32.7 and 96.3 % and 16.2 MJ/kg; 94.5%, 13.2, 26.2 and 15.3 MJ/kg, respectively (unpublished data, 1994).

2.6 Contribution of tropical pastures to milk production of the dairy cow

Forages comprise 35% to 70% of the DM in the diets of lactating dairy cows. Forage quality impacts DM intake, diet energy density, dietary grain and protein supplementation, feed costs, and lactation performance (Shaver, 2001).

With few exceptions, tropical pastures provide low to medium quality feeds for milk production and it is important to utilize these feeds to the best advantage. There is considerable scope for selecting and planting species of higher feeding value, provided that these species are high yielding, persistent and considerable increase in production are possible. There is potential for improving milk production with better grazing management, particularly by grazing less mature herbage (Stobbs and Thompson, 1978).

Production of grazing ruminants is often constrained in part of the year because of low concentrations of essential nutrients in forage. Little (1982); McDowell *et al*. (1984) and Winks (1984) reported that in the seasonally dry tropics of northern Australia, the Americas and Africa forages contain inadequate concentrations of nitrogen, phosphorus, sulphur and sodium for at least part of the annual cycle. Minson and McLeod (1970) reported that the dry matter digestibility (DMD) of tropical grasses is generally lower than that of temperate grasses.

The quality of DM voluntarily eaten by an animal is the most important factor controlling the productive value of a feed. The intake of pasture herbage is largely controlled by the bulk in the rumen; the more rapidly the breakdown and digestion of feed proceeds, the faster the rate of passage (Thornton and Minson, 1973).

Tropical herbages are relatively low in digestibility and have a low voluntary intake. Dairy cows grazing some tropical pasture swards, with low leaf yields and inaccessible leaf have difficulty in harvesting sufficient feed to maintain stable production. Grazing times on tropical pastures, particularly when trailing legumes and tall stemmy plants are present, have been observed to be excessively long (10-12 hr/24 hr) compared to an average of 6-7 hr/24 hr on higher quality temperate pastures (Stobbs and Thompson, 1978).

Grazing behaviour is also a determinant factor in forage intake. The amount of time spent grazing is dependent on the quantity and quality of herbage on offer, and on the physiological state of the animal (Dalley *et al*. 2001) and the above are important factors influencing herbage intake (Forbes, 1995). Consequently, a major factor limiting milk production from grazed pasture is low herbage intake, which poses particular problems for management of high genetic merit dairy cows at pasture (Mayne *et al*. 1997).

Animals take small bites from tropical pasture swards and increase biting rate in an attempt to increase herbage intake. When cows have difficulty in satisfying their nutrient requirements, grazing is extended into the night. At certain times of the year over 50 per cent of total grazing time is recorded between evening and morning milking. The proportion of night grazing increases with the degree of heat stress. This therefore, emphasizes the need for good night–paddocks for cows grazing tropical pastures as this practice has been confirmed to increase milk production (Stobbs and Thompson, 1978). Increase in herbage intake with increasing herbage allowance would result in an increase in rate of DM intake but not due to an increase in grazing time.

Wilson and Minson, (1980) reported that the higher the proportion of stem in the pasture the lower will be the proportion of energy transferred to meat, milk or wool. Stem DMD declines rapidly with age and in mature herbage stem DMD is lower than that of leaf. The low marginal milk responses to concentrate supplements when cows are consuming highly digestible pastures may be associated with insufficient NDF in the diet. Increasing the amount of cereal grain fed will provide additional fibre to the cow and would be important in maintaining rumen function. There is considerable conjecture as to the concentration of NDF required in the diet of grazing cows to maintain rumen environment especially when they graze highly digestible pastures because of insufficient NDF intake (Wales *et al*. 2000).

Forage cell walls provide the fibre that ruminant livestock require for normal rumen function. Plant cell walls are composed mostly of structural carbohydrates and lignin that accounts 40 to 80% of the organic matter in forage crops. Cell walls limit feed intake and digestibility of forages (Buxton, 1996). Poor quality forages because of their lower voluntary intake complicate the delicate matter of energy balance in the early lactating cow, however, as a result of high milk production, the cow must consume all the DM possible (Guthrie and West, 2001).

Cowan *et al*. (1974) reported that the average production per cow from tropical pastures was in the range of 10 to 12 kg/day for Friesian cows, 7 to 9 kg/day for Jersey and 6 to 10 kg/day for crossbred cattle. They also opined that milk production from potential of tropical was 4,000 kg/lactation for Friesian and 2,700 kg for Jersey. Good quality tropical pastures however, allow animals to build up body reserves for the next lactation. Some steaming up with concentrates may be necessary for cows in poor condition and gains of 0.4 kg/cow/day or more are desirable to allow for growth of the foetus (Stobbs and Thompson, 1978).

Despite being fibrous feeds of low digestibility, tropical pastures are capable of producing good live-weight gains and there is considerable scope for integrating such pastures into dairy feeding programmes (Stobbs and Thompson, 1978). Well-managed tropical pastures are capable of reasonable levels of production once peak production has been achieved. It has been reported that cows grazing improved tropical pastures are capable of producing milk up to about 2 000 kg per lactation.

2.7 Nutrient requirements of the lactating dairy cow

The dairy cow requires five major classes of nutrient - energy, protein, minerals, vitamins, and water. All five are essential for normal health and productive purposes, but some, such as minerals and vitamins, are needed only in very small amounts. Next to water, the greatest requirement is for energy followed by the need for protein. Without adequate energy, utilization of all other nutrients is impaired (Bath *et al*. 1978).

Energy is the most common nutrient limiting lactation. During early lactation, the peak in feed intake lags behind the peak in milk production. Milk production usually peaks approximately six weeks into lactation, whereas feed intake peaks four weeks later at ten weeks after calving. During this ten-week period, the cow is in negative energy balance (i.e., more energy is being put into the production of milk than is taken in through her diet). To meet their needs, cows rely on their body stores of fat (known as body condition). For every kilogram of body fat mobilized, enough energy can be supplied to support 3.2 kg of milk (Donna *et al*. 2001).

Usually energy is the first limiting nutrient for high milk yield because of low energy content of forages. Prolong energy shortage lead to serious body weight and body conditions losses and may affect reproductive efficiency. Maintaining energy balance in the early lactating cows is extremely difficult, especially with low energy forage (Guthrie and West, 2001).

The metabolic activity and the "will to milk" in the early lactating cows are extremely high. For example in the U.S.A. most of the cows reach peak milk production around 35 days in lactation and do not reach energy balance until 10 to 12 weeks (70 to 85 days) into lactation. Most early lactation cows, because of their slow response to increasing DMI, are usually in negative balance from one or two days after calving until 70 to 85 days into lactation. This issue of balancing energy in early lactation is complex because of the interaction between body condition (reflecting degree of fat deposition) and the period of time after calving that cows reach their peak DMI. These are influenced by forage quality and voluntary DMI (Guthrie and West, 2001).

A certain amount is used to maintain her body tissues, which are constantly undergoing the many chemical reactions that sustain life. A growing heifer needs extra energy for the tissue that she is adding to her body during her growth from a calf to a mature cow. A pregnant cow needs additional energy for building the tissues of the foetus developing in her uterus. A lactating cow requires still more energy to manufacture the milk that is being secreted by her mammary glands each day. A non-pregnant, non-lactating mature cow needs only enough feed each day to provide sufficient energy for maintenance.

When feed is restricted, a dairy cow will use the available energy for maintenance and reproduction at the expense of growth and lactation. Therefore, it is important to supply adequate energy if normal growth, high milk production, and more profits are to be obtained. Lactating cow often draws from their body fat deposits when there is inadequate supply of energy in the diet. When body fat is depleted, she uses the available energy first for maintenance. Any energy left above the maintenance requirement can be used for milk production. Drastic drops in milk production after two to three months of lactation are often the result of inadequate energy after body energy stores are depleted.

In a lactating cow, energy for milk production is needed in addition to that required for maintenance, growth, and reproduction. Although other milk components have some effect, energy requirements vary primarily with the amount of milk produced and the fat content of the milk.

There is overemphasis on mineral and vitamin supplementation as often practiced without adequate attention given to energy and protein needs of animals. Because of this protein is a limiting factor for high milk production in most dairy herds (Bath *et al*.1978).

For protein to be utilized by the dairy cow, it must first be broken down by digestion to amino acids from which it was made. Proteins from various sources have different combinations of amino acids. Some amino acids can be made within the body from other compounds, but only plants and bacteria can make others. In a ruminant animal like the cow there are billions of microorganisms in its rumen which are capable of synthesizing proteins for their cells from amino acids and non-protein nitrogen sources derived from the cows diet.

These microbial proteins subsequently are digested and absorbed by the cow, giving her a source of all essential amino acids even though her diets may not have contained all of them in adequate amounts. Cows given purified diets with all of the nitrogen in the form of urea and ammonium salts did not only survived and maintained themselves, but also produced as much as 5,000 kg of milk in a year and reproduced normally. This demonstrated that ruminants could live without preformed protein in their ration so long as nitrogen is available to ruminal microorganisms for protein synthesis.

In order to maximize the biological efficiency of milk production, cows should be fed diets that provide the balance of nutrients appropriate for their stages of lactation and milk production potential. This is rarely achievable in stall-feeding systems, where samples of dietary ingredients eaten can be analyzed. However, the balanced complete diets in which the ingredients are blended in correct proportions, with addition of appropriate mineral and vitamins can be fed according to individual cow production (Kellaway *et al*. 1993).

In a complete mixed ration feeding system, responses in milk production to additional energy was higher in early lactation than in mid or late lactation (Broster, 1972). Stockade (1999) also reported that the provision of supplementary feeds to cattle at pasture improve animal performance over and above what could be achieved from pastures alone to maintain production during periods of pasture shortages and overcome limitations in pasture quality at unfavourable times of the year.

An animal's nutrient requirements during lactation can be higher than that for other physiological functions. The type of supplement offered to dairy cows affects milk responses (Stockade, 1997). Stockade (2000) reported that the objectives of supplementation were to increase total DM and ME intakes, however cows generally substitute the supplement for some of the pastures they would have otherwise eaten. He also indicated that comparative costs of pasture and supplements vary through time, however, in pasture based dairy systems, once farmers have invested in growing pasture, it is economically important to ensure its effective use.

Substitute of supplement for pasture is an important factor that must be considered when feeding any supplementary feed to grazing dairy cows (Leaver *et al*. 1968; Meijs and Hoekstra, 1984; Grainger and Matthew, 1989; Kellaway and Porta, 1993). The concept of energy as most important among other nutrients deserves assessment and its application in animal production.

This requires the understanding of energy system, which is composed of feed energy values and energy requirements of the animal. A good diet will accurately reflect on the ability of an animal to perform a certain amount of work as maintaining the animal, supporting a certain milk yield and growth rate (Weiss, 2001).

The feed and nutrients requirements of ruminant animals in most tropical countries are not well documented. Similarly scant information on feed composition is available but not necessarily applicable to grazing cows. Cows are very selective grazers. Cows prefer leaf to stem; green to dead material and high environmental temperatures is one factor that has affected feed intake (Chacon and Stobbs, 1976).

Recent updates of the nutrient requirement of dairy cattle have pinpointed that DMI is fundamentally important because it establishes the amount of nutrients available to an animal for health and production. Actual or accurately estimated DMI is important for the formulation of diets to prevent underfeeding or overfeeding of nutrients and to promote efficient nutrient use. Relatively underfeeding of nutrients restricts production and can affect the health of the animal, while overfeeding increases feed costs, result in excessive excretion of nutrients into the environment, and excessively high levels may be toxic or have adverse health effects (NRC, 2001).

2.8 Importance of energy and protein in dairy rations

The relationship between protein and energy in rations for ruminants is of great importance in order to obtain a maximal utilization of nutrient supply for milk production. Balch (1967) reported that when energy is limiting the response per unit of protein diminishes where as if energy is not limiting, the increasing response per unit of protein can be explained by the present knowledge in rumen fermentation for microbial protein productions. If the level of fermentable intake can be increased and combined with the appropriate amount of degradable protein, more microbial protein will be synthesized in the rumen and passed to the small intestine for absorption as the amino acids.

Kaufmann (1981) reported that the bacterial transformation in the rumen include an extensive degradation of feed protein (FP) and an energy-dependent bacterial protein (BP) synthesis. Therefore the cow has two protein sources at the intestine to cover the amino acid requirements, the BP and the undegraded part of the protein feed.

A reduced intake of digestible nutrients especially energy, is the main cause of low production. The protein content of tropical pastures is generally low and the concentration falls rapidly with pasture maturity. Trials in which energy and protein supplements are fed to cows grazing tropical pastures have shown that protein is less limiting than energy (Hamilton *et al*. 1970).

Studies on the composition of milk from cows grazing tropical pasture swards also suggested that the intake of digestible energy is the major factor limiting production (Stobbs and Thompson, 1978). Low digestibility of tropical pastures species is the major cause of low milk production in dairy cows in the tropics. Even temperate species grown in hot humid conditions have been shown to have a lower digestibility (Minson and McLeod, 1970) and therefore have a lower milk production potential.

In Finland, the protein/energy relationship required for maintenance in dairy cattle ration is 84 g digestible crude protein/Food unit (DCP/FU) (6.5 g DCP/MJ). The protein needed per kg FCM is 57 g DCP and the corresponding energy requirement is 0.37 FU. When milk production is 10 kg FCM/day, the protein/energy relationship in the whole ration should be 106 g DCP/FU (8 g DCP/MJ), whereas at the level of 30 kg FCM/day it should be 136 g DCP/FU (10-11g DCP/MJ). These values are about the same as the norms for the other Nordic countries (Syrjala, 1981).

High-energy requirements of high yielding cows in early lactation are often not covered. Lack of energy leads to reduce BP synthesis. The relationship between energy and protein metabolism explains the comparable reactions of energy deficit and protein overfeeding. Both conditions lead to high NH_3 excess in the rumen, high blood and milk urea contents. These conditions could lead to liver and fertility problems in the cow. Moreover an energy deficit combined with lack BP results in lower milk protein content (Kaufmann, 1981).

Therefore a combination of high milk protein content together with high urea level may be a sign of fertility problems caused by protein excess in the ration; whereas low milk protein content with high urea level may be a sign of fertility problems caused by energy underfeeding (Kaufmann, 1981). The difficulties in protein metabolism and its relations to milk composition and fertility problems can only be overcome by an optimal energy supply and by using proteins with lower degradation rate (Kaufmann, 1981).

Wales *et al*. (2001) in a study on protein supplementation of mid lactating cows grazing limited amounts of Paspalum (*Paspalum dilatatum Poir*.) in dominantly irrigated pasture reported that response in milk production was limited due to low metabolizable energy consumption however, the supply of an additional energy increased milk production.

In dairy cows the interrelationship between protein and energy yielding nutrients is crucial. The level of protein in the ration can influence performance by changing overall plane of nutrition that is associated with digestibility and intake. The amount of protein supplied to tissues can alter the pattern and efficiency of absorbed nutrient used by the animal particularly in early lactation where protein supplementation favors partitioning of available nutrients towards mammary secretion.

Protein supplementation in early lactation enhance partitioning of available nutrients towards the mammary glands secretion due to the effects of glucose and fatty acids metabolism, all interacting with the endocrine system within a metabolic framework that tends to conserve those nutrients (amino acids, glucose) that are in short supply relative to demand. Response to increased input of amino acids depend both on physiological state of the cow and balance of all nutrients absorbed from the gastrointestinal tract. Thus the interrelationship between protein and energy yielding nutrients both within the rumen and within the ruminants' body can have a big effect on the overall pattern on nutrient utilization.

The major nutrients absorbed from the guts of ruminants are acetic, propionic and butyric acids from the rumen and amino acids, glucose and lipid from the intestine. Once absorbed, these nutrients contribute to the general metabolic pool which also has inputs of nutrients derive, in short term, from body stores. In the long term all inputs to the general metabolic pool come from nutrients absorbed from the guts (Oldham, 1984).

A balanced feeding of lactating cow is fundamental to milk production as well as health and fertility. Energy is an important nutrient for dairy cows both before and after calving and there is no substitute for energy in the diets of ruminants. A balance of energy and protein is required, even before calving and in the dry season (Lotthammer, 1991).

CHAPTER THREE

MATERIAL AND METHODS

3.1 Location

The experiment was carried out at the Koronivia Research Station - Livestock Research Unit, Nausori in the Central Division (18°S, 178° 30′ E) which is situated 19 Km north of Suva at an altitude of about 15-m above sea level. The annual rainfall is about 3,050 mm and mean annual temperature is 24.4°C. The average rainfall, temperature and humidity during the experimental period (19 August – 22 December 2002) were 4.5mm, 23.4^{0}C and 77.2% respectively (Appendix 12a).

3.2 Animals, diets and experimental design.

Thirty farm born milking cows of Friesian breed, 6-7 years old, 3- 4 lactations, mean pre-experimental body weight of 428 ± 6.48 kg with an average of 92 days in lactation were allotted randomly to five diets in a completely randomized design with six replications. Each cow was ear tagged for individual identification purposes and represented an experimental unit.

The treatments were forage alone (T_1) and forage + concentrate diets with molasses included at 0 (T_2), 5 (T_3), 10 (T_4) or 15 % (T_5) levels. The feedstuffs and ingredients used for the concentrate diets were dried brewer's grains, mill mix, copra meal, salt, micro-ingredients and molasses. The concentrate diets were formulated to contain 18 % CP on DM basis, the level considered optimal for dairy cows raised under the tropical conditions of Fiji (Crest Feed, Nausori, Fiji, 2002). The concentrate diets were formulated to be isonitrogenous and isocaloric. Table 1 presents the percentage composition of the concentrate diets while Table 2 presents the proximate composition of the feedstuffs used in formulating the experimental diets.

Table 1: Percentage composition of experimental diets

	DIETS			
Feedstuff/Ingredients	0% (T_2)	5% (T_3)	10% (T_4)	15% (T_5)
Mill mix	53.0	43.0	34.0	25.0
Molasses	-	5.0	10.0	15.0
Dried brewers grain	5.0	10.0	14.0	18.0
Coconut meal	40.0	40.0	40.0	40.0
Salt (NaCl)	0.5	0.5	0.5	0.5
Premix	1.5	1.5	1.5	1.5
TOTAL	**100.0**	**100.0**	**100.0**	**100.0**
Calculated CP	18.5	18.5	18.5	18.5

Table 2: Proximate composition of feedstuffs used for the experimental diets.

	Feedstuffs				
Proximate composition	Mill Mix	Molasses	Dried brewers grain	Coconut meal	Mineral Premix
Dry matter - DM (%)	88.0	77.4	98.3	90.0	-
On dry matter basis Crude protein	16.3	3.5	23.5	18.0	-
Crude fibre	9.5	0.0	14.4	9.0	-
Ether extract	6.0	0.0	0.7	7.5	-
Ash	6.4	8.9	-	5.3	-
Gross energy (MJ/kg)	16.0	12.6	13.7	15.4	-
Phosphorus (mg/kg)	-	-	-	-	3252
Potassium (mg/kg)	-	-	-	-	3787
Sulphur (%)	-	-	-	-	1.32
Calcium (%)	-	-	-	-	5.30
Magnesium (%)	-	-	-	-	2.60
Iron (mg/kg)	-	-	-	-	1.81
Manganese (mg/kg)	-	-	-	-	344
Copper (mg/kg)	-	-	-	-	20.4
Zinc (mg/kg)	-	-	-	-	52.2
Sodium (%)	-	-	-	-	3.19

3.3 Feeding and management

3.3.1. Grazing

The experiment started in August 19, 2002 and ended in December 22, 2002 thus lasted for 126 days. An adaptation period of 15 days was allowed the animals to get used to the treatments before data collection. The cows were grazed in 16 night paddocks composed of Setaria (*S. sphacelata*) as the main grass. The paddocks were stripped depending on their size and the cows grazed the paddocks on rotational basis for 25 - 28 days. During the day, the cows were grazed on three stripped paddocks located near the milking shed on a 15 - 18 days rotation. The cows had access to fresh clean drinking water and mineral lick blocks.

Representative herbage samples of what the cows ate were collected at the beginning, middle and end of the experiment. The samples were dried, processed and stored until required for chemical analysis. Estimation of voluntary herbage intake of cows in the paddocks was according to the procedure of Parker *et al*. (1990) and intake of each cow was determined using the following formula: -

$$\text{Forage intake, kg/d} = \frac{\text{Faecal output, kg/d}}{1 - \text{herbage digestibility}}$$

3.3.2. Concentrate feeding and management

The diets were prepared on a weekly basis from the same batch of feedstuffs and ingredients. During each milking time at 0600 and 1500 h, 300 g of the prepared concentrate was given to avoid spillage, however the rest of the concentrate portion (7.4kg) for each cow was given after the morning and evening milking in individual feeding stalls before they returned to the pasture for grazing. The amounts of concentrate offered in the feeding stalls were estimated at the ratio of 2 litres of milk to 1 kg of concentrate (Samson, 1993).

Concentrate diets offered to the cows were reduced or increased depending on intake and refusals recorded on a daily basis to determine actual intake. Total feed intake for each cow was the sum of voluntary forage intake and concentrate diet offered.

3.4 Data collection.

3.4.1 Milk yield and composition

Milk yield was recorded daily during the morning (0600h) and evening (1500h) milking sessions to determine actual daily milk yield using the Waikato Milk Meters, (Waikato, NZ). Milk samples were collected at the pre-experimental period and 32, 60, 90, and 120 days after treatment started into 200 mls cylindrical vacutainers sampling bottles (Ecolab, NZ) from cows in each treatment. Milk samples collected each period were analyzed for milk fat and protein. FCM was calculated using the following equation (Annon. 1999):

$$FCM = (15 \times FAT/100 + 0.4) \times MILK$$

where:
FAT = milk fat percentage (%)
MILK = milk yield (kg)

3.4.2 Blood composition

With all safety precautions, 5 -10 ml of blood samples was collected from the jugular vein in the morning before feeding at pre-experimental period, 18 and 92 days of experiment. Blood was collected through the jugular vein and 5 -10 ml of blood was taken. The blood was allowed to clot at room temperature for approximately 15 minutes and then placed on ice and later centrifuged (Quantum Scientific PTY Ltd, Queensland, Australia) for 10 minutes at 1500g to separate the serum and stored at – 80^0 C until required for analysis. The serum samples were analyzed for blood glucose and BUN.

3.4.3 Body condition score

Cows were weighed at the beginning of the experiment and biweekly immediately after the morning milking. BCS were assessed visually at the start and end of the experiment using 1-5 condition scoring system (Selk, undated) detailed below. BCS of the cows was evaluated according to treatment.

1. Lower ribs have limited covering, thus are quite visible. Deep cavity between tailhead and pin bones. Bones structures appear extremely sharp.
2. Lower ribs can be felt, but are not prominent. Areas between tail head and pin bones depressed but bone structure has some covering.
3. Lower ribs are smooth. Area between tailhead and pin bones appears smooth without signs of fat deposition. Bone structures are rounded.
4. Lower ribs appear flat with no overhanging shelf effect. Area between tailhead and pin bones is rounded with signs of fat deposition.
5. Bone structure of the backbone, short ribs and pin bone region is not apparent. Tailhead is surrounded with fat deposits.

3.5 Digestibility studies

The procedure of Parker *et al*. (1990) was used for the digestibility study. In brief: intra-ruminal chromium controlled release capsule (CRC, Captec (NZ) Ltd, Auckland) was administered orally to the cows using a dosing gun to stabilize the chromium release rate in the rumen. Towards the end of the trial (days 122 -126) faeces were collected by grab sampling twice a day. Faecal samples were dried in a forced -air oven at 70^{O}C for 48 h before chromium level was determined by using the procedure of Costigan and Ellis (1987). Apparent nutrient digestibility coefficients of cows in concentrate diets with molasses included at 0, 5, 10 and 15 % levels were calculated from the method used for mixed diets outlined by Crampton (1956) as follows:-

$$S = \frac{100\,(T - B)}{s} + B$$

where S = digestibility of the concentrate supplement
B = digestibility of the basal diet (forage from grazing)
T = digestibility of the mixed diets i.e. concentrate supplement and basal diet (forage from grazing)
s = proportion of concentrate supplement in the mixed diet.

Feed refusals were collected each day, weighed and dried in a forced-air oven at 70^0 C for 48h. The processed samples of herbage, concentrate diets and faeces were bulked separately and milled with a laboratory mill (Chris and Norris Ltd; Process Engineers, Chelmsford, UK) to pass through 1.77 mm sieve and stored in air tight plastic bottles until required for analysis.

3.6 Analytical Methods

Proximate chemical analyses for available nutrients in the forage, concentrate diets and faecal samples were carried out according to AOAC (1990). All analyses were carried out in triplicate. DM was determined by drying all samples to constant weight at 70^0C for 48 hr in a forced–air oven. Ash content was determined by incineration at 600^0 C for 3 h, while N was determined by micro-Kjeldahl procedure. CP was estimated as N x 6.25. Analysis of the fibre fractions, NDF, ADF and ADL was according to the outlined procedures of Goering and Van Soest (1991).

Gross energy (GE) values of forage, concentrate diets and faeces were determined by a bomb calorimeter (Adiabatic bomb, Parr Instrument Co. Molin, IL) using thermochemical benzoic acid as standard. Milk fat and protein analyses were carried out according to the procedures outlined by Kirk and Sawyer (1991) and AOAC (1991), respectively. Blood glucose was estimated by a colorimetric assay based on the use of hexokinase and glucose-6-phosphate dehydogenase (Kunst *et al*. 1983), while BUN concentration was estimated by the method of Talke and Schubert (1965).

3.7 Statistical analysis

Data on voluntary DMI, growth rate, blood and milk constituents, milk yield, BCS and nutrient digestibility were subjected to statistical analysis using MINITAB software (Minitab, 2000). Mean, standard error of mean (SEM), analysis of variance (ANOVA) of blood glucose, BUN, milk protein and fat were determined. Curvilinear regression was used to determine the correlation coefficient (r^2) over time to see where the curve line fits the closest data of milk protein and fat concentration. Where there is significant difference, the least significant difference (LSD) test was used for mean separation.

CHAPTER FOUR

RESULTS

4.1 Proximate chemical composition of diets.

Chemical composition of the forage (*Setaria sphacelata*) and experimental diets is presented in Table 3. DM content of the forage (T_1) (15.8 %) was significantly (P<0.05) lower than those of the concentrate diets (T_2, T_3, T_4 and T_5) which had DM content ranging from 88.6 to 89.5 %. CP content of the concentrate diets was within the range of 18.0 -18.2 % compared to 11.1% for forage. Ash content of the forage was however higher than those of the concentrate diets. Fibre fractions (NDF, ADF, ADL, hemicellulose and cellulose) were higher in T_2, T_3, T_4 and T_5 than in T_1. However, among the concentrate diets T_2 had higher NDF than T_3, T_4 and T_5. GE (MJ/kg DM) content of the forage (15.9 MJ/kg DM) was close to those of the concentrate diets which were in the range of 16.2 - 16.7 GE MJ/kg DM.

4.2 Dry matter intake, average daily gain, milk yield and body condition score.

Performance characteristics of cows in the different treatments are presented in Table 4. Forage DM intake of cows in T_1 was higher than those of cows in T_2, T_3, T_4 and T_5 (Appendix 1a). However the differences observed were not significant (Appendix 1b). Concentrate DM intake increased with increase in the level of molasses in diets (Appendix 2a) however concentrates intakes were not significant (Appendix 2b).

Total DM intakes (forage + concentrate) were significantly higher (P<0.001) for cows on concentrate diets than those on forage only. However, differences among concentrate diets were not significant (P>0.001), (Appendix 3a, b). The percentage of forage DM intake was higher than concentrate DM intake of cows on forage + concentrate with or without molasses.

Table 3: Proximate chemical composition of forage and experimental diets.

	DIETS						
Components	T_1	T_2	T_3	T_4	T_5	S.E.D.	L.S.D.
Dry matter - DM (%)	15.8	89.5	88.9	88.7	88.6	20.7	40.4
On dry matter basis							
Crude protein	11.1	18.1	18.0	18.0	18.2	18.2	3.8
Ether extract	2.7	5.3	6.3	6.3	6.4	1.0	2.0
Ash	12.2	6.4	6.6	6.8	7.1	1.6	3.2
Neutral detergent fibre	27.1	38.2	36.5	34.6	33.9	2.7	5.4
Acid detergent fibre	12.5	20.2	20.4	20.5	20.8	2.3	4.6
Acid detergent lignin	6.8	10.7	10.8	10.8	10.9	1.1	2.2
Hemicellulose	14.6	18.0	16.1	14.1	13.1	1.2	2.4
Cellulose	5.7	9.5	9.6	9.7	9.9	1.1	2.2
Organic matter	87.8	93.6	93.4	93.2	92.9	1.6	3.2
Gross energy (MJ/kg DM)	15.9	16.3	16.7	16.7	16.2	0.2	0.4

S.E.D. : standard error of the difference.

Table 4: Performance characteristics of lactating dairy cows fed forage alone or forage + concentrate diets with different levels of molasses

	DIETS							
Parameters	T_1	T_2	T_3	T_4	T_5	S.E.M	L.S.D.	Sig.
No of cows	6	6	6	6	6	-	-	-
Initial live-weight (kg)	430	430	433	426	426	6.5	-	-
Final live-weight (kg)	447	455	457	451	449	6.7	-	-
Weight gain (kg)	17	25	24	25	24	2.1	16.24	ns
Average daily gain [ADG] (g/d)	134	194	193	196	193	0.02	0.13	ns
Forage intake (kg/d)	10.5	9.2	8.7	8.6	8.1	0.43	3.31	ns
Concentrate (kg/d)	-	5.9	5.9	6.1	6.5	0.43	0.78	ns
Total dry matter intake (kg/d) (Forage + Concentrate)	10.5	14.9	14.6	14.6	14.6	0.49	3.16	*
Percentage of forage intake	100	60.9	59.6	58.2	55.8	-	-	-
Percentage of concentrate intake	0	39.1	40.4	41.8	44.2	-	-	-
Average milk yield (lt)	914.8	924.5	1221.4	1418.4	1017.9	56.2	371.6	*
Average daily milk yield (lt)	7.3	7.3	9.7	11.3	8.1	0.45	2.95	*
Fat corrected milk - FCM (kg)	6.3	6.3	8.4	9.2	6.8	0.37	2.47	ns
Body condition score (BCS)	2.5	3.3	4.0	4.1	3.5	0.11	0.46	***

ns = not significant
*, *** $P < 0.05$ and $P < 0.001$ respectively

Average daily live-weight gains (ADG) of cows were 134, 194, 193, 196 and 193 g/d for T_1, T_2, T_3, T_4 and T_5, respectively (Appendix 4a). ADG of cows on concentrate diets were not statistically different from those of cows on forage alone (Appendix 4b).

Average milk yield of cows were 914.8, 924.5, 1221.4, 1418.4 and 1017.9 l for T_1, T_2, T_3, T_4 and T_5, respectively (Appendix 5a). Milk yield of cows in T_1 was lowest. Among cows in the concentrate diets, milk yield was highest in cows that received treatment T_4, followed by cows in T_3, T_5 then T_2. Average milk yield among the treatments were significantly different (($P<0.05$) (Appendix 5b). Milk yield of cows in T_4 was 503.6, 493.9, 197 and 400.5 l higher than those of cows in T_1, T_2, T_3, and T_5, respectively. Average daily milk yield followed the same trend as average milk yield ($P<0.05$) (Appendix 5b). FCM among the treatments was not significantly different from each other (Appendix 5a,b).

BCS of cows in T_1, T_2, T_3, T_4 and T_5 were 2.5, 3.3, 4.0, 4.1 and 3.5, respectively. BCS was significantly different ($P<0.001$) (Appendix 6a) and treatments had significant influence on BCS of cows (Appendix 6b). Comparatively T_3 and T_4 cows were better in BCS than the other three treatments.

4.3 Blood glucose

Table 5 represents data on the effect of treatments on blood glucose concentration of cows during the experimental period. Blood glucose concentration at the pre-experimental period was comparatively low and all cows had similar concentration (Appendix 7a). However, when the cows had fully adjusted to the treatments, blood glucose concentration peaked at day 18. In addition the cows in T_2, T_3, T_4, and T_5 had significantly higher ($P<0.05$) blood glucose concentrations than those in T_1 (Appendix 7b). Periods and treatments had effects on blood glucose of cows ($P<0.001$) (Appendix 7c) and mean blood glucose concentrations were 2.37 ± 0.29, 2.63 ± 0.32, 2.80 ± 0.29, 2.80 ± 0.40 and 3.00 ± 0.33 mmol/l for T_1, T_2, T_3, T_4, and T_5, respectively.

Table 5: Blood glucose concentration (mmol/l) at three selected times for lactating cows fed forage alone or forage supplemented with concentrate with varying levels of molasses

			DIETS					
Period (days)	T_1	T_2	T_3	T_4	T_5	s.e.m	l.s.d	significance
0	1.0	0.9	1.3	1.0	1.2	0.13	0.805	ns
18	2.8	3.4	3.5	3.5	3.7	0.99	0.568	*
92	3.3	3.6	3.6	3.9	4.1	1.25	0.537	ns
mean	2.37	2.63	2.80	2.80	3.00	-	-	-
s.e.m	0.29	0.32	0.29	0.40	0.33	-	-	-
l.s.d	0.94	0.57	0.67	0.53	0.57	-	-	-
significance	***	***	***	***	***	-	-	-

ns = not significant.
*, *** ($P < 0.05$) and ($P < 0.001$) respectively

4.4 Blood urea-N

Table 6 represents BUN concentration of cows at the pre-experimental period and during experimental period (Appendix 8a). At the pre-experimental period BUN concentration was not significantly different among the treatments. However, when the cows had adjusted to the treatments, BUN peaked at18 d with a significant ($P<0.05$) difference between cows in T_2, T_3, T_4, and T_5 (Appendix 8b) on one hand and T_1 on the other. Differences between the former were not significant.

Compared to the BUN obtained on 18 d, it was observed that as the experiment progressed towards the end at 92 d a simility existed among treatments in BUN concentration (Appendix 8c). Mean BUN concentration was 3.2±0.18, 4.4±0.33, 4.0±0.30, 3.9±0.23 and 4.0±0.43 mmol/l for T_1, T_2, T_3, T_4, and T_5, respectively.

Table 6: BUN (mmol/) concentration at three selected times for forage alone or forage supplemented with concentrate with varying levels of molasses.

	DIETS							
Period (days)	T_1	T_2	T_3	T_4	T_5	s.e.m	l.s.d	significance
0	3.5	3.2	2.7	3.3	2.9	0.25	1.56	ns
18	3.2	5.6	5.6	4.5	5.1	0.26	1.39	*
92	3.0	4.5	3.7	3.8	4.0	0.15	1.05	ns
mean	3.2	4.4	4.0	3.9	4.0	-	-	-
s.e.m	0.18	0.33	0.30	0.23	0.43	-	-	-
l.s.d	0.97	1.28	1.32	1.12	2.05	-	-	-
significance	ns	**	*	ns	ns	-	-	-

ns = not significant
*, ** (P<0.05) and (P<0.01) respectively

4.5 Milk protein

Milk protein concentration measured at the pre-experimental and on a monthly basis during the experimental periods for cows in T_1, T_2, T_3, T_4, and T_5 are presented in Table 7 (2.9, 2.9, 3.0, 2.8 and 2.9) while individual cow data is presented in Appendix 9a. There were no significant differences (P>0.05) among cows at the pre-experimental period (Appendix 9b). Also, the concentration of milk protein on monthly intervals did not differ significantly between the treatments. Mean milk protein concentration of cows was 2.9±0.09, 2.9±0.12, 3.0±0.10, 2.8±0.09 and 2.9±0.08 % for T_1, T_2, T_3, T_4, and T_5, respectively.

There was a significant increase in milk protein over time during the study period (Figure 1, Appendix 9c). Milk protein increased with time and reached the highest level between 60 and 70 days for all diets. Between 41 % (15 % molasses) and 75 % (10 % molasses) of variability in milk protein was explained by differences in period of milking. A highly significant (P<0.001) correlation coefficient was established between milk protein concentration and period (days) with $r^2 = 0.70$, $r^2 = 0.67$, $r^2 = 0.49$ and $r^2 = 0.41$ for forage alone and forage plus concentrate diets with 0%, 5% and 15% molasses inclusion, respectively. Similarly there was a significant

(P<0.05) correlation coefficient between milk protein and period for cows on forage + 10 % molasses concentrate, $r^2 = 0.75$. The degree of closeness between the relationships of milk protein concentration over time can be explained by the quadratic equations below:

$T_1 = -0.0002x^2 + 0.0275x + 2.2629$; $T_2 = -0.0002x^2 + 0.0339x + 2.1171$;

$T_3 = -0.0002x^2 + 0.0204x + 2.5886$; $T_4 = -0.0002x^2 + 0.0273x + 2.34$

$T_5 = -0.0001x^2 + 0.0166x + 2.5857$

Table 7: Milk protein (%) concentration of cows fed forage alone or forage supplemented with concentrate with varying levels of molasses

			DIETS					
Period (days)	T_1	T_2	T_3	T_4	T_5	s.e.m	l.s.d	significance
0	2.1	1.9	2.4	2.2	2.4	0.08	0.47	ns
30	3.3	3.4	3.5	3.3	3.4	0.06	0.43	ns
60	3.0	3.1	3.1	3.0	3.0	0.07	0.50	ns
90	3.0	2.9	3.0	2.9	2.9	0.04	0.28	ns
120	2.8	2.8	3.0	2.5	3.0	0.07	0.43	ns
mean	2.9	2.9	3.0	2.8	2.9	-	-	-
s.e.m	0.09	0.12	0.10	0.09	0.08	-	-	-
l.s.d	0.34	0.44	0.55	0.42	0.37	-	-	-
significance	***	***	*	***	***	-	-	-

ns = not significant
*, *** P< 0.05 and P < 0.001 respectively

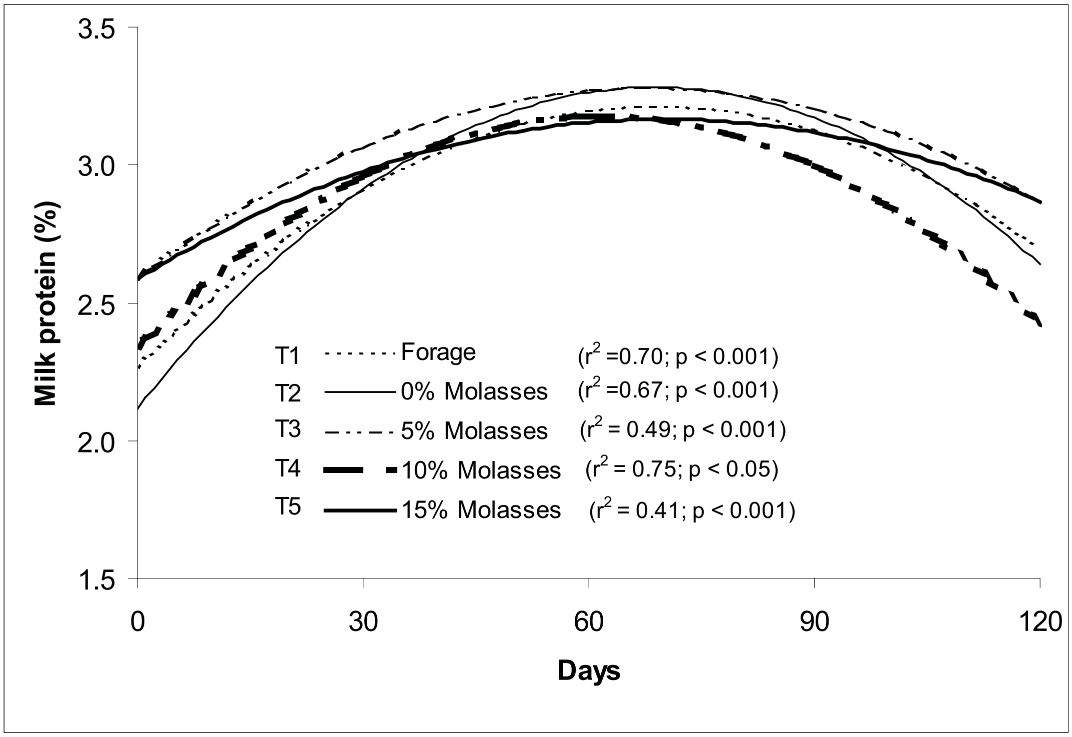

Figure 1: Trend of milk protein concentration of cows fed forage alone or forage supplemented with concentrate with varying levels of molasses on monthly intervals over the experimental period.

4.6 Milk fat

Milk fat concentration at the pre- and on monthly intervals over the experimental period for cows fed the five diets is presented in Table 8 (3.17, 3.33, 3.20, 3.00 and 2.97) while individual cow data is presented in Appendix 10a. Milk fat concentration of cows in all treatments followed the same trend as milk protein ($P>0.05$), (Appendix 10b).

Effect of experimental days on milk fat production of cows in the different diets is represented graphically in Figure 2 and statistically in Appendix 10c. Mean milk fat concentration of cows were 3.17±0.182, 3.33±0.152, 3.20±0.127, 3.00±0.161 and 2.97± 0.169 % for T_1, T_2, T_3, T_4, and T_5, respectively and experimental days had significant influence ($P< 0.05$; $P< 0.001$) on milk fat concentration of cows in all treatments (Table 8). It was observed that after the initial adjustment period the concentration of milk fat improved significantly for cows in T_2 ($P<0.05$) and T_1, T_4, and T_5 ($P<0.001$) respectively.

Table 8: Milk fat (%) concentration of cows fed forage alone or forage supplemented with concentrate with varying levels of molasses..

	DIETS							
Period (days)	T_1	T_2	T_3	T_4	T_5	s.e.m	l.s.d	significance
0	1.5	2.0	2.2	1.7	1.5	0.16	0.99	ns
30	3.6	2.9	3.0	2.9	3.4	0.12	0.78	ns
60	2.9	3.0	3.0	2.7	2.7	0.07	0.47	ns
90	3.1	3.4	3.3	2.9	3.0	0.01	0.65	ns
120	3.5	3.6	3.3	3.4	3.2	0.14	0.95	ns
Mean	3.17	3.33	3.20	3.00	2.97	-	-	-
s.e.m	0.182	0.152	0.127	0.161	0.169	-	-	-
l.s.d	0.834	0.789	0.776	0.710	0.844	-	-	-
significance	***	*	ns	***	***	-	-	-

ns = not significant; *, *** $P< 0.05$ and $P< 0.001$ respectively

Figure 2 illustrates a significant increase ($P<0.001$) in milk fat during the study period. Milk fat increased with time and reached the highest levels between 90 and 120 days for all diets. Coefficient of determination (r^2) between milk fat and period (days) were 0.61, 0.92, 0.95 and 0.75 for cows on forage alone and forage + concentrate with 0%, 5%, 10%, and 15 %. The degree of closeness between the relationships of milk protein concentration over time can be explained by the quadratic equations below:

$T_1 = -0.0002x^2 + 0.0355x +1.8629$; $T_2 = -0.00000009x^2 + 0.0228x +2.0829$

$T_3 = -0.0001x^2 + 0.0204x +2.2743$; $T_4 = -0.0002x^2 + 0.0209x +1.8971$

$T_5 = -0.0002x^2 + 0.0329x +1.8171$

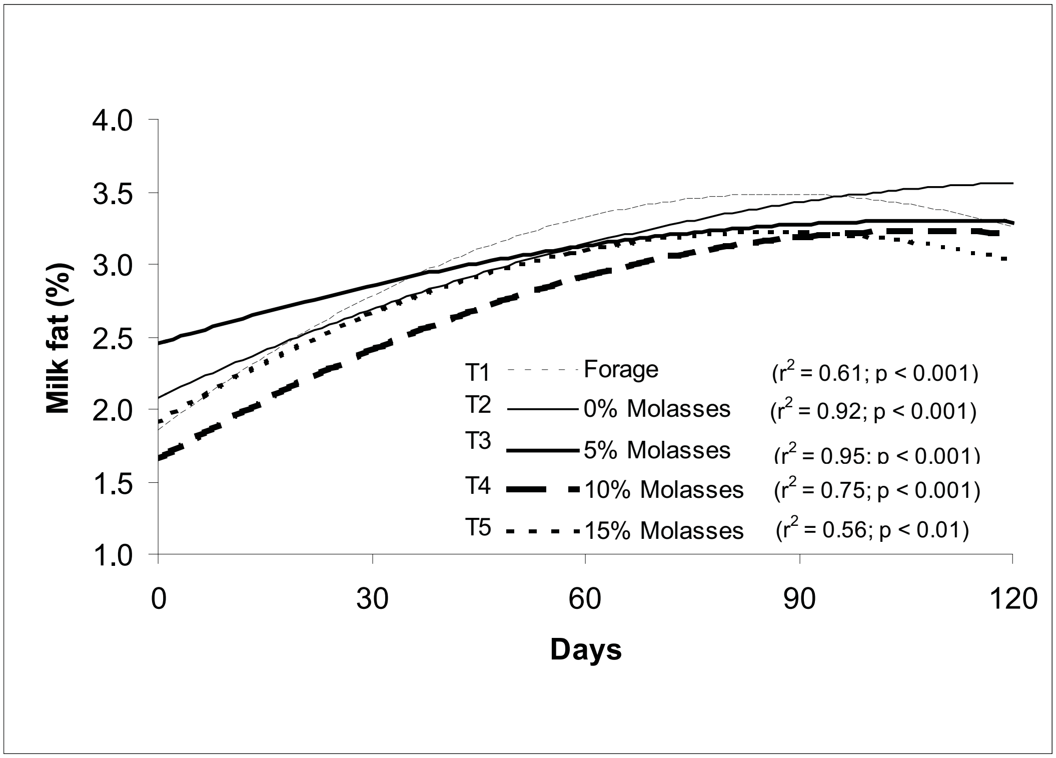

Figure 2: Trend of milk fat concentration of cows fed forage alone or forage supplemented with concentrate with varying levels of molasses on monthly intervals over the experimental period.

4.7 Apparent nutrient digestibility coefficients

Table 9 represents data on apparent nutrient digestibility coefficients of cows while Appendix 11a represents data on individual cow apparent nutrients digestibility coefficient according to treatments.

The digestibilities of all components (DM, CP, NDF, ADF, ADL, OM, and energy) measured were significantly higher (P<0.001) for cows on T_2, T_3, T_4 and T_5 than those on T_1 (Appendix 11b). Cows in the concentrate diets showed no statistically significant differences in the digestibility of DM, CP, NDF, ADF and ADL nutrients (P>0.001). However OM and energy digestibility were significantly higher (P<0.001) for cows on T_4 while apparent digestibility of other nutrients were observed to decrease with increase in levels of molasses included to the concentrate diets.

Table 9: Apparent nutrients digestibility coefficient of cows fed forage alone or forage supplemented with concentrate with varying levels of molasses.

	DIETS							
Nutrients (%)	T_1	T_2	T_3	T_4	T_5	s.e.m	l.s.d	significance
Dry matter	56.6	59.5	61.2	70.6	68.9	1.05	2.21	***
Crude protein	57.8	66.5	67.2	67.7	65.8	1.1	0.86	***
NDF	51.8	63.5	64.2	64.6	62.9	0.9	0.52	***
ADF	51.3	62.7	63.0	66.0	62.3	0.9	0.82	***
ADL	50.6	61.7	62.6	62.7	61.7	0.8	0.78	***
Organic matter	52.4	61.6	62.2	69.7	63.3	1.0	0.74	***
Energy	52.1	60.7	61.6	65.9	61.9	0.8	0.73	***

NDF - Neutral detergent fibre; ADF- Acid detergent fibre; ADL - Acid detergent lignin
*** $P<0.001$

CHAPTER FIVE

DISCUSSION

5.1 Composition of forage and concentrate diets

DM and CP contents of the *Setaria sphacelata* used in this trial are in agreement with values reported by Gohl (1981). CP content of 11.1 % suggested that the herbage was of medium quality. The high ash content of the forage indicates that it was high in minerals. Compared to most tropical grasses the fibre fractions were low. Also its energy value was consistent with estimates for forages fed to ruminant livestock in other tropical countries (Butterworth, 1964). Compared to other grass species in Fiji, *Setaria sphacelata* has high DM yield, nutritive value and persistence. These qualities have over the years attracted dairy farmers in Fiji to its usage (Ranacou, 1985).

All the concentrate diets had similar DM content and analyzed CP and GE contents are similar to calculated values. The diets were formulated to be isonitrogenous and isocaloric so as to remove nitrogen and energy as variables. The average CP content of 18.1% for the concentrate diets is the same as value recommended to meet milk production requirements of lactating dairy cows in the tropical environment of Fiji (Crest Feed, Nausori, Fiji 2002). Also the CP content of the forage and concentrate diets are within recommended levels suggested by National Research Council (NRC), (2001) as adequate to meet the requirements of the live-weight of cows used in this trial.

NDF indicates an index of bulk and it was observed to decrease with increasing levels of molasses in the concentrate diets and this could be due to the diluting effects of molasses. NDF content of the concentrate diets was higher than the minimum range of 25 to 28 % recommended by NRC, (1989) as adequate for an efficient rumen environment. However, the average NDF value of 35.8 % is below concentrations of 55 - 60 % DM which may limit feed intake (Meissner *et al* 1991). ADF content ranged from 20.2 to 20.8% and this was similar in value to minimum range of 19 to 21 % recommended as ideal in ruminant diets (NRC, 1989). However, all the concentrate diets had similar contents of organic matter and energy.

5.2 Voluntary dry matter intake (DMI), average daily gain, milk yield and body condition score.

Voluntary DMI is important in nutrition because it establishes the amount of nutrients available to an animal for health and production (NRC, 2001). It is also influenced primarily by dietary and animal factors. DM content of diets was observed to influence total DMI of cows. The higher DMI in the forage + concentrate diets above the forage alone supports Laird and Leaver (1981) who reported that DMI of cows increased linearly as percentage of DM in the concentrate diets increase.

DMI of the concentrate diets increased with the addition of molasses. Molasses is a concentrated plant juice, and as such contains a wide range of trace minerals, vitamins, sugars (sucrose, glucose and fructose, usually about 2:1:1) and is particularly rich in potassium and sulphur (Sudan and Leng, 1986). In this experiment molasses might have acted mainly to increase efficiency of utilization of the diets.

Improved DMI of cows in forage + concentrate diets is in agreement with Berry and Pena (1981), Gill *et al.* (1981), and Yan *et al*. (1997), who reported higher total feed intake in diets of dairy cows supplemented with molasses. The level of molasses used in the concentrate diets was within the range reported by Hatch and Beeson (1972). The cows were healthy throughout the experiment indicating that the levels of molasses used were not detrimental. The incidence of reduced milk yield, scouring in some cows and ketosis (Losada and Preston 1974) were not observed in any cow throughout the experimental period.

All the cows grazed the same paddocks on rotational basis together, and none of the differences in average milk yield can be attributed to differences in pasture quality. The cows on supplemented diets ate slightly less forage because they received supplementary feeding. This observation is in conformity with Spiekers *et al*. (1991) who reported that with higher intake of concentrate the intake of forage was lower. The cows on forage + concentrate diets were higher in average milk yield.

The above average milk yield of cows in forage + concentrate diets than those of cows on forage alone is in agreement with Sawal and Kurar (1998) who reported higher level of milk yield with higher input of concentrate with straws and hays as roughage. The average milk yield of cows on forage + 5, 10 and 15 % molasses concentrate diets were higher than of cows on forage alone and forage + 0 % molasses concentrate diet. This observation is in agreement with Yan *et al*. (1997) who reported improvement in milk production with dietary molasses inclusion up to 250 g/kg DM. However in this trial cows on forage + 15 % molasses concentrate diet had lower milk yield than those on forage + 5 and 10 % molasses concentrate diets, indicating that lower levels of molasses improved milk yield than a higher level and this agrees with Lofgreen and Otagaki (1960a) who earlier reported that diets that constitute more than 10% molasses reduces milk yield. However, it contradicts the reports that inclusion of molasses at 26% (Murphy, 1999) or 31 % (Yan *et al*. 1997) in total DM in a complete diet of grass silage/concentrate significantly increased milk yield and protein concentration.

Average daily milk yield of cows in this experiment was higher than national average daily milk production (Singh *et al*. 1985; FAO, 1991 and Rokomatu, 2001). The high average daily milk yield of cows on forage + 10 and 5 % molasses concentrate diets at 11.3 and 9.7 litres, respectively demonstrates that the inclusion of molasses in concentrate diets at 5 to 10 % level seems ideal as supplementary feed to grazing cows on *Setaria sphacelata* for improved milk yield in the tropical environment of Fiji

The amount of fat deposited on an animal's body contributes to what is referred to as body condition. Visually and meaningfully, the best indicators of body condition are the amount of fat on the backbone, hips and ribs and around the base of the tail (i.e., at the junction of the tail with body) and the prominence of the pin bones (Domeoq *et al*. 1997). BCS followed the pattern of ADG of the cows. The differences obtained between the treatments suggested variation in the efficiency of utilization of energy released during digestion. The lower body condition of cow on forage alone seems to indicate that the cows utilized all absorbed nutrients from the forage for maintenance and milk production and therefore has minimum available to store as fat. Furthermore, the low BCS for cows on forage alone and forage + 0% molasses concentrate diet suggested a repartitioning of nutrients from body fat to other tissue compared to cows on forage + 5 and 10% molasses concentrate diets.

5.3 Blood glucose

Blood glucose increased with levels of molasses in the concentrate diets. Molasses is usually used as an intake stimulant and energy source for cattle. The increase observed indicates that cows responded positively and differently to available energy in the diets. Maglad *et al*. (1983) reported higher blood glucose levels when sheep were fed diets that contained 15 and 20 % molasses. Blood glucose obtained in this trial suggests stable level of VFA and an increase in the proportion of propionic acid in the rumen. This might have resulted in faster and complete fermentation of the less fibrous carbohydrate in the molasses based concentrate diets.

Furthermore, Marty and Peterson (1970) and Ndumbe *et al*. (1964) reported that increase in blood glucose could be attributed to an increase in the proportion of propionic acid at the expense of acetic acid as the molasses content of diet increases. Although the concentrate diets were isocaloric, in this trial, it was observed that the group that had higher intake of the concentrate diet (Table 5) had higher blood glucose concentration, and this observation is in line with the report of Dhimann *et al*. (1991), but disagrees with Lykos *et al*. (1997). Blood glucose levels obtained is similar to values reported by Kawashima *et al*. (2002) and also within the normal ranges for cattle with greatest between diet differences (Thorpe *et al*.2000). Blood glucose levels in the current study meet the extensive glucose requirement of the lactating dairy cow (Reynolds *et al*. 1988).

5.4 Blood urea-N

BUN concentration increased markedly after adjustment to the molasses based concentrate diets at 18 d. The significant effect of period on the BUN of cows on forage + 5 % molasses concentrate diets suggest that microbial protein fermentation and fixation was better at low molasses concentrate diet. However, BUN of cows on other diets seems to suggest that ruminal ammonia was not well utilized for optimal microbial growth and this led to protein shortage.

When rumen microbes under utilized ammonia (converted to microbial protein), this is absorbed across the rumen wall into the blood. This can shift blood pH and when converted to urea is released into the blood as BUN (McIlmoyle, 2003). Blood-N is used as a supplementary indicator of nitrogen utilization and feeding adequacy in dairy cows (Eckart, 1980; Kaufmann, 1982; Oltner *et al*. 1985) and the main theory behind this concept is that urea concentrations in blood can provide information on nitrogen losses following absorption of ammonia from the gut (particularly the rumen)

BUN levels for cows in this trial are in line with values reported by Yan *et al* (1997) for dairy cows. The differences observed in BUN with increase in molasses support the finding of

Maglad *et al*. (1983) with sheep. Overall, BUN levels of cows in this trial fell below the 10mg/100ml level reported by Preston (1982) as indicative of efficient BUN utilization.

5.5 Milk protein

Milk protein concentration was affected by period and diets (Table 7). The decrease in milk protein concentrations is in line with Murphy (1999) who reported that increasing molasses in diets resulted in a decline in milk protein level. Contrarily, Keady and Murphy, (1998) and Murphy (1999) reported increase in milk protein concentration when molasses was included in forage silage diets and attributed the increase to microbial protein synthesis and amino acid production. Increase in milk protein concentration could be the consequence of increase in energy intake associated with increasing proportion of molasses in the diets (Yan *et al*. 1997).

Robinson (1996) stated that typical milk protein would decrease as the stage of lactation progressed in the range of 3.6 to 3.8 %, however, in this trial milk protein concentration was observed to increase with duration i.e. the number of days in the trial. Comparatively, milk protein values in this study are within the reference range of 2.80 - 4.00 described by Eckles *et al*. (1951) for dairy cows. The data on milk protein concentration seems to indicate that the cows accumulated nitrogen in the blood that was transformed to nitrogen during milk synthesis, an indication of dietary protein and carbohydrate fermentation; rumen efficiency and protein/energy balance.

Except for the difference observed on 18 d for BUN, blood urea and milk protein did not differ among treatments but varied in relation to period. Dietary sources and amount of energy, CP and fat are associated with milk protein production and the distribution of N fractions of milk. In this trial, milk protein concentration followed very closely to pattern of BUN, although milk protein tended to be less than BUN. This observation is in agreement with Rosler *et al*. (1993) who reported that milk protein tended to be less than BUN in cows fed diets varying in rumen degradable protein. It has been postulated that a surplus of N intake increases blood urea-N. Moreover there is a close relationship between blood urea-N and milk protein, and milk protein is affected as the ratio between protein and energy intake increases. However, in this trial there seems to be no explanation why BUN was greater than milk protein.

5.6 Milk fat

Milk fat concentration was observed to decrease with increase in the level of molasses in the concentrate diets. A number of dietary factors such as amount of roughage intake and forage to concentrate ratio may cause variable response in milk fat concentration. The forage to concentrate ratio of total DM intake in this trial was in the range of 55 – 61 forage and 39 - 44 concentrate (Table 4). The forage to concentrate ratio is consistent with the report of Atkinson (1998) that diets containing 50 or more roughage and at least, 21% ADF and 28% NDF facilitates rumen condition that would yield acceptable level of fat. The concentration of milk fat obtained in this trial is consistent with normal milk fat concentration of Holstein Friesian cows.

The effect of molasses on milk fat concentration in this trial concurs with McKendrick (1996) who reported that partial replacement of concentrate with cane molasses reduced milk fat of cows on grass silage based diet. Furthermore the drop in milk fat concentration observed is in line with a number of Australian studies with grazing cows that showed equivocal effects of feeding molasses on milk fat concentration (Yan *et al*. 1997). Consequently, the resultant effect of molasses on milk fat concentration disagrees with Mayne (1989) and Woods (1990) who did not find significant differences in milk fat when molasses replaced concentrate or silage in the rations of dairy cows.

5.7 Apparent nutrient digestibility coefficient.

DM digestibility in cows fed forage + concentrate diets were similar but differed significantly from cows in forage alone diet. Khalili (1993) and Khalili *et al*. (1993) reported that molasses improved DM and OM digestibilities when crossbred cattle were fed tropical hay-based diets. The cows responded well to the digestibility of DM and OM. Generally, OM digestibility (OMD) is used to predict the value of ME of diets offered to animals. The higher the OMD, the higher the expected ME. The feed with higher OMD is expected to provide more energy and therefore more production, i.e. high live weight gain and milk yield. And this was the trend obtained in this experiment with respect to live weight gain and milk yield. The cows that received forage + 10 and 5 % molasses concentrate diets had higher OMD compared to the other diets. This may be the reason for the corresponding low milk yield and live-weight gain obtained in cows on those diets. Comparatively there was a decrease in OMD at 15 % molasses concentrate diet.

Increasing the rate of fibre digestion is of major importance as a way to improving animal productivity on roughage based diets (Preston and Leng, 1985). Among the forage + molasses concentrate diets the digestibility of fibre fractions (NDF, ADF, ADL) were lowest only at the forage + 15 % molasses concentrate diet, the highest level used in this trial. The reduction in apparent digestibility of NDF and ADF might be related to low glucogenic characteristics of rumen fermentation due to low concentration of propionic acid (Marty and Preston, 1970). The feeding of molasses at higher levels has been reported to decrease ruminal fibre digestion (Ahmed and Kay, 1975; Khalili and Huhtanen, 1991; Osuji *et al*. 1995; Hall, 2003) and cellulose digestion, (Jones and Peralta, 1981; Sutton *et al*. 1981; Sutton 1979). The depression in fibre digestion could be attributed to low ruminal pH. In this study the low digestibility of NDF and ADF in cows on forage +15% molasses concentrate diet could related to the level of molasses and not to level of protein because all the diets were isonitrogenous. However, NDF, ADF and ADL digestibility of the concentrate diets was above 60 % level, indicating that the level of protein in the diets was nutritionally adequate to facilitate the effective digestion of the fibre fractions by rumen microbes.

In the present study molasses supplementation did not reduce energy and CP digestibility an indication that available energy and CP in the diets were efficiently utilized for production purposes. The concentrate diets were isonitrogenous and isocaloric and these may be responsible for the similarities in their digestibility compared to forage alone. Fibre fractions (NDF, ADF and ADL) digestibility was high and close in cows in the forage + concentrate diets and this seems to indicate that cows grazed mostly the succulent parts (leaf and stem) of the forage and this enhanced fermentative action by rumen microbes with little effects of molasses in the concentrate diets.

In this trial molasses did not reduce CP and energy digestibility an indication that available protein and energy were efficiently utilized for production purposes. Overall apparent nutrient digestibility coefficients of cows in the forage alone (*Setaria sphacelata*) were above 50 % while the forage + molasses concentrate diets were above 60 %. The apparent nutrient digestibility coefficients of the forage (*Setaria sphacelata*) alone demonstrated that it was of medium nutritive quality and therefore could be used as a basal diet for lactating dairy cows. The cows effectively utilized the molasses concentrate diets for maximum ADG and milk production.

5.8 Conclusion and Recommendations

Compared to what operates at the specialized dairying units in Fiji, the overall milk production and body condition scores of cows offered the molasses concentrate diets were higher than the national standard. In most dairy farms in Fiji, there are no laid down feeding standard with respect to the quantity of molasses, mill mix and copra meal that could be mixed as supplements to lactating dairy cows grazing Setaria or other grass species. The effective inclusion of brewers' dry grains in the concentrate diets used in this trial also contributes to the list of feed resources for dairy animals however this is not presently used in Fiji. Data obtained in this trial indicates that milk yield from cows consuming concentrate diets were higher than those in forage alone.

A comparison of the concentrate diets, indicates that diets with molasses were better in average daily milk yield, fat corrected milk and body condition score indicating that molasses can improve the above parameters in the diets of lactating dairy cows. However, among the molasses concentrate diets, cows on the 10 % molasses based concentrate (T_4) were best in average daily milk yield, fat corrected milk and body condition score, followed closely by those on 5 % (T_2) and the lowest 15 % molasses (T_5). The inclusion of molasses at high levels has been noted to decrease milk production (Wood, 1990), increase health problems including sub-clinical ketosis (Losada and Preston, 1974), molasses toxicity (Preston and Willis, 1974) and loose feaces, which is often associated with diarrhoea (Scott, 1953). Although all cows remained healthy through out the experimental period, molasses level above 15 % would not be recommended in the concentrate diets of dairy cows in Fiji.

To appreciate the role of locally available feed resources it is imperative to have knowledge of nutrient composition to facilitate the formulation of concentrate diets that can meet nutritional requirements (protein and energy) of the lactating dairy cow in tropical environment of Fiji. Locally available feedstuffs such as dried brewers' grain, mill mix, coconut meal with a non-fibre carbohydrate (NFC) energy source such as molasses provides sufficient protein and energy in the concentrate diets of lactating dairy cows for maintenance and milk production. However, the NFC energy source in the form of molasses should not exceed 10 % level in the concentrate diet.

This study therefore demonstrated that lactating dairy cows in Fiji needs a level of readily fermented energy source such as molasses in their diets, however a level above 10 % in the concentrate diet is not nutritionally suitable for lactating dairy cows. Finally, based on production parameters, molasses levels that ranges between 5 - 10 % are recommended over 15 % level. However, for optimum milk yield, FCM, BCS, milk and blood constituents and apparent nutrient digestibility coefficients, molasses at the 10 % level is recommended in the concentrate diets of lactating dairy cows on a basal diet of *Setaria sphacelata* in Fiji.

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APPENDICES

APPENDIX 1a

FORAGE INTAKE (kg/d) IN COWS ON DIFFERENT LEVELS OF MOLASSES SUPPLEMENTS DIETS.

TREATMENT	Day 1	Day 2	Day 3	Day 4	Day 5	Average
Forage	12.10	9.46	12.10	8.26	11.47	10.68
Forage	9.60	9.74	9.68	8.69	9.23	9.39
Forage	7.58	15.40	8.55	17.50	12.90	12.39
Forage	9.97	14.20	8.99	8.90	12.22	10.86
Forage	9.80	9.80	10.26	9.69	8.50	9.61
Forage	8.96	14.30	9.89	8.60	8.96	10.14

Average = 10.5 (n=6)

0% molasses	9.74	7.65	7.53	9.68	15.23	9.56
0% molasses	8.79	9.65	8.64	9.69	13.24	9.98
0% molasses	8.75	10.11	13	8.45	7.89	9.64
0% molasses	7.89	7.52	9.63	8.63	9.68	8.67
0% molasses	8.62	8.57	8.06	9.56	8.52	8.67
0% molasses	10.11	9.11	8.08	7.03	7.05	8.28

Average = 9.1 (n=6)

5% molasses	7.46	11.06	10.91	5.70	6.04	8.23
5% molasses	12.10	10.10	5.40	6.65	14.50	9.75
5% molasses	8.34	5.94	6.76	6.87	5.34	6.65
5% molasses	9.62	7.63	6.90	6.36	14.80	9.06
5% molasses	7.80	9.63	7.63	5.25	12.12	8.49
5% molasses	7.56	12.63	14.62	6.89	7.96	9.93

Average = 8.7 (n=6)

10% molasses	7.06	6.2	8.79	12.3	12.5	9.37
10% molasses	9.72	6.28	7.83	6.35	7.2	7.48
10% molasses	11.1	6.5	13.21	7.54	11.52	9.97
10% molasses	7.54	10.98	8.32	5.09	6.89	7.76
10% molasses	7.17	8.42	7.81	8.24	9.69	8.27
10% molasses	9.61	6.51	9.53	7.75	7.91	8.26

Average = 8.5 (n=6)

15% molasses	9.10	6.35	5.68	6.89	8.21	7.25
15% molasses	5.60	9.48	6.20	7.64	7.4	7.26
15% molasses	7.91	12.30	9.81	12.10	12.6	10.94
15% molasses	9.22	7.37	5.97	6.85	8.56	7.59
15% molasses	6.51	8.14	12.61	9.60	7.5	8.87
15% molasses	5.80	5.38	8.51	8.13	9.57	7.48

Average = 8.2 (n=6)

APPENDIX 1b

ANOVA FOR FORAGE INTAKE

Forage feed intake				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	213.03		
Diet	4	19.325	4.831	0.650
Residual	25	193.705	7.748	

APPENDIX 2a

CONCENTRATE INTAKE (g/d and kg /d) IN COWS ON DIFFERENT LEVELS OF MOLASSES SUPPLEMENT DIETS.

TREATMENTS	Average concentrate (DM) (g/d)	Average concentrate (DM) (kg/d)
0% molasses	6149.7	6.1
0% molasses	5323.9	5.3
0% molasses	5271.2	5.3
0% molasses	5790.1	5.8
0% molasses	5678.7	5.7
0% molasses	6542.6	6.5
Average	**5792.7**	**5.8 (6)**
5% molasses	5734.2	5.7
5% molasses	7008.0	7.0
5% molasses	5098.2	5.1
5% molasses	5867.9	5.9
5% molasses	5847.3	5.8
5% molasses	5928.9	5.9
Average	**5914.1**	**5.9 (6)**
10% molasses	4948.1	4.9
10% molasses	6028.2	6.0
10% molasses	6949.9	6.9
10% molasses	6638.5	6.6
10% molasses	6006.9	6.0
10% molasses	6028.0	6.0
Average	**6099.9**	**6.1 (6)**
15%molasses	6716.9	6.7
15%molasses	6577.6	6.6
15%molasses	5584.6	5.6
15%molasses	7323.6	7.3
15%molasses	6168.2	6.2
15%molasses	6141.2	6.1
Average	**6418.7**	**6.4 (6)**

Values in parentheses indicate number of animals

APPENDIX 2b

ANOVA FOR CONCENTRATE INTAKE

Concentrate feed intake				
Source of variation	d.f.	s.s	m.s	F.probability
Total	23	9.7933		
Diet	3	1.4033	0.4678	0.366
Residual	20	8.390	0.4195	

APPENDIX 3a

TOTAL DRY MATTER INTAKE (forage + concentrate).

TREATMENTS	Forage intake (kg/d)	Concentrate intake (kg/d)	Total feed intake (Forage + concentrate) (kg/d)
Forage	10.7	0.0	10.7
Forage	9.4	0.0	9.4
Forage	12.4	0.0	12.4
Forage	10.9	0.0	10.9
Forage	9.6	0.0	9.6
Forage	10.1	0.0	10.1
Average	**10.5**	**0.0**	**10.5 (6)**
0% molasses	9.6	6.1	16.6
0% molasses	10.0	5.3	14.1
0% molasses	9.6	5.3	15.6
0% molasses	8.7	5.8	17.3
0% molasses	8.7	5.7	12.7
0% molasses	8.3	6.5	13.2
Average	**9.1**	**5.8**	**14.9 (6)**
5% molasses	8.2	5.7	13.8
5% molasses	9.8	7.0	19.4
5% molasses	6.7	5.1	10.8
5% molasses	9.1	5.9	14.4
5% molasses	8.5	5.8	14.0
5% molasses	9.9	5.9	14.9
Average	**8.7**	**5.9**	**14.6 (6)**
10% molasses	9.4	4.9	16.7
10% molasses	7.5	6.0	12.4
10% molasses	10.0	6.9	17.3
10% molasses	7.8	6.6	13.2
10% molasses	8.3	6.0	14.1
10% molasses	8.3	6.0	14.0
Average	**8.5**	**6.1**	**14.6 (6)**
15%molasses	7.2	6.7	12.2
15%molasses	7.3	6.6	13.4
15%molasses	10.9	5.6	18.8
15%molasses	7.6	7.3	16.0
15%molasses	8.9	6.2	13.3
15%molasses	7.5	6.1	14.0
Average	**8.2**	**6.4**	**14.6 (6)**

Values in parentheses indicate number of animals

APPENDIX 3b

ANOVA FOR TOTAL FEED INTAKE (kg/d)

Total feed intake (forage + concentrate).				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	261.567		
Diet	4	85.493	21.373	0.036
Residual	25	176.073	7.043	

APPENDIX 4a

WEIGHT GAIN.

TREATMENTS	Initial weight (I) (kg)	Final weight (F) (kg)	Difference (F - I) (kg)	Weight gain (kg/head/day)
Forage	390	435	45	0.357
Forage	460	478	18	0.143
Forage	415	424	9	0.071
Forage	480	488	8	0.063
Forage	430	448	18	0.143
Forage	405	408	3	0.024
Average	**430**	**447**	**17**	**0.134 (6)**
0% molasses	355	380	25	0.198
0% molasses	420	430	10	0.079
0% molasses	450	456	6	0.048
0% molasses	430	479	49	0.389
0% molasses	435	475	40	0.317
0% molasses	490	507	17	0.135
Average	**430**	**455**	**25**	**0.194 (6)**
5% molasses	355	358	3	0.024
5% molasses	425	466	41	0.325
5% molasses	460	481	21	0.167
5% molasses	435	484	49	0.389
5% molasses	450	473	23	0.183
5% molasses	470	479	9	0.071
Average	**433**	**457**	**24**	**0.193 (6)**
10% molasses	535	562	27	0.214
10% molasses	350	379	29	0.230
10% molasses	430	447	17	0.135
10% molasses	450	485	35	0.278
10% molasses	400	424	24	0.190
10% molasses	390	406	16	0.127
Average	**426**	**451**	**25**	**0.196 (6)**
15%molasses	370	400	30	0.238
15%molasses	420	431	11	0.087
15%molasses	450	477	27	0.214
15%molasses	425	450	25	0.198
15%molasses	465	490	25	0.198
15%molasses	420	448	28	0.222
Average	**425**	**449**	**24**	**0.193 (6)**

Values in parentheses indicate number of animals.

APPENDIX 4b

Analysis of variance (ANOVA) and least significant difference (LSD)

Weight gain				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	4941.9		
Diet	4	279.5	69.9	0.824
Residual	25	4662.3	186.5	
Average daily gain				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	0.31116		
Diet	4	0.01760	0.0044	0.823
Residual	25	0.29357	0.01174	

APPENDIX 5a

AVERAGE MILK YIELD , DAILY MILK YIELD, FCM OF LACTATING DAIRY COWS DURING THE EXPERIMENTAL PERIOD.

TREATMENTS	Total milk yield (l)	Average daily milk yield (l)	Fat corrected milk (FCM) (kg)
Forage	700.7	5.56	4.74
Forage	941.0	7.47	6.91
Forage	687.6	5.46	4.55
Forage	1053.80	8.36	7.84
Forage	1306.6	10.37	8.35
Forage	799.2	6.34	5.21
Average	**914.8**	**7.3**	**6.31 (6)**
0% molasses	770.4	6.11	5.11
0% molasses	664.8	5.28	4.65
0% molasses	1404.2	11.14	8.91
0% molasses	809.40	6.42	5.63
0% molasses	673.6	5.35	4.72
0% molasses	1224.3	9.72	9.05
Average	**924.5**	**7.3**	**6.33 (6)**
5% molasses	903.8	7.17	6.77
5% molasses	1287.8	10.22	8.36
5% molasses	678.6	5.39	4.83
5% molasses	1278.50	10.15	8.23
5% molasses	1217.2	9.66	8.23
5% molasses	1962.40	15.57	13.61
Average	**1221.4**	**9.7**	**8.39 (6)**
10% molasses	827.6	6.57	5.49
10% molasses	1438.2	11.41	8.84
10% molasses	1626.6	12.91	10.54
10% molasses	1890.9	15.01	11.86
10% molasses	1311.3	10.41	8.73
10% molasses	1415.6	11.23	9.78
Average	**1418.4**	**11.3**	**9.24 (6)**
15%molasses	866.5	6.88	6.18
15%molasses	831.4	6.60	5.73
15%molasses	1138.73	9.04	7.35
15%molasses	1053.8	8.36	6.79
15%molasses	1120.60	8.89	7.04
15%molasses	1096.1	8.70	7.13
Average	**1017.9**	**8.1**	**6.75 (6)**

Values in parentheses indicate number of animals.

APPENDIX 5b

ANOVA FOR AVERAGE TOTAL AND DAILY MILK PRODUCTION (lt) AND FAT CORRECTED MILK.

Average milk yield				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	3569449		
Diet	4	1127687	281922	0.043
Residual	25	2441762	97670	
			l.s.d	**371.6**
Average daily milk yield				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	224.709		
Diet	4	71.033	17.758	0.043
Residual	25	153.676	6.147	
			l.s.d	**2.948**
Fat corrected milk - FCM				
Source of variation	d.f.	s.s	m.s	F.probability
Total	29	145.111		
Diet	4	42.149	10.537	0.064
Residual	25	102.962	4.118	

APPENDIX 6a

BODY CONDITION SCORE.

TREATMENTS	BODY CONDITION SCORE
Forage	2.5
Forage	2.0
Forage	3.0
Forage	2.0
Forage	3.2
Forage	2.5
Average	**2.5 (6)**
0% molasses	3.0
0% molasses	3.0
0% molasses	4.0
0% molasses	3.0
0% molasses	3.5
0% molasses	3.0
Average	**3.3 (6)**
5% molasses	4.0
5% molasses	4.0
5% molasses	4.0
5% molasses	4.0
5% molasses	4.5
5% molasses	3.5
Average	**4.0 (6)**
10% molasses	4.0
10% molasses	5.0
10% molasses	3.5
10% molasses	4.0
10% molasses	4.0
10% molasses	4.0
Average	**4.1 (6)**
15%molasses	3.5
15%molasses	3.5
15%molasses	3.5
15%molasses	3.5
15%molasses	3.5
15%molasses	3.5
Average	**3.5 (6)**

Values in parentheses indicate number of animals.

APPENDIX 6b

ANOVA FOR BODY SCORE

Source of variation	d.f.	s.s	m.s	F.probability
Total	29	13.31187		
Diet	4	9.502	2.3755	0.001
Residual	25	3.8167	0.1527	

APPENDIX 7a

BLOOD GLUCOSE (RAW DATA)

TREATMENTS	Day 0	Day 18	day 92
Forage	1.1	3.1	3.0
Forage	1.1	3.2	3.1
Forage	1.0	3.0	3.4
Forage	1.1	3.5	3.1
Forage	0.8	1.1	3.6
Forage	0.9	3.0	3.3
Average	**1.0**	**2.8**	**3.3 (6)**
0% molasses	0.8	3.5	3.3
0% molasses	1.0	3.7	4.0
0% molasses	0.8	3.9	3.8
0% molasses	1.0	2.6	3.4
0% molasses	0.9	3.0	3.6
0% molasses	1.1	3.5	3.3
Average	**0.9**	**3.4**	**3.6 (6)**
5% molasses	1.4	3.6	4.3
5% molasses	1.2	3.7	3.6
5% molasses	1.5	3.4	3.4
5% molasses	1.2	3.5	3.5
5% molasses	1.4	3.6	3.7
5% molasses	1.3	3.2	3.3
Average	**1.3**	**3.5**	**3.6 (6)**
10% molasses	1.0	3.8	5.3
10% molasses	0.9	3.5	3.7
10% molasses	1.0	3.6	3.5
10% molasses	1.1	3.4	3.6
10% molasses	1.1	3.6	3.7
10% molasses	1.1	3.3	3.5
Average	**1.0**	**3.5**	**3.9 (6)**
15% molasses	1.3	3.9	3.8
15% molasses	1.5	3.6	3.7
15% molasses	1.2	3.7	4.3
15% molasses	1.0	3.5	4.1
15% molasses	1.3	3.4	5.0
15% molasses	1.0	4.3	3.6
Average	**1.2**	**3.7**	**4.1 (6)**

Values in parentheses indicate number of animals.

APPENDIX 7b

ANOVA FOR BLOOD GLUCOSE - COMPARING TREATMENTS IN EACH PERIOD

Blood glucose, day 0.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	14.9937		
Diet	4	3.5287	0.8822	0.138
Residual	25	11.465	0.4586	
Blood glucose, day 18.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	8.587		
Diet	4	2.8787	0.7197	0.032
Residual	25	5.7083	0.2283	
			l.s.d	**0.5682**
Blood glucose, day 92.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	1354.490		
Diet	4	213.49	53.37	0.348
Residual	25	1141	45.64	

APPENDIX 7c

ANOVA FOR BLOOD GLUCOSE COMPARING EACH TREATMENT OVER THE EXPERIMANTAL PERIOD

Forage only				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	26.5828		
Day	2	17.9244	8.9622	<.001
Residual	15	8.6583	0.5772	
			l.s.d	**0.935**

Forage + concentrate with 0% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	30.6694		
Day	2	27.5078	13.7539	<.001
Residual	15	3.1617	0.2108	
			l.s.d	**0.565**

Forage + concentrate with 5% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	25.6600		
Day	2	21.2133	10.6067	<.001
Residual	15	4.4467	0.2964	
			l.s.d	**0.670**

Forage + concentrate with 10% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	49.1311		
Day	2	46.3811	23.1906	<.001
Residual	15	2.7500	0.1833	
			l.s.d	**0.527**

Forage + concentrate with 15% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	32.2450		
Day	2	28.990	14.4950	<.001
Residual	15	3.2550	0.2170	
			l.s.d	**0.573**

APPENDIX 8a

BLOOD UREA-N (BUN) - RAW DATA

TREATMENTS	day 0	Day 18	day 92
Forage	4.2	5.0	3.9
Forage	4.1	2.5	2.8
Forage	3.4	3.2	2.6
Forage	2.4	3.3	2.9
Forage	4.4	2.2	2.8
Forage	2.7	3.1	3.0
Average	**3.5**	**3.2**	**3.0 (6)**
0% molasses	2.2	6.2	3.9
0% molasses	2.0	5.4	5.5
0% molasses	3.6	7.2	5.7
0% molasses	3.1	5.8	4.7
0% molasses	4.9	4.0	3.3
0% molasses	3.5	4.9	4.0
Average	**3.2**	**5.6**	**4.5 (6)**
5% molasses	2.6	5.1	5.1
5% molasses	2.7	7.2	3.3
5% molasses	2.9	5.4	4.5
5% molasses	2.5	5.5	2.7
5% molasses	2.9	3.7	2.6
5% molasses	2.8	6.4	3.8
Average	**2.7**	**5.6**	**3.7 (6)**
10% molasses	3.1	4.9	3.2
10% molasses	3.4	4.0	4.4
10% molasses	4.4	4.8	4.0
10% molasses	3.3	4.4	4.5
10% molasses	3.5	6.2	3.6
10% molasses	2.1	2.5	2.8
Average	**3.3**	**4.5**	**3.8 (6)**
15% molasses	2.3	3.0	4.5
15% molasses	4.1	6.0	5.7
15% molasses	3.8	5.7	2.5
15% molasses	2.0	4.2	4.0
15% molasses	3.8	6.7	4.4
15% molasses	1.9	4.9	3.0
Average	**2.9**	**5.1**	**4.0 (6)**

Values in parentheses indicate number of animals.

APPENDIX 8b

ANOVA FOR BUN COMPARING TREATMENTS IN EACH PERIOD.

Blood urea-N, day 0.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	54.2020		
Diet	4	10.937	2.734	0.211
Residual	25	43.265	1.731	
Blood urea-N, day 18.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	57.508		
Diet	4	23.235	5.809	0.009
Residual	25	34.273	1.371	
			l.s.d	**0.5682**
Blood urea-N, day 92.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	33.507		
Diet	4	11.882	2.9705	0.023
Residual	25	21.625	0.865	

APPENDIX 8c

ANOVA FOR BUN OF TREATMENTS OVER PERIOD

Forage only				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	10.1850		
Day	2	0.8633	0.4317	0.515
Residual	15	9.3217	0.6214	
Forage + concentrate with 0% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	33.023		
Day	2 7.82	16.858	8.429	0.005
Residual	15	16.165	1.078	
			l.s.d	**1.277**
Forage + concentrate with 5% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total				
Day	2	10.648	5.324	0.027
Residual	15	17.303	1.154	
			l.s.d	**1.322**
Forage + concentrate with 10% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	16.5628		
Day	2	4.1544	2.0772	0.115
Residual	15	16.5628		
Forage + concentrate with 15% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	17	56.249		
Day	2	14.524	7.262	0.106
Residual	15	41.725	2.782	

APPENDIX 9a

MILK PROTEIN (%) - RAW DATA.

TREATMENTS	day 0	day 30	Day 60	Day 90	day 120
Forage	2.0	3.4	2.6	3.0	3.1
Forage	2.4	3.3	3.1	2.9	2.4
Forage	1.5	3.1	3.0	3.5	3.0
Forage	2.0	3.4	3.5	3.2	3.0
Forage	2.2	3.3	2.7	2.7	2.9
Forage	2.3	3.2	3.1	2.8	2.4
Average	**2.1**	**3.3**	**3.0**	**3.0**	**2.8(6)**
0% molasses	2.1	3.3	2.9	2.6	2.7
0% molasses	1.3	3.6	3.8	3.1	3.3
0% molasses	1.4	3.2	2.5	3.2	3.0
0% molasses	2.0	3.5	2.9	2.7	2.0
0% molasses	2.0	3.5	3.5	3.0	2.9
0% molasses	2.5	3.4	3.3	2.9	2.8
Average	**1.9**	**3.4**	**3.1**	**2.9**	**2.8 (6)**
5% molasses	3.0	4.5	3.7	3.4	3.2
5% molasses	2.3	3.4	3.8	3.0	3.3
5% molasses	2.2	3.7	3.3	2.8	2.9
5% molasses	2.0	3.1	3.0	3.1	2.5
5% molasses	1.8	2.7	2.5	2.8	2.8
5% molasses	3.0	3.4	2.6	3.0	3.3
Average	**2.4**	**3.5**	**3.1**	**3.0**	**3.0 (6)**
10% molasses	1.8	3.2	3.0	2.9	2.8
10% molasses	2.0	3.8	3.7	2.9	1.6
10% molasses	2.0	2.9	2.8	2.7	2.6
10% molasses	2.0	3.3	2.8	3.0	2.8
10% molasses	2.5	3.1	2.7	2.9	2.7
10% molasses	2.8	3.4	2.9	3.2	2.6
Average	**2.2**	**3.3**	**3.0**	**2.9**	**2.5 (6)**
15% molasses	2.4	3.1	3.4	3.2	2.9
15% molasses	2.1	3.3	2.5	3.0	3.0
15% molasses	2.4	3.8	2.7	2.9	3.1
15% molasses	2.8	3.7	3.1	2.5	2.7
15% molasses	2.3	2.9	2.9	2.8	3.2
15% molasses	2.1	3.9	3.4	3.0	3.4
Average	**2.4**	**3.4**	**3.0**	**2.9**	**3.0 (6)**

Values in parentheses indicate number of animals.

APPENDIX 9b

ANOVA FOR MILK PROTEIN COMPARING TREATMENTS IN EACH PERIOD

Milk protein concentration, day 0.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	4.9187		
Diet	4	1.0253	0.2563	0.4692
Residual	25	3.8933	0.1557	

Milk protein concentration, day 30.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	3.5280		
Diet	4	0.1947	0.0487	0.4342
Residual	25	3.3333	0.1333	

Milk protein concentration, day 60.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	4.6537		
Diet	4	0.1753	0.0438	0.91
Residual	25	4.4783	0.1791	

Milk protein concentration, day 90.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	1.43367		
Diet	4	0.07533	0.01883	0.844
Residual	25	1.35833	0.05433	

Milk protein concentration, day 120.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	4.3830		
Diet	4	1.0713	0.2678	0.122
Residual	25	3.3117	0.1325	

APPENDIX 9c

ANOVA FOR MILK PROTEIN OF TREATMENTS OVER PERIOD

Forage				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	7.14667		
Day	4	5.11667	1.27917	<.001
Residual	25	2.03000	0.08120	
			l.s.d	**0.3388**
Forage + concentrate with 0% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	11.5830		
Day	4	8.1147	2.0287	<.001
Residual	25	3.4683	0.1387	
			l.s.d	**0.4429**
Forage + concentrate with 5% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	9.1297		
Day	4	3.7247	0.9312	0.009
Residual	25	5.4050	0.2162	
			l.s.d	**0.5529**
Forage + concentrate with 10% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	7.5080		
Day	4	4.4613	1.1153	<.001
Residual	25	3.0467	0.1219	
			l.s.d	**0.4151**
Forage + concentrate with 15% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	6.17500		
Day	4	3.7500	0.93750	<.001
Residual	25	2.42500	0.09700	
			l.s.d	**0.3703**

APPENDIX 10a

MILK FAT – (%) RAW DATA

TREATMENTS	Day 0	Day 32	Day 60	day 90	day 116
Forage	0.4	3.8	3.0	2.9	2.9
Forage	1.5	4.0	3.4	3.7	4.1
Forage	2.8	2.9	2.9	2.9	2.8
Forage	3.0	3.5	2.7	4.0	4.4
Forage	0.2	3.7	2.5	2.5	3.7
Forage	1.2	3.7	3.0	2.8	2.8
Average	**1.5**	**3.6**	**2.9**	**3.1**	**3.5 (6)**
0% molasses	1.5	3.4	2.8	3.5	3.1
0% molasses	1.2	2.1	3.8	3.7	3.8
0% molasses	1.8	2.5	2.2	3.2	2.5
0% molasses	2.7	1.8	3.0	2.9	4.4
0% molasses	2.0	4.3	2.8	3.6	4.1
0% molasses	2.8	3.3	3.5	3.8	3.5
Average	**2.0**	**2.9**	**3.0**	**3.4**	**3.6 (6)**
5% molasses	2.3	3.3	3.6	4.3	4.7
5% molasses	2.2	3.1	2.7	2.2	2.7
5% molasses	1.8	3.5	3.3	3.4	3.65
5% molasses	3.0	1.5	2.8	3.2	2.9
5% molasses	2.1	2.9	2.9	3.0	3.1
5% molasses	2.0	3.5	2.8	3.9	2.5
Average	**2.2**	**3.0**	**3.0**	**3.3**	**3.3 (6)**
10% molasses	1.3	3.1	2.7	2.5	3.1
10% molasses	1.4	3.1	3.3	2.1	2.7
10% molasses	2.1	3.5	2.3	2.8	2.6
10% molasses	2.4	2.4	2.5	3.2	3.7
10% molasses	1.2	2.7	3.0	3.5	4.0
10% molasses	2.0	3.0	2.7	3.4	4.2
Average	**1.7**	**2.9**	**2.7**	**2.9**	**3.4 (6)**
15% molasses	1.2	3.7	2.7	3.7	4.9
15% molasses	2.2	3.9	2.5	2.7	3.1
15% molasses	1.0	3.7	2.6	2.4	3.7
15% molasses	1.0	2.2	3.0	3.3	2.5
15% molasses	2.1	3.5	2.3	2.8	1.9
15% molasses	1.5	3.4	3.2	3.1	3.1
Average	**1.5**	**3.4**	**2.7**	**3.0**	**3.2 (6)**

Values in parentheses indicate number of animals.

APPENDIX 10b

ANOVA FOR MILK FAT **COMPARING TREATMENTS IN EACH PERIOD**

Milk fat , day 0.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	21.3080		
Diet	4	3.9147	0.9787	0.261
Residual	25	17.3393	0.6957	
Milk fat , day 30.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	13.0017		
Diet	4	2.1933	0.5483	0.309
Residual	25	10.8083	0.4323	
Milk fat , day 60.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	4.3470		
Diet	4	0.5120	0.1280	0.516
Residual	25	3.8350	0.1534	
Milk fat , day 90.				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	8.7267		
Diet	4	1.1967	0.2992	0.429
Residual	25	7.5300	0.3012	
Milk fat, day 120				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	16.3980		
Diet	4	0.5372	0.1343	0.929
Residual	25	15.8608	0.6344	

APPENDIX 10c

ANOVA FOR MILK FAT OF **TREATMENTS OVER THE PERIOD**

Forage alone				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	21.3080		
Day	4	16.5513	4.1378	<.001
Residual	25	12.2917	0.4917	
			l.s.d	**0.834**
Forage + concentrate with 0% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	20.2147		
Day	4	9.1980	2.2995	0.003
Residual	25	11.0167	0.4407	
			l.s.d	**0.789**
Forage + concentrate with 5% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	14.0187		
Day	4	3.3820	0.8455	0.127
Residual	25	10.6367	0.4255	
Forage + concentrate with 10% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	22.6297		
Day	4	13.7147	3.4287	<.001
Residual	25	8.9150	0.3566	
			l.s.d	**0.710**
Forage + concentrate with 15% molasses				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	24.8680		
Day	4	12.2713	3.0678	0.001
Residual	25	12.5967	0.5039	
			l.s.d	**0.844**

APPENDIX 11a

APPARENT NUTRIENT DIGESTIBILITY COEFFICIENT - RAW DATA

TREATMENTS	DM	CP	OM	ENERGY	NDF	ADF	ADL
Forage	56.5	58.7	53.3	52.1	51.8	50.9	50.7
Forage	55.7	57.3	52.8	52.1	51.7	51.4	50.5
Forage	56.7	57.5	52.4	51.4	51.8	51.4	50.3
Forage	57.5	57.1	52.2	51.8	51.8	51.6	51.1
Forage	56.4	57.7	50.3	52.0	51.6	51.1	50.0
Forage	56.9	58.5	53.5	52.8	51.9	51.5	51.1
Average	**56.6**	**57.8**	**52.4**	**52.1**	**51.8**	**51.3**	**50.6**
			(6)				
0% molasses	59.2	66.7	61.9	59.8	63.6	62.9	62.1
0% molasses	58.6	66.4	61.1	61.7	63.5	62.8	62.3
0% molasses	59.6	66.1	61.5	60.1	63.4	62.2	60.3
0% molasses	62.3	66.5	61.8	61.5	63.7	62.8	62.8
0% molasses	53.1	67.1	61.4	60.6	63.3	62.8	61.7
0% molasses	64.5	66.0	61.8	60.4	63.4	62.5	61.3
Average	**59.6**	**66.5**	**61.6**	**60.7**	**63.5**	**62.7**	**61.7**
			(6)				
5% molasses	61.8	67.2	62.4	61.0	65.1	63.2	63.1
5% molasses	62.1	66.7	63.7	61.4	64.9	63.1	62.5
5% molasses	62.3	67.7	62.7	61.9	64.4	63.6	62.1
5% molasses	59.1	67.5	63.5	60.8	63.8	63.2	62.3
5% molasses	61.3	66.7	64.9	62.8	63.2	62.9	63.3
5% molasses	60.5	67.3	62.6	61.6	63.7	62.2	62.3
Average	**61.2**	**67.2**	**63.3**	**61.6**	**64.2**	**63.0**	**62.6**
			(6)				
10% molasses	70.8	67.9	70.0	66.8	64.5	65.9	63.0
10% molasses	70.6	67.4	69.9	65.8	64.9	65.0	62.7
10% molasses	71.0	68.3	69.4	66.6	64.8	66.1	62.0
10% molasses	70.4	67.0	69.3	65.6	64.4	66.7	64.2
10% molasses	70.1	67.6	70.1	65.0	64.2	66.9	61.8
10% molasses	70.5	68.2	69.6	65.4	65.1	65.6	62.2
Average	**70.6**	**67.7**	**69.7**	**65.9**	**64.6**	**66.0**	**62.7**
			(6)				
15% molasses	68.2	65.8	61.4	62.5	63.3	60.1	62.3
15% molasses	69.4	66.1	62.1	61.8	63.2	62.5	62.0
15% molasses	69.6	65.4	61.8	62.1	62.6	63.9	61.8
15% molasses	69.3	65.0	62.8	61.4	62.7	62.8	61.2
15% molasses	68.5	65.7	62.6	62.9	63.6	62.3	61.5
15% molasses	68.2	66.8	62.3	60.5	62.2	62.1	61.4
Average	**68.9**	**65.8**	**62.2**	**61.9**	**62.9**	**62.3**	**61.7**
			(6)				

Values in parentheses indicate number of animals.

APPENDIX 11b

ANOVA FOR APPARENT NUTRIENT DIGESTIBILITY

DM				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	966.912		
Diet	4	880.569	220.142	0.001
Residual	25	86.343	3.454	
			l.s.d	**2.210**
CP				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	962.6783		
Diet	4	953.3847	238.3462	0.001
Residual	25	9.2936	0.3717	
			l.s.d	**0.860**
NDF				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	708.7178		
Diet	4	703.8715	175.9679	0.001
Residual	25	4.8463	0.1939	
			l.s.d	**0.5235**
ADF				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	776..6207		
Diet	4	764.6579	191.1645	0.001
Residual	25	11.9628	0.4785	
			l.s.d	**0.823**
ADL				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	657.0000		
Diet	4	646.1655	161.5414	0.001
Residual	25	10.8345	0.4334	
			l.s.d	**0.783**
OM				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29	1356.8555		
Diet	4	1347.2361	336.8090	0.001
Residual	25	9.6194	0.3848	
			l.s.d	**0.738**

Energy				
Source of variation	d.f.	s.s.	m.s.	F.probability
Total	29			
Diet	4	764.6579	191.1645	0.001
Residual	25	11.9628	0.4785	
			l.s.d	**0.727**

APPENDIX 12A
CLIMATIC DATA DURING THE EXPERIMENTAL PERIOD.

Date	Number of days	Actual date of the month	Total number of days	Months in serial number	Weeks in serial numbers	Rainfall (mm)	Temperature (^0C)	Relative Humidity (%)
August (19/08/02)	1	19	1	1	1	13.5	20.6	94
	2	20	2	1	1	20.7	30.0	95
	3	21	3	1	1	0.7	21.9	94
	4	22	4	1	1	0.2	21.9	87
	5	23	5	1	1	0.0	21.7	55
	6	24	6	1	1	0.0	23.0	52
	7	25	7	1	1	3.1	22.1	64
	8	26	8	1	2	0.0	23.2	89
	9	27	9	1	2	0.5	24.0	83
	10	28	10	1	2	0.0	27.0	80
	11	29	11	1	2	0.0	23.4	70
	12	30	12	1	2	4.4	22.5	76
	13	31	13	1	2	5.0	22.5	91
September	14	1	1	2	2	12.2	20.0	95
	15	2	2	2	3	26.8	20.9	93
	16	3	3	2	3	1.7	22.5	85
	17	4	4	2	3	0.0	22.4	88
	18	5	5	2	3	0.2	21.7	65
	19	6	6	2	3	0.0	19.5	54
	20	7	7	2	3	0.0	19.0	79
	21	8	8	2	3	0.0	18.5	79
	22	9	9	2	4	0.0	18.6	76
	23	10	10	2	4	0.0	20.5	79
	24	11	11	2	4	0.0	21.7	75
	25	12	12	2	4	6.1	22.3	78
	26	13	13	2	4	0.6	23.5	95
	27	14	14	2	4	5.8	20.5	95
	28	15	15	2	4	1.3	21.0	79
	29	16	16	2	5	44.9	21.0	96
	30	17	17	2	5	31.4	19.5	94
	31	18	18	2	5	3.4	19.0	80
	32	19	19	2	5	0.0	26.5	77
	33	20	20	2	5	0.0	21.8	67
	34	21	21	2	5	0.5	23.1	73
	35	22	22	2	5	1.1	23.3	63
	36	23	23	2	6	10.9	24.5	88
	37	24	24	2	6	5.4	25.5	93
	38	25	25	2	6	48.6	27.2	89
	39	26	26	2	6	0.0	24.2	84
	40	27	27	2	6	0.0	23.5	59
	41	28	28	2	6	0.0	25.0	52
	42	29	29	2	6	0.0	24.0	62
	43	30	30	2	7	0.0	24.8	66

October	44	1	1	3	7	0.0	25.0	66
	45	2	2	3	7	0.0	25.2	75
	46	3	3	3	7	0.0	24.3	76
	47	4	4	3	7	2.5	24.9	79
	48	5	5	3	7	0.0	24.7	69
	49	6	6	3	7	0.5	23.8	76
	50	7	7	3	8	9.6	23.0	83
	51	8	8	3	8	0.7	22.1	90
	52	9	9	3	8	0.0	23.0	65
	53	10	10	3	8	0.2	21.6	53
	54	11	11	3	8	5.2	21.8	69
	55	12	12	3	8	1.2	22.5	65
	56	13	13	3	8	10.6	24.1	82
	57	14	14	3	9	0.2	25.2	78
	58	15	15	3	9	1.1	24.7	79
	59	16	16	3	9	trace	26.0	76
	60	17	17	3	9	2.5	51.1	76
	61	18	18	3	9	38.5	24.5	81
	62	19	19	3	9	3.2	25.4	94
	63	20	20	3	9	0.0	24.0	74
	64	21	21	3	10	0.0	25.4	69
	65	22	22	3	10	0.4	26.3	84
	66	23	23	3	10	1.2	26.6	80
	67	24	24	3	10	trace	26.0	6
	68	25	25	3	10	0.0	26.0	969
	69	26	26	3	10	0.0	24.9	58
	70	27	27	3	10	0.0	23.7	62
	71	28	28	3	11	0.0	23.3	64
	72	29	29	3	11	4.4	26.5	76
	73	30	30	3	11	1.2	26.6	82
	74	31	31	3	11	0.0	26.4	78

November	75	1	1	4	11	0.0	24.6	79
	76	2	2	4	11	3.1	25.1	75
	77	3	3	4	11	9.8	26.2	77
	78	4	4	4	12	5.1	24.3	85
	79	5	5	4	12	2.5	24.8	80
	80	6	6	4	12	2.0	26.0	79
	81	7	7	4	12	40.6	26.6	77
	82	8	8	4	12	1.1	26.0	84
	83	9	9	4	12	7.25	26.6	84
	84	10	10	4	12	3.6	25.9	85
	85	11	11	4	13	1.7	26.1	77
	86	12	12	4	13	0.0	25.2	75
	87	13	13	4	13	4.8	24.6	75
	88	14	14	4	13	3.6	23.8	94
	89	15	15	4	13	1.2	24.8	79
	90	16	16	4	13	0.6	25.0	90
	91	17	17	4	13	1.1	24.3	84
	92	18	18	4	14	0.0	24.3	77
	93	19	19	4	14	14.3	25.7	78
	94	20	20	4	14	20.7	25.3	85
	95	21	21	4	14	0.0	24.3	87
	96	22	22	4	14	0.0	24.3	71
	97	23	23	4	14	0.5	25.3	64
	98	24	24	4	14	0.0	25.2	69
	99	25	25	4	15	0.2	25.3	63
	100	26	26	4	15	0.0	26.0	83
	101	27	27	4	15	0.0	24.5	66
	102	28	28	4	15	0.3	24.3	61
	103	29	29	4	15	0.0	23.4	96
	104	30	30	4	15	0.0	23.9	69

December	105	1	1	5	15	0.0	23.7	63
	106	2	2	5	16	1.3	23.8	78
	107	3	3	5	16	9.1	25.6	91
	108	4	4	5	16	1.4	26.1	92
	109	5	5	5	16	16.7	27.4	84
	110	6	6	5	16	0.9	26.7	91
	111	7	7	5	16	22.3	26.4	75
	112	8	8	5	16	0.0	26.2	82
	113	9	9	5	17	0.6	26.6	69
	114	10	10	5	17	0.0	26.5	69
	115	11	11	5	17	0.0	26.5	62
	116	12	12	5	17	0.0	27.6	72
	117	13	13	5	17	0.0	25.8	63
	118	14	14	5	17	0.5	25.0	55
	119	15	15	5	17	6.1	26.3	77
	120	16	16	5	18	18.7	26.4	94
	121	17	17	5	18	22.2	26.5	91
	122	18	18	5	18	37.6	27.2	84
	123	19	19	5	18	34.1	27.2	76
	124	20	20	5	18	21.0	26.9	81
	125	21	21	5	18	41.0	26.1	94
22/12/02	126	22	22	5	18	16.7	26.1	92