Paper 1

Use of *Indigofera zollingeriana* as a Forage Protein Source in Dairy Goat Rations

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Introduction

Indigofera zollingeriana is a valuable shrubby legume that has been utilised by farmers to improve dairy goat productivity in some areas in Indonesia. Use of Indigofera in Indonesia has not been wide spread but some dairy goat farmers use this forage plant as protein source instead of commercial concentrate because of the high cost of the latter. The quality of feed at farm level often varies due to changes in the composition of some feed materials and this in turn leads to unstable milk production and quality, particularly towards the end of the lactation period.

The availability of the Indigofera herbage at the farm seems to be dependent on the plant production system. It has been recommended that a tea plantation model be used to enable an ideal and proportional harvest of young and old leaves so that the quality of herbage remains high (Abdullah and Suharlina, 2010). The use of wilted Indigofera forage including leaves and edible twigs has been shown to improve the average daily gain of local goats up to 52.38 g/day in North Sumatera (Tarigan, 2009). This is understandable because Indigofera is highly nutritional (Hassen et al., 2008), having a protein content of 27 to 31%, digestible protein 75 to 87%, utilisable fibre (NDF 49–57%; ADF 32–38%), high dry matter digestibility (72–81%), and low total tannin content (0.09–0.65%) (Abdullah, 2010).

It has been reported that farmers face the problems of high feed cost and rapid reduction of milk production two months prior to the end of lactation period if commercial feed is used. Based on the above information, an experiment using pelleted pure Indigofera feed (PIF) was conducted at Bangun Karso Farm. The objectives of the experiment were to determine the effect of PIF on milk production prior to end of lactation, the feed cost and efficiency of protein use.

Materials and methods

The experiment was conducted at Bangun Karso Farm which has been producing goat milk for more than 5 years. The farm is located in the Cijeruk district about 18 km from Bogor. Eight does comprising 4 lactating Saanen and 4 lactating Etawah crossbred (EC) goats were used in the study. Each breed group was divided into two groups of 2 animals each and fed two different rations, namely ration F1consisting of 60% elephant grass + 40% commercial concentrate or ration F2 consisting of 60% elephant grass + 40% PIF (Apdini, 2011). The Saanen and EC does were in the third and second lactation, respectively. Each ration was given 4 times daily with a minimum amount of 4% live weight for 1 month prior to the end of

the lactation period. The nutritional composition of the rations was determined according to Apdini (2011). Ration F1 contained 48.25% DM, 8.31% ash, 12.76% crude protein, 32.01% crude fibre, 33.94% NFE and 57.98% TDN while ration F2 contained 48.85% DM, 7.82% ash, 17.23% crude protein, 28.56% crude fibre, 34.81% NFE and 65.77% TDN. The measured parameters are shown in Table 1. Data were analysed using statistical group comparisons (Cooper and Schindler, 2003) and descriptive analysis.

Results and Discussion

The use of the PIF in ration resulted in a higher DM digestibility of the feed (17 to 73%), feed efficiency (8 to 17%), protein use efficiency (1 to 2.5%), average milk production (121 to 383 mL/day), lower feed costs (USD 0.10 to 0.39) and feed conversion values than the commercial concentrate. Daily milk production of the does fed the commercial feed tended to decrease drastically (Figure 1) as indicated by the k-value as shown in Table 1. Drastic reduction of milk production occurred in the Saanen goats that consumed commercial feed. However, when PIF was given in the ration, the daily milk production of both groups of goats stabilised towards the end of the lactation period. Based on feed DM digestibility, feed and protein use efficiency, the Saanen goats seemed to be more responsive to PIF in the ration than the EC does.

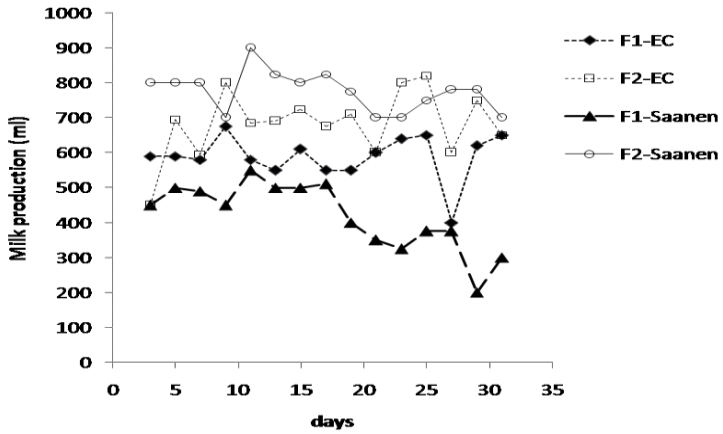

Figure 1. Change of goat milk production of end-lactation Period
F1 -60% elephant grass + 40% commercial feed; F2 - 60% elephant grass + 40% pure Indigofera feed (PIF). Data extracted from Apdini (2011).

Table 1. Use of pure Indigofera in dairy goat rations compared with the commercial Feed

	Saanen		Etawah Crossbred	
	CF	PIF	CF	PIF
Feed DM digestibility (%)*	40.59	70.13	45.47	63.08
Feed efficiency (%)[1]*	17.25	34.75	24.55	32.5
Feed conversion (kg feed/L milk)	5.8	2.9	4.1	3.1
Protein use efficiency (%)[2]*	4.50	7.00	5.35	6.20
Milk production (mL/day)[3]*	379	762	539	660
Feed cost (USD/L milk)[4]	0.93	0.54	0.67	0.57
k-value of milk production[5]	-8.57	-2.85	-0.32	3.54

*Source: data were calculated from Apdini (2011), CF = F1: 60% elephant grass + 40% commercial feed, PIF = F2: 60% elephant grass + 40% pure Indigofera feed (PIF); [1]Portion of feed DM utilised to produce 1L of milk, [2]proportion of feed protein utilised for milk protein, [3]Average milk production (1month prior end-lactation period), [4]cost of feed required for producing 1L milk (CF USD 0.28/kg and PIF USD 0.33). [5]determination value (-) = reduction, (+) = increment.

Economically, the use of 40% PIF in the ration could reduce feed conversion ratio and costs by about 42% for the Saanen and 15% for the EC goats. Since feed contributes approximately 70% towards the cost of production, substituting PIF for commercial feed would reduce feed costs and provide more profits to the farmer. Thus this study showed that the use of Indigofera herbage is very effective in stabilising milk production before termination of the lactation period while improving the quality and reducing the cost of feed.

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Paper 2

Protein Requirement for the Maintenance and Gain of Growing Goats Fed *Leucaena leucocephalade* Roughage-Based Diets in Thailand

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Introduction

For many areas, goats are a major source of income for farmers, and there have been many reports of crossbreeding programmes aimed at improving the productivity of native goats. It has been reported that farmers could utilise the different Saanen crossbreds to improve pre-weaning growth rate of goats in Southern Thailand (Supakorn and Pralomkarn, 2009). Pralomkarn et al. (1995) reported that Thai native and Anglo-Nubain × Thai native goats have similar protein and energy requirements for growth. This experiment was designed to quantify the protein requirements for maintenance and growth of growing Anglo-Nubain crossbred goats fed under tropical conditions in Thailand.

Materials and methods

Sixteen male Anglo-Nubain crossbred goats (weighing 19.03 ± 0.3 kg, aged 6 to 12 mo) were housed in individual pens and fed *Leucaena leucocephalade* roughage-based diets with water and minerals provided *ad libitum*. They were assigned in a completely randomised design and fed one of the four feeding treatments consisting of cassava chip supplementation at the rate 0, 0.5, 1.0 and 1.5% of body weight for a 91-day period. The weight of feed offered and refused was recorded and feed sampled daily. Feed samples were analysed using standard methods and animals were weighed weekly. The crude protein intake (CPI) and average daily gain (ADG) data were regressed against time using linear regression (regression equation; CPI = a + b ADG).

Results and Discussion

The results indicated that increased levels of cassava chips resulted in linear (P<0.05) increases in roughage and protein intakes. However, the ADG was not different between groups (Table 1). The protein requirement determined from the regression of ADG on CPI exhibited a significant linear relationship [CPI = 1.1474 ADG + 157.35, (R^2 = 0.45; P<0.001; RSD = 5.54; n = 12)] (Figure 1). The crude protein requirement for maintenance and gain (100 g ADG) were 157 and 272 g/d, respectively.

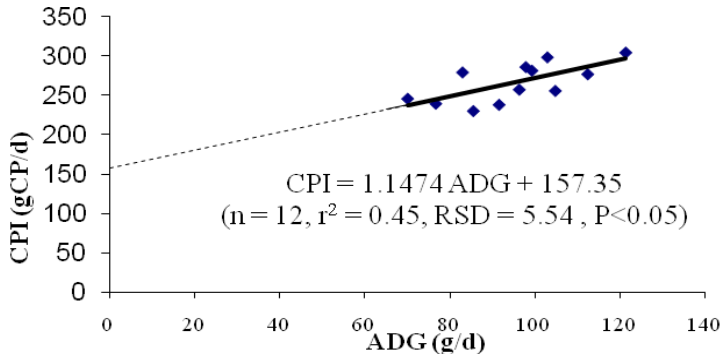

Figure 1. The relationship between crude protein intake and average daily gain.

Table 1. Body weight and intake of growing goats given levels of cassava chip supplementation.

Item	Levels of cassava chip (%BW)				*P*-value[1]		
	0	0.5	1.0	1.5	L	Q	C
Number animal, head	*n = 4*	*n = 4*	*n = 3*	*n = 4*			
Initial weight, kg	19.34	19.09	18.57	19.10	-	-	-
Final weight, kg	27.95	27.30	26.49	28.75	ns	ns	ns
Average body weight, kg	23.65	23.20	22.53	23.93	ns	ns	ns
Average daily gain, g/d	94.56	90.28	87.01	106.04	ns	ns	ns
Roughage intake, kg DM/d	1.12	1.02	0.94	0.93	**	ns	ns
Concentrate intake, kg DM/d	0	0.10	0.19	0.29	**	ns	ns
Total feed intake, kg DM/d	1.12	1.12	1.13	1.22	ns	ns	ns
Crude protein intake, kg CP/d	0.29	0.27	0.25	0.25	**	ns	ns

[1]: Probability of a significant (P<0.05) effect of levels or of a linear (L) or quadratic (Q) or cubic (C) effect of feeding levels.

Conclusions

The results indicated that the protein requirement for maintenance and growth for growing Anglo-Nubain crossbred goats fed a Leucaena roughage-based diet with varying levels of cassava chips under tropical condition were 157 and 272 g crude protein/d, respectively.

Acknowledgements

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Paper 3

Yield and Quality of Forage affected by Molybdenum Fertiliser and Legume Genotypes

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Introduction

Agricultural land in the tropics and subtropics are generally low in nitrogen which is required in relatively high quantity and has a very significant effect on the productivity of plants, including forage crops. Poor quality forage, including forage of low nitrogen content limits livestock productivity. A large amount of nitrogen is present in the atmosphere (79% by volume), but the majority of the plants cannot utilise it directly from the atmosphere. In principle, increasing the nitrogen supply in the soil for plants could be done by increasing biological nitrogen fixation or by the addition of inorganic nitrogen fertilizers. The continuous use of artificial nitrogen fertilizers can lead to negative impact on the environment. Therefore, in order to support the concept of sustainable agriculture, efforts to increase the supply of nitrogen through biological nitrogen fixation by Rhizobium symbiosis with legumes is appropriate. This study was carried out to examine the influence of molybdenum fertilization and legume species on yield and quality of forage in mixed cropping with Guinea grass (*Panicum maximum*) in the field.

Materials and methods

The investigation was carried out at the Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Indonesia. A randomised block design with a factorial pattern group with 2 factors and 3 replications was used. The first factor consisted of three legume species; namely Kudzu (*Pueraria phaseoloides*), Calopo (*Calopogonium mucunoides*), and mixed Kudzu with Calopo, while the second factor was the molybdenum fertiliser given at 4 levels; namely 0, 3, 6 and 9 g/kg seed.

Results and Discussion

The results showed that the legume species significantly ($P<0.05$) affected the yield and quality of forage crops, while molybdenum fertilizer did not significantly affect the yield and crude protein content of the forage crops (Table 1). Kudzu showed higher dry matter yield (11.19 t/ha) than other treatments. The molybdenum fertiliser at the rate of 6 g/kg seed produced the highest crude protein content (10.73%) (Table 2).

Table 1. Mean dry matter yield of three legume genotypes treated with molybdenum fertilizer

Treatment	Dry matter yield (tonnes/ha)			
	Cutting sequence			
	First	Second	Third	Total
Legume				
Kudzu	2.86[a]	4.20[a]	4.13[a]	11.19
Calopo	2.63[ab]	4.19[a]	3.96[ab]	10.78
Kudzu + Calopo	2.38[b]	3.49[b]	3.41[b]	9.28
Molybdenum				
Without Mo	2.58	3.84	3.60	10.02
3 g kg^{-1}seed	2.62	3.85	3.98	10.45
6 g kg^{-1}seed	2.66	4.05	4.02	10.73
9 g kg^{-1}seed	2.38	4.09	3.73	10.20

[ab]Means within column with different superscripts differ at $P<0.05$

Table 2. Mean crude protein content (%) of three legume genotypes treated with molybdenum fertilizer

Treatment	Crude Protein (%)			
	Cutting sequence			
	First	Second	Third	Total
Legume				
Kudzu	12.15	10.97	10.05[a]	11.06
Calopo	11.73	10.63	8.96[b]	10.44
Kudzu + Calopo	11.78	10.88	9.37[ab]	10.68
Molybdenum				
Without Mo	11.51	10.76	9.32	10.53
3 g kg^{-1}seed	11.91	10.76	9.10	10.59
6 g kg^{-1}seed	11.83	11.06	9.81	10.90
9 g kg^{-1}seed	12.32	10.71	9.61	10.88

[ab]Means within column with different superscripts differ at $P<0.05$

Paper 4

The Use of Rain Tree Pods as a Feed Supplement for Dairy Goats

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Introduction

The rain tree *(Saman samanea)* is a tropical legume and the pods of the rain tree are easily available in the dry season. It is generally known that these pods have been appreciatively eaten by cattle (Staples and Elevitch, 2006). Studies demonstrated that the rain tree pod has the advantage of enhancing microbial growth in the rumen of buffaloes (Jetana et al*.,* 2011a,b) and cattle (Jetana et al*.,* 2010). The objectives of the experiment were to determine and compare the effects of supplementation with either commercial pellets (CCP) or the pellets produced from rain tree pods (RTPP) on the whole tract apparent digestibility of DM, OM and fibre, ruminal microbial production, milk production, quality of milk and capital cost of milk production**.**

Materials and methods

The experiment was conducted with 14 *Saanen* dairy goats (weighing 29.0–58.0 kg). The animals were randomly divided into two groups of 7 animals each. Group 1 (38.4 ± 0.62 kg) was fed *ad libitum* with 2.46 kg corn silage (fresh weight) and supplemented with 1 kg of CCP (fresh weight), and Group 2 (40.9 ± 0.74 kg) was fed *ad libitum* with 2.46 kg corn silage (fresh weight) and supplemented with 1 kg of RTPP (fresh weight). The crude protein content in CCP (15.0%) and RTPP (15.2%) was similar. The CCP contained 865 g DM/kg, 31 g ash and 440 g NDF based on g/kg DM basis while RTPP contained 764 g DM/kg, 62.3 g ash, 200 g NDF, 45.3 g phenolic compounds, 10.8 g condensed tannins, 170 g total sugar and 90 g sucrose per kg DM basis.

Two studies were conducted over 35 days. The first study determined milk production and milk quality for 35 days, whilst the second study determined the nutrient digestion and microbial production in the rumen. The samples were collected for digestion and microbial production in the rumen for 7 days, during day 28 to 35 of experimentation. The animals were housed in individual pens during the experimental period with facilities for separate urine and feces collections. The feed intake and milk production of each goat were recorded daily and 20 mL of milk were taken as a sub-sample into each plastic container for chemical analysis. Total fat was determined by a simple UV spectrophotometric method (Forcato et al., 2005); milk protein was calculated by total N in milk (Micro Kjeldahl, AOAC 2000) multiplied by 6.38. Total solids were determined by taking 10 g of milk samples in 50-ml Erlenmeyer flasks and kept at 80ºC in a hot air oven for 24 hours. The ash in the milk samples was determined by burning them to a constant weight in a muffle furnace at 550ºC for 8 hours. Milk lactose was calculated by subtracting total fat, protein and ash from total solids.

On day 28 to 35, urine was collected in plastic bags containing 100 mL of 7% HCl to maintain a pH below 3. Total daily urine was weighed and sub-samples were taken, diluted 5 times with distilled water, and stored at 4ºC for PD analysis (IAEA-TECDOC-495, 1997). Total daily faeces were weighed and sub-samples (20%) were then stored at 4 ºC for chemical analysis. Ten percent of the representative aliquots of offered feed, refused feed and faecal samples were collected and stored at –20ºC. At the end of each sampling period, samples from each animal were pooled and dried in a hot air oven at 65ºC, for 72 hours, prior to analysis for dry matter (DM), ash, nitrogen (N), and neutral detergent fibre (Van Soest *et al.* 1991). Fresh drinking water was provided throughout the experiments. Purine derivatives in the urine were measured as allantoin, uric acid, xanthine and hypoxanthine and microbial-N in the rumen was calculated using equation of Jetana et al. (2003).

Results and Discussion

Table 1 shows that the RTPP intake was greater than that of CCP intake, but none of the supplemental diets affected corn silage intakes. However, digestibility coefficients of DM and OM were generally lower in goats in the RTPP than those in the CCP group. It is possible that the rain tree pods contained higher available sugar (sucrose) than the CCP diet decreasing the pH in the rumen (Hindrichsen and Kreuzer, 2009) and thus the activity of cellulolytic microbes leading to depressed fibre digestion (Table 1) (Hoover, 1986).

Lower microbial production recorded in goats supplemented with RTPP (Table 1) was in contrast with the reports by Jetana et al. (2010, 2011a,b) who demonstrated that a high sugar and protein content in the rain tree pod has advantages of enhancing the efficiency of microbial yield in the rumen of buffaloes and cattle. The contradicting results may be due to i) different animal species used, ii) different processing methods for the rain tree pods, iii) the rate of passage in animals fed the RTPP diet may be faster than in those fed the CCP diet resulting in excess non-fermentable N sources in the rumen to be fermented in the hindgut, iv) binding of condensed tannins to available nutrients (N) in the RTPP supplemental diet and v) the high content of tannins inhibiting some microbial activity (Waghorn, 2008). Though the average milk production (mL/day/$BW^{0.75}$) (Figure1) and capital cost of milk production (US dollar/kg milk) were lower (Table 1), the contents of protein, lactose and total solids in the milk were higher in goats supplemented with RTPP than in those supplemented with CCP (Table 1). The high lactose in milk is not surprising as there is high sucrose in the RTPP while the high protein in milk is probably due to the escape of tannin-protein complexes in RTPP diet from rumen fermentation, subsequently digested in the small intestine and absorbed for production of protein in milk.

Table 1. Intake, coefficient of digestion, ruminal microbial nitrogen production, milk composition and capital cost of milk production in *Saanen* goats fed corn silages and supplemented with two types of concentrate pellet

	Type of concentrate pellet		SED[1]
	CCP	RTPP	
Body weight live(kg)	38.4	40.9	1.56
Metabolic body weight (kg)	15.4	16.1	0.46
Total dry matter (DM)	1.30[b2]	1.44[a]	0.03
Concentrate pellet DM	0.70[b]	0.83[a]	0.02
Corn silage DM	0.59	0.60	0.01
Total organic matter (OM)	1.22[b]	1.35[a]	0.02
Total neutral detergent fibre (NDF)	0.69[b]	0.75[a]	0.02
The coefficients of (decimal)			
DM	0.76[a]	0.68[b]	0.02
OM	0.80[a]	0.72[b]	0.02
NDF	0.84[a]	0.78[b]	0.02
Purine derivatives in urine (mmol/day)			
Allantoin	19.2	15.5	1.92
Uric acid	7.40[a]	1.11[b]	0.58
Xanthine + Hypoxanthine	0.89	1.01	0.11
Total Purine derivatives	27.4[a]	17.6[b]	1.91
MN in the rumen (N g/day)[3]	29.1[a]	17.2[b]	2.30
Chemical composition of milk (g/kg)			
Fat	45.6	42.1	4.62
Protein	34.0[b]	39.7[a]	2.76
Lactose	23.3[b]	34.7[a]	2.94
Total ash	9.56	9.97	0.50
Solids non fat	64.0[b]	84.4[a]	2.69
Total solids	110[b]	127[a]	4.88
Capital of milk produced			
Milk yield (g/day)	922[a]	570[b]	1.92
Milk produced capital (US dollar/kg milk)	0.40[a]	0.35[b]	0.02

[1] Standard error of difference

[2ab]Values within the same row with different superscripts are significantly (P<0.05) different. Values within the same row without superscripts are not significantly (P<0.05) different

[3] Purine derivatives in milk was not included for calculation

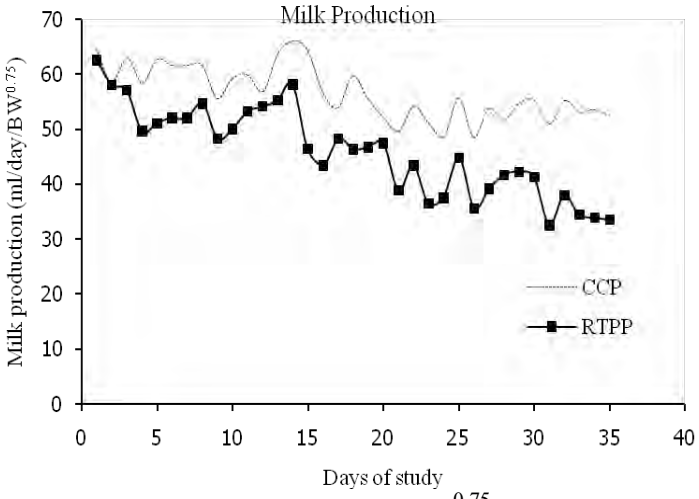

Figure 1. The average milk production (mL/day/$BW^{0.75}$) of dairy *Saanen* goats fed different types of concentrate pellets.

Conclusion

The study demonstrated an approach to use natural feed resources as an alternative feed supplement to improve the quality of milk in dairy goats. The practical implication of this study is that it would be benefit the smallholder farmers to use rain tree pods because it improves milk quality.

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Paper 5

Effect of Jerusalem Artichoke Supplementation on Methanogenic Achaea in Dairy Goats using Real Time PCR Technique

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Introduction

Early research on rumen methanogenic achaea focused on the reduction the loss of dietary energy for the ruminant, but lately, the objective was to mitigate methane from enteric fermentation to reduce environmental pollution (Hindrichsen et al., 2004). Inulin is a polydisperse non-starch polysaccharide naturally occurring as a storage carbohydrate in some 36,000 plant species. The main sources of inulin are chicory and Jerusalem Artichoke (*Helianthus tuberosus* L.) (Böhm et al., 2005). Inulin is considered as archetypal prebiotic and has been used successfully in monogastric animals but we know of few studies to investigate the direct effect of inulin on methanogenic achaea in rumen fluid. The objective of the present study was to determine the effect of supplementing inulin powder from Jerusalem Artichoke in diet on methanogenic bacteria in dairy goats using real-time PCR technique (Yu et al., 2005).

Materials and methods

Six female crossbred Saanen (>75% pure) goats were allocated to two treatment groups. All animals were fed with purple guinea grass (*Panicum maximum* TD 58) *ad libitum* and supplemented with concentrate at 1.5% BW (20% CP). In the control group no inulin was given to the animals while in the treatment group 10% inulin from Jerusalem Artichoke *(Helianths tuberosus)* was added to the diet. All animals were kept in individual pens and received water and mineral blocks *ad libitum*. Rumen contents were collected on day 0, 1, 7 and 14 at post-morning-feeding and immediately used for direct total protozoa and bacteria counts using a haemocytometer (Galyean, 1989). The DNA was immediately extracted from the rumen content.

Community DNA was extracted from 0.2 mL aliquots of rumen fluid to which 1 mL of lysis buffer was added and homogenised for 5 min for DNA extraction. DNA was purified using High Pure PCR Template Preparation Kit (Roche, Germany). Species-specific primers used

the 16s gene, methanogens. The primer set sequences was MET630F [16S gene, methanogens (GGATTAGATACCCSGGTAGT)] and MET803R [16S gene, methanogens (GTTGARTCCAATTAAACCGCA)] were chosen from Christophersen (2007) and Skillman et al., (2006). Real-time PCR amplification was done using a FastStart Essential DNA Green Master (Roche, Germany).

Results and Discussion

Populations of total protozoa and total bacteria in the rumen fluid counted under an optical microscope are shown in Table 1. There was no significant difference among treatments (P>0.05) in the total protozoal population at 14 day after 10% inulin treatment. The protozoal count was 15.17 $\times 10^5$ cell/mL rumen content after treatment compared to 12.50 $\times$ 10^5 cell/mL rumen content for the control. Total bacteria counts and pH of the rumen of goats on day 0, 1, 7 and 14 of treatment with 10% inulin were not significantly different between groups (P>0.05).

Table 1. Effect of inulin on methanogenic achaea, total protozoa and total bacteria in rumen fluid.

Sampling (day)	Methanogen ($\times 10^7$copies/mL)		SEM	Total Protozoa ($\times 10^5$/mL)		SEM	Total Bacteria ($\times 10^9$/mL)		SEM
	control	Inulin		control	Inulin		control	Inulin	
0	4.19	11.85	0.89	16.50	15.83	0.92	24.93	15.27	4.19
1	4.24	6.33	2.42	6.00[a]	10.17[b]	1.11	16.00	12.80	1.66
7	7.57[a]	14.56[b]	0.26	12.83	14.00	4.37	10.00	11.67	2.63
14	10.16	9.98	0.87	12.50	15.17	3.22	6.33	9.20	1.43

[a,b]Values in the same row with different superscript differ significantly (P < 0.05).
SEM = standard error of the mean.

Methanogenic bacterial diversity was investigated using real-time PCR technique. The results showed that there were no significant differences among treatments (P>0.05) on population of methanogens at day 14 of with 9.98 $\times$ $10^7$and 10.15 $\times$ 10^7 copies/mL, respectively, for the treatment and control groups (Figure 1). The results indicate that addition of 10% inulin did not affect the population of methanogens in the rumen of dairy goats.

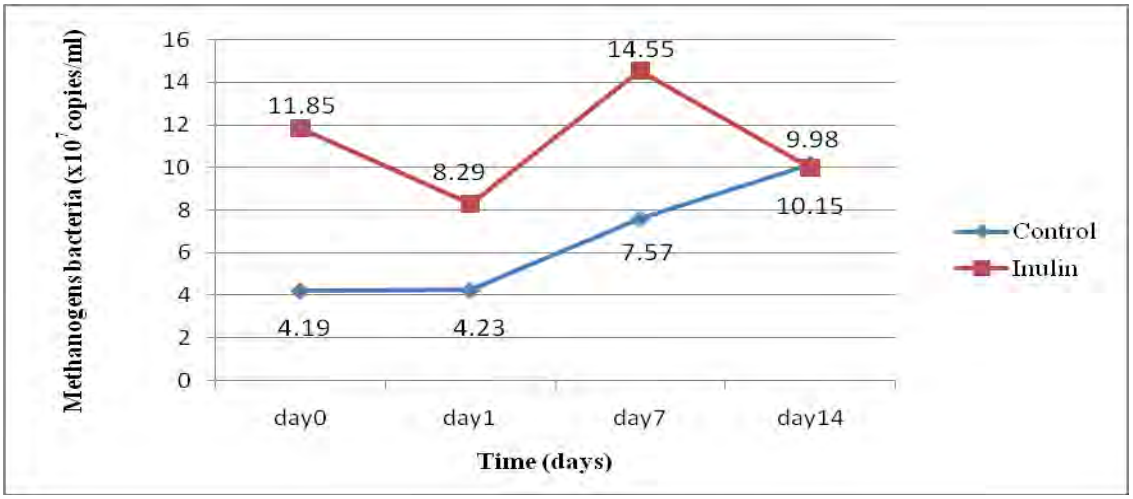

Figure 1. Populations of the rumen methanogens of goats treated with 10% inulin.
The rumen fluid samples were collected at days 0, 1, 7 and 14 after post-morning-feeding.

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Paper 6

Production and Quality of Pasture with Introduced Legumes for Dairy Goats

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Introduction

Goats can consume a wide variety of forages and consuming good quality forages will result in higher milk production in dairy goats. The feeding of legume forage species will increase the compliance with the protein needs of dairy goats. Uptake of minerals including N, P, and Ca from the soil can increase the quality of forage (Karti, 2010). In ruminants, volatile fatty acids (VFA) contribute up to 70% of the caloric requirement (Bergman, 1990) and fermentability of organic matter can be measured by its VFA production (Despal et al., 2011) while protein by its NH_3 production. The latter can be assimilated by rumen microorganisms for growth and other production functions of the host animals. The purpose of this study was to determine the effect of introducing legume intercropping with *Brachiaria humidicola* in pasture for feeding of dairy goats.

Materials and methods

The plant materials used were *B. humidicola* pasture with three kinds of legumes namely *Pueraria javanica*, *Centrosema pubescens* and *Calopogonium mucunoides.* The NPK fertiliser, manure and soil potential microorganisms used for this study were obtained from the Agrostology Laboratory, Faculty of Animal Science, Bogor Agricultural University. The experiment used a randomised block design with eight treatments and four replicates. The treatments were P_1: Control (pasture consists of only *Brachiaria humidicola*); P_2: *B. humidicola* combined with *Pueraria javanica*, *Centrosema pubescens* and *Calopogonium mucunoides* with NPK fertiliser; P_3: *B. Humidicola* with *P. javanica,* P_4: *B. Humidicola* with *C. pubescens;* P_5: *B. Humidicola* with *C. mucunoides;* P_6: *B. Humidicola* with *P. Javanica* and *C. pubescens;* P_7: *B. Humidicola* with *P. javanica* and *C. mucunoides and* P_8: *B. humidicola* with *P. javanica*, *C. pubescens* and *C. mucunoides.* Treatment P_3 to P_8 were given NPK at half doses, manure and potential soil microorganisms. The data were analysed using ANOVA and the differences between mean treatments were analysed using the Duncan Multiple Range Test (DMRT).

Results and Discussion

Dry matter production and P and K uptakes of plants were significantly increased with the introduction of legumes (P_2–P_8) compared to the control. Production of DM in treatments with half doses of inorganic fertiliser, manure and potential microorganisms (P_3, P_5, P_6, P_7

and P_8) were significantly higher than that using the inorganic fertiliser alone (P_2). Uptakes of N and Ca in the treatment with half doses of the inorganic fertiliser, manure and potential microorganisms (P_3–P_8) were significantly higher than using inorganic fertilizer only (P_2). Uptakes of Mg from P_3 and P_7 were significantly higher than those in P_1, P_2 and P_4. The best treatment was P_7, followed by P_3, P_5 and P_8 for DM production and mineral uptake (Table 1).

The results showed that the introduction of legumes with *B. humidicola* pasture (P_2-P_8) increased (P<0.05) the DM digestibility, VFA and NH_3, while no difference was observed among treatments on organic matter digestibility. The treatment which combined NPK fertilisers with manure and potential microorganisms (P_7, P_8, and P_5) significantly (P<0.05) increased the digestibility of DM, VFA, and NH_3 compared to the control (Table 1). The total VFA produced in this study was between 82.65 to 153.04 mM which is sufficient for the optimal growth of rumen microorganisms. The total VFA from a single feed with legume browse plants was higher than the legume browse mixed with grass (Astuti et al., 2011).

The NH_3 produced from protein fermentation in the experiment was sufficient for the growth of dairy goats as reported by Despal et al. (2011).

Table 1. The effect of introducing legumes on DM production, N, P, K, Ca and Mg uptake of plants, DMD, OMD, VFA and NH_3

Treat-ments	DM Prod (g/0.25 m^2)	Uptake of plant (mg/0.25 m^2)					Variables			
		N	P	K	Ca	Mg	KCBK (%)	KCBO (%)	VFA (mM)	NH_3 (mM)
P1	37.5^{d}	80.5^{c}	6.1^{c}	73.9^{d}	18.2^{d}	31.9^{bc}	43.3^{c}	47.2	82.7b	7.9^{c}
P2	110.7^{c}	116.2c	18.8^{ab}	210.3^{bc}	32.1^{d}	28.8^{c}	57.2^{a}	55.9	153.0^{a}	16.5^{a}
P3	171.2a	287.7^{a}	20.6^{a}	313.4^{a}	73.6^{b}	51.4a	52.5^{b}	51.5	108.3^{b}	13.4^{b}
P4	108.5^{c}	213.8^{b}	14.1^{b}	150.9^{c}	69.5^{c}	24.9^{c}	56.4^{a}	54.3	108.3^{b}	13.7^{b}
P5	171.8^{a}	235.3^{ab}	20.6^{ab}	307.4^{ab}	70.4^{b}	37.8^{ab}	54.3^{a}	53.1	141.4^{a}	12.7^{b}
P6	148.0^{b}	192.5^{b}	14.8^{ab}	156.9^{c}	57.7^{c}	44.4^{ab}	54.3^{a}	53.9	87.3^{b}	15.9^{a}
P7	175.2^{a}	268.1^{a}	19.3a	271.6^{ab}	94.6a	52.6^{a}	53.9^{a}	52.8	131.0^{a}	15.1^{a}
P8	156.6^{b}	223.9^{a}	12.5^{bc}	230.2^{b}	86.1a	32.9^{bc}	54.1^{a}	52.1	116.7^{a}	14.9^{a}

Notes: The treatments were P_1: Control (*Pasture consists of Brachiaria humidicola*), P_2: *B. Humidicola* with *Pueraria javanica*, *Centrosema pubescens* and *Calopogonium mucunoides* with fertiliser NPK), P_3: *B. humidicola* with *P. javanica,* P_4: *B. humidicola* with *C. pubescens,* P_5: *B. Humidicola* with *C. mucunoides,* P_6: *B. Humidicola* with *P. javanica* and *C. pubescens,* P7: *B. Humidicola* with *P. javanica* and *C. mucunoides,* P_8: *B. humidicola* with *P. javanica*, *C. pubescens* and *C. mucunoides.* DMD = dry matter digestability, OMD = organic matter digestability. Different superscripts within column show significant differences (P <0.05).

Conclusion

The introduction of legumes with *B. humidicola* pasture increased DM production, mineral uptake (N, P, K, Ca and Mg), DM digestibility, VFA and NH_3 production (P_3–P_8). Dry matter production, mineral uptake in treatments with half doses of inorganic fertilisers, manure and soil potential microorganisms (P_3–P_8) were higher than using inorganic fertiliser (P_2) and control (P_1). Treatments P_7, P_8, and P_5 increased DM digestibility and VFA and NH_3 production compared to the control. The best treatment in this study was P_7 (*B. humidicola* pasture with *P. javanica* and *C. mucunoides*) followed by P_8 (*B. humidicola* pasture with *P. javanica*, *C. pubescens* and *C. mucunoides*).

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Paper 7

Evaluation of Tree Leaves as a Crude Protein and Energy Supplement to the Low Quality Diets of Dairy Goats

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Introduction

Goats are predomiantly raised on natural pastures or stall-fed on low quality hay and crop residues in many developing countries, including Pakistan. In Pakistan, transhumant, nomadic and sedentary farming are the common goat production systems, where goats are extensively grazed on natural rangelands. In the last few decades, the carrying capacity of these pastures have deteriorated due to continuous overgrazing, recurrent droughts and lack of range improvement practices. In addition to the declining quantity, quality of the surviving pasture has deteriorated due to over-utilisation and a consequent depletion of highly palatable and nutritious forage species. The year-round feed availability in these rangelands also fluctuates with a prolonged winter and summer feed scarcity periods. During the pasture scarcity periods, goats are stall-fed on low quality rangeland-hay and crop residues. These low quality diets impede goat productivity due to low dry matter (DM) intake, digestibility and overall feeding value. Alternatively, supplementation of these low quality forages with CP and energy rich tree-foliages can enhance DM intake, digestibility and milk yield in goats. Our previous studies revealed that *Grewia oppositifolia* and *Ziziphus mauritiana* have better nutrient composition among 14 promising fodder trees, and are well adapted to Pakistan's arid and semi arid regions. However, the feeding value of local tree leaves needs to be evaluated due to the negative affect of tannins on palatibility, DM digestibility and bioavliability of dietary protein. The present study was therefore designed to investigate the potential of *G. oppositifolia* and *Z. mauritiana* leaves as CP and energy supplement to the low quality diets of goats.

Materials and methods

The leaves of *G. oppositifolia* and *Z. mauritiana* were harvested in a single batch and dried in shade, mixed, and transported to the Livestock Research Station Mansehra, Pakistan, for the experimental studies. Ruminal CP degradability kinetics of the supplements were determined by the method of Khan et al. (2009), using three mature Beetal bucks fitted with permanent ruminal cannulae. Lactation responses to the supplements were tested with sixteen Beetal goats (Average BW = 44.56 ± 4.20 kg). The goats were grazed on the natural pasture as a single flock and supplemented with dried leaves of *Z. mauritiana* (490 g), *G. oppositifolia* (415 g), a mixture of *Z. mauritiana* (245 g) and *G. oppositifolia* (210 g) or cottonseed cake (CSC; 250 g) on iso-nitrogenous basis for 10 weeks. Milk yield was recorded daily, and

samples of feed and milk were collected weekly. The DM content of feed samples was determined by oven drying at 103°C for 24 h (6496; ISO, 1999), and CP (6.25 × N) was determined using the Kjeldahl method (ISO 5983; ISO, 2005). Tannins were analysed by the method described by Khan et al. (2009). Milk samples were analysed for total solids and protein (6.38 × N) according to AOAC (1995). Fat contents in fresh milk samples were determined using Gerber method. Solid not fat was calculated by subtracting fat contents from the total solids. *In sacco* degradability, milk production and composition data were analysed with the PROC GLM procedure in Statistical Analysis System.

Results and Discussion

The mean (n = 12) CP content of *Z. mauritiana*, *G. oppositifolia* and CSC were 141, 165 and 269 g/kg DM, respectively. Contents of condensed tannins were higher (P<0.01) in the *Z. mauritiana* (33 g/kg DM) than *G. oppositifolia* (0.6 g/kg DM). Leaves from *G. oppositifolia* were appreciably high (35 g/kg DM) in Ca. Due to high content of condensed tannins, *Z. mauritiana* leaves had the lowest rate (P<0.001) of degradation (0.11/h) and effective degradability of CP (620 g/kg) at rumen outflow rates of 0.06. Cotton seed cake had the highest rate (0.17/h) of degradability, and effective degradation of CP (780 g/kg). The leaves of *G. oppositifolia* were intermediate in the degradation kinetics. Daily milk yield differed (P<0.001) among the supplements (Table 1). The high bypass CP in *Z. mauritiana* were efficiently utilised by goats as shown by the high (P<0.05) milk yield. Nevertheless, *G. oppositifolia* and CSC were not significantly different in milk production parameters. Among the supplements a high (P<0.05) milk fat content of 5.6 g/100 g milk was recorded with CSC and *G. oppositifolia.*

Table 1. Mean yield of milk and milk composition of Beetal goats

Parameters	*Z. mauritiana*	*G. oppositifolia*	CSC	Mixed leaves	SEM	Significance
Milk yield (g/d)	569 [a]	459 [b]	445 [b]	458 [b]	14.7	***
Protein %	3.6	3.7	3.4	3.5	0.72	NS
Fat %	5.2[ab]	5.6[a]	5.6[a]	5.0[b]	1.98	*
Total solid %	12.5	12.9	13.2	12.3	2.44	NS
Solid not fat%	7.5	7.3	7.9	7.4	2.87	NS

[abc] shows significant (P<0.05) differences between diets; * P<0.05; *** P<0.001; NS, non-significant (P>0.05); SEM, standard error of means.

Conclusions

The CP in *Z. mauritiana*, with approximately 3% condensed tannin (33 g/kg DM), degraded slowly and provided high bypass CP which resulted in higher milk yield. *G. oppositifolia* and CSC were not significantly different in milk production parameters. Leaves from *Z. mauritiana* and *G. oppositifolia* trees could be conserved by drying and fed as a supplement to minimise the production losses that invariably occur during the prolonged feed scarcity period in the tropical arid and semi arid regions.

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Paper 8

Assessment of *Grewia oppositifolia* Leaves as Crude Protein Supplement to Low Quality Diets of Goats

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Introduction

Goats are characterised by their efficient grazing behaviour and functional digestive system and thrive well under the tropical arid and semi-arid regions. Compared to other farm animals, the population of goats has increased rapidly in the harsh environmental and feed scarcity zones of the tropics. For example, in Pakistan the number of goats has increased from 29.9 million in 1986 to 59.8 million in 2011. This population growth is attributed to the drastic changes in the pattern of range-based feed resources in the country over this period. Recurrent droughts with concomitant overgrazing have severely affected vegetation growth in the natural pastures. Shrubs and trees stay behind as the dominant surviving fodder species that are better utilised by goats compared to other livestock species. Under these harsh environmental and feeding zones, goats play a vital role in providing a livelihood to poor smallholder or landless farmers. However, the productivity of goats is very low, as they are mostly grazed on low quality pastures. Moreover, the year-round feed availability in the rangelands fluctuates with prolonged winter and summer feed scarcity periods. Alternatively, goats are stall fed on crop residues and lower quality range hay (Davendra et al., 2000). These lower quality forage based diets impede the productive performance of goats. Leguminous tree foliage being rich in fermentable organic matter, protein and minerals could be used as a supplement to these low quality diets; and enhance their intake, digestibility and animal performance. *Grewia oppositifolia* is one the promising fodder trees, well-adapted to the arid, hilly, and semi-hilly regions of South Asia. The present study was therefore designed to investigate the potential of *G. oppositifolia* leaves as a low-cost crude protein (CP) supplement to the low-quality forage diets of growing goats.

Materials and methods

Leaves of *G. oppositifolia* were harvested from communal rangelands over the harvesting season (December to March) at 30-day intervals, dried in shade, mixed, and transported to the Animal Research Facilities of Agricultural University Peshawar for the studies. To investigate the effect of *G. oppositifolia* supplementation of dry matter (DM) intake, digestibility and N retention in goats, a balanced trial was conducted with four mature Beetal Bucks (48 ± 2.3 kg BW) in a 4 × 4 Latin square design. The animals were fed with a basal diet of chopped sorghum hay (CP 47.8 ± 3.45 g/kg DM) *ad libitum*. The basal diet was supplemented with cottonseed cake (CSC) or the CSC was replaced at the rates of 0.50, 0.75, and 1.00 g/g with *G. oppositifolia* leaves. The animals were housed in individual metabolic

crates with a device fitted for the separate collection of feaces and urine. The animals were adapted to the diets for 10 days, and data and samples were collected daily in the last 5 days of each period. To evaluate changes in BW gain in response to the supplements, 32 (26 ± 3 kg BW; 10 ± 1 month of age) grazing goats were randomly assigned to four diets for 3 months. The grazing goats were supplemented with CSC or the various combinations of CSC: *G. oppositifolia* leaves. Animals were weighed every 2 weeks to determine BW changes. The samples were air dried at 70°C, ground to 1 mm; and analysed for the DM content by oven drying at 103°C for 24 h (6496; ISO, 1999) and CP (6.25 × N) by the Kjeldahl method (ISO 5983; ISO, 2005). The mineral contents were determined as described elsewhere by Khan et al. (2011). Data were analysed with the PROC GLM procedure in Statistical Analysis System (SAS, Version 9.2).

Results and Discussion

Grewia oppositifolia leaves maintained a higher CP content (>164 g/kg DM) during the harvesting period. The leaves were rich in Ca and K with average values of 41 and 89 g/kg DM, respectively. The leaves were also a good source of micro-minerals Zn (41 mg/kg DM), Fe (32 mg/kg DM), and Mn (202 mg/kg DM). Intakes of hay and total DM and digestibility in goats did not differ with the stepwise substitution of CSC with *G. oppositifolia* leaves. Goats retained the N in each diet, however, quantitatively N retention did not differ among the diets (Table 1). Addition of the leaves increased BW gain in the grazing goats ($P<0.05$). Among the supplemented groups, lambs fed with *G. oppositifolia* leaves showed higher BW gain (124 g/day).

Table 1. Dry matter (DM) intake, apparent DM and CP digestibility, and N retention in response to substitution of cotton seed cake (CSC) with *Grewia oppositifolia* leaves

	CSC: *G. oppositifolia*				SEM
	100: 0	50: 50	25: 75	0: 100	
DM intake g/d	611	612	618	709	63.1
DM digestibility g/kg	480	496	500	484	22.3
CP digestibility g/kg	664	644	629	614	26.4
N retained g/d	6.11	6.08	6.19	6.67	0.923
BW gain g/d	90.6^{b}	110^{ab}	114^{ab}	124^{a}	11.4

Values are means; SEM = standard error of the mean.
^{a,b}means with different superscripts are significantly different ($P<0.05$)

Conclusions

The results demonstrated that *G. oppositifolia* leaves provide good quality green fodder during the prolonged winter feed scarcity period, and that the leaves can be efficiently utilised as a CP supplement for the low-quality diets of sheep.

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Paper 9

Effect of Intersowing Italian Ryegrass (*Lolium multiflorum*) with Dwarf Napier Grass on Yield and Quality for Biomass Use

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Introduction

Intersowing of Italian ryegrass (*Lolium multiflorum* Lam, extremely early-maturing variety, Hanamiwase) with dwarf Napier grass (*Pennisetum purpureum* Scumach) was examined for yield and fibre quality in April-harvested Italian ryegrass as biomass use under 2 cutting frequencies and 3 planting densities of dwarf Napier grass to obtain the best frequency and density of Napier grass at the establishment year.

Materials and methods

The study was conducted on Andisols in the Kibana Field, University of Miyazaki, located at 51 m above sea level in southern Kyushu, Japan (31° 82'N and 131° 41'E). The trial was conducted from November 2009 to April 2010 and temperature and rainfall data were monitored via Miyazaki Meteorological Observatory. Plots were arranged in a randomised complete design with 3 replications (main plots) and each subplot (plant density) had 4 rows, at 4-m long × 5-m width with 1-m and 2-m spacing between subplots and main plots, respectively (Khairani et al., 2011). The seeds of Italian ryegrass cv Hanamiwase (Snow brand seed) were sown at 2 g/m^2 into the inter-row space of dwarf Napier grass plot which had different planting densities (1, 2 and 3 plants/m^2) on 14 November 2009. Plots were occupied in the same ratio by both Italian ryegrass and dwarf Napier grass. Plots were rain-fed and fertilised two times on 14 November 2009 and 2 March 2010 using chemical compound fertiliser at the rate of 10 g N, P_2O_5 and K_2O, each m^2/yr.

The grass was measured for plant height, plant length and tiller number before harvest on 5 April 2010 by cutting at 5 cm above the soil surface using a quadrant of 50 cm × 50 cm. Herbage mass was measured for fresh and dry weights. The fresh yield (g/m^2) of Italian ryegrass was calculated as follows: (1) Plant spacing at 1 and 2 plants m^2 of dwarf Napier grass was calculated by yield of quadrant × 2, because the area of dwarf Napier grass was calculated at 0.25 and 0.5 m^2 for 1 and 2 plant/m^2, respectively (2) Plant spacing at 3 plants m^{-2} of dwarf Napier grass was calculated by yield of quadrant × 1, because the area of dwarf Napier grass was 0.75 m^2 for 3 plants/m^2. The dry matter (DM) yield was calculated according to Tarawali et al. (1995).

Samples were analysed in duplicates for *in vitro* dry matter digestibility (IVDMD), neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) contents using a detergent digestion protocol as described by Vogel et al. (1999). Samples

were processed by the fibre extraction protocol (Vogel et al., 1999), and the ANKOM procedure (ANKOM 220 Fibre Analyser, Model 220v). IVDMD content was determined by the pepsin-cellulase digestion method (Goto and Minson, 1977).

One-way Analysis of Variance (ANOVA) was carried out using SPSS (version 15.0) and mean separation was tested using the least significance difference (LSD) method at 5% significance level. Pearson correlation coefficients were calculated among growth attributes, DM yield, cell wall components and IVDMD (for each parameter, total n = 36).

Results and Discussion

Dry matter yields of Italian ryegrass were significantly (P<0.05) higher, where it was sown at 1 plant/m^2 (1.926–1.931 Mg/ha) and 2 plants/m^2 (1.891–1.899 Mg/ha) of dwarf Napier grass plot than sown at 3 plants/m^2 (0.820–1.146 Mg/ha), while the NDF, ADF and ADL contents ranged from 50.4–54.7%, 36.4–38.6% and 6.8–8.3%, respectively. The increase in plant density led to significantly (P<0.05) decreased tiller number, fresh and DM yield, and IVDMD of Italian ryegrass with no significant difference in fibre or structural carbohydrate compositions in Italian ryegrass (P>0.05).

Table 1. Correlation coefficients of growth attributes†, yield†, yield components†, chemical compositions† and *in vitro* dry matter digestibility† of Italian ryegrass

	Ethanol production potential	PH	PL	TN	FY	DMY	NDF	ADF	ADL
PH	ns	–							
PL	ns	.596**	–						
TN	.759**	-.346*	ns	–					
FY	.953**	ns	ns	.829**	–				
DMY	.973**	ns	ns	.815**	.976**	–			
NDF	ns	ns	.374*	ns	ns	ns	–		
ADF	ns	.357*	.412*	ns	ns	ns	ns	–	
ADL	ns	ns	ns	ns	ns	ns	ns	.707**	–
IVDMD	ns	ns	ns	ns	ns	ns	-.331*	ns	ns

† PH, plant height; PL, plant length; TN, tiller number; FY, fresh yield; DMY, dry matter yield; NDF, neutral detergent fibre; ADF, acid detergent fibre; ADL, acid detergent lignin; IVDMD, *in vitro* dry matter digestibility.
* Significant at P<0.05, ** significant at P<0.01 by Pearson's correlation analysis (n = 36), ns at P>0.05.

Conclusions

Dry matter yield, cellulose and hemicellulose contents of Italian ryegrass decreased significantly (P<0.05) with increased plant density of dwarf Napier grass

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Paper 10

Effect of Feeding Pattern on Rumen Microorganism Population in Saanen Goats

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Introduction

Rumen microorganisms, especially the methanogenic bacteria and protozoa are the main contributing factors of enteric methane production, which contributes to the overall production of greenhouse gas (GHG) in the atmosphere causing global warming. Factors influencing ruminal methanogen production include; level of intake, type and quality of feed and environmental temperature (Shibata and Terada, 2010; Mirzaei-Aghsaghali and Maheri-Sis, 2011), but limited studies have been conducted to examine the effect of feeding system (e.g. cut-and-carry (pen-feeding) vs. grazing) on the population of ruminal methanogens.

Materials and methods

Six female crossbred Saanen goats (12 months, 30.5 ± 5 kg) were divided equally into two groups; cut-and-carry (pen-feeding) and grazing systems. All animals in the cut-and-carry group were fed *ad libitum* with purple guinea grass (*Panicum maximum* TD58) as basal roughage. Animals in the grazing group were allowed to graze between 0900 to 1800h (continuous grazing at a stocking rate of 3 goats/200 m^2). Concentrate feed was offered at a restricted amount of 1.5% BW (20% CP) at 0830 h daily. Rumen content of each animal was collected using a suction pump 4 h after the goats were fed the concentrates on days 0, 1, 7 and 14. Rumen contents were processed for the quantification of 16S gene copies of methanogens archaea using real-time PCR assay(LightCycler® Nano System version 1.0, Roche). Microscopic direct counting of the total bacteria and protozoa population was also carried out. Statistical analyses were conducted using SAS (1989) v6.12 and differences between means considered to be significant at $P<0.05$.

Results and Discussion

For the grazing goats, the average methanogenic archaes at day 14 was 3.36×10^7 copies/mL rumen content, which was significantly lower ($P<0.05$) than in the cut-and-carry goats ($10.15 \times 10^7$16S rRNA copies/mL rumen content) (Figure 1). Populations of rumen protozoa and bacteria of grazing goats were not significantly different from those of goats fed by cut-and-carry (Table 1). Rumen pH of grazing goats (7.70) was higher ($P<0.05$) than that of the cut-and-carry goats (6.70). Feed intake of concentrates was not significantly different ($P<0.05$) between cut-and-carry goats (464.86 gDM) and grazing goats (479.86 gDM). The CP of

purple guinea grass for grazing goats (8.81%) was not significantly different ($P>0.05$) from that of the cut-and-carry goats (10.12%). NDF content (67.04%) of grass for cut-and-carry was significantly ($P<0.05$) higher than that for grazing goats (60.65%) because grazing goats can select to consume good quality grass of lower NDF than that those in the cut-and-carry system. Since fibre content has a major effect on ruminant methane emissions (Graeme et al., 2000) it might be possible that grazing goats produce less methane than the cut-and-carry goats as indicated by the lower counts of methanogens in the grazing goats.

Table 1. Some rumen microorganism parameters in cut-and-carry and grazing Saanen goats.

	Day	Feed of Goats		SEM
		Cut-and-carry	Grazing	
Bacteria	0	24.93×10^9	15.73×10^9	2.43
(cells/mL rumen content)	1	16.00×10^9	16.27×10^9	1.43
	7	10.00×10^9	09.67×10^9	1.15
	14	06.33×10^9	04.73×10^9	1.08
Protozoa	0	16.50×10^5	14.33×10^5	1.58
(cells/mL rumen content)	1	$06.00^b \times 10^5$	$17.33^a \times 10^5$	1.82
	7	12.83×10^5	12.50×10^5	1.97
	14	12.50×10^5	11.33×10^5	1.54
Methanogens	0	$04.19^a \times 10^7$	$01.10^b \times 10^7$	0.31
(16S rRNA gene copies/mL rumen content)	1	$04.23^a \times 10^7$	$01.59^b \times 10^7$	0.28
	7	$07.57^a \times 10^7$	$04.50^b \times 10^7$	0.25
	14	$10.16^a \times 10^7$	$03.37^b \times 10^7$	0.57

Values with different small superscript letters in the same column are significantly different ($P<0.05$)

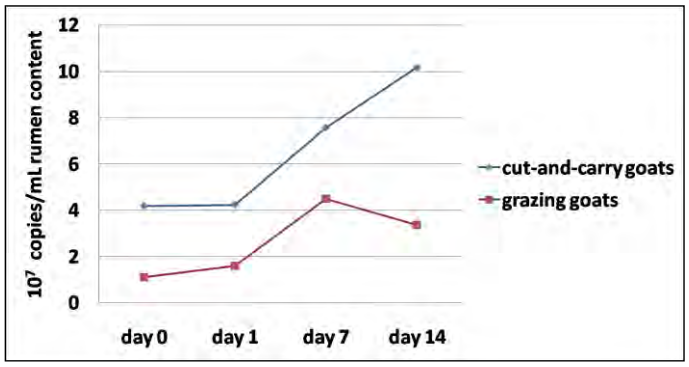

Figure 1. Methanogen counts of cut-and-carry and grazing goats.

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Paper 11

Supplementation of Leucaena and *Acacia mangium* Willd Foliages on Microbial N Supply, Digestibility and N Balance in Saanen Goats

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Introduction

Locally available feed resources, particularly crop residues, protein foliages and agro-products should be utilised to cut production cost and to meet the increasing demand feed for animal production. Ruminant feeding systems based on poor quality roughage where protein is one of the first limiting factors may require additional protein to maintain an efficient rumen ecosystem that will stimulate nutrient intake and improve animal performance (Preston and Leng, 1987). The purpose of this study was to evaluate the effectiveness of supplementing dairy goats with protein foliages such as *Leucaena* and *Acacia mangium*Willd in a rice straw-based diet.

Materials and methods

Twelve Saanen goats selected from a commercial farm based on similar body weight (27.0 ± 3.5 kg) were used for this study. The goats were housed in individual pens and allowed 3 weeks to adapt to experimental conditions. The goats were randomly allocated to three treatment groups in a 3 x 3 Latin square experiment (replicated 4 times). Each goat was given rice straw as roughage plus the respective treatment diet. The diets were iso-nitrogenous and iso-energetic containing cassava pulp, molasses, urea and commercial mineral and vitamin mix. The experimental treatments were (i) soybean meal (SBM), (ii) partial substitution of SBM with Leucaena (*Leucaena leucocephala*) foliage or (iii) partial substitution of SBM with *Acacia mangium* Willd foliage.

Results and Discussion

Microbial N supply in terms of microbial N yield (gN/d) and the efficiency of microbial synthesis (gN/kg DOMR), and microbial protein synthesis (gCP/d) among the treatment groups were not significantly ($P>0.05$) different (Table 1).

Replacing Leucaena and *Acacia mangium* Willd did not significantly affect average nutrient and digestible nutrient intakes, except, as expected, that total tannin and condensed tannin intakes of goats fed Leucaena foliage, were higher ($P<0.05$) than those of *Acacia mangium* foliage and SBM.

Table 1 Effect of soybean meal substitution with foliages on digestible organic matter intake (DOMI), microbial N supply and proportion of microbial protein synthesis in dairy goats.

	Dietary treatments			
	Control	Leucaena	*Acacia mangium* Willd	SEM
DOMI, kg/d	1.3	1.2	1.2	0.03
Digestible nutrient intake, kg/d				
Organic matter	1.25	1.21	1.20	0.058
Crude protein	0.20	0.20	0.19	0.009
Neutral detergent fiber	0.57	0.59	0.59	0.019
DOMR, kg/d *	0.8	0.8	0.8	0.02
Microbial N supply				
gN/d	15.0	14.6	13.9	0.32
gN/kgDOMR	18.7	18.7	18.6	0.64
Microbial protein, gCP/d	93.6	91.3	86.6	1.97

* DOMR = digestible OM fermented in the rumen, calculated as 0.65 x DOM intake (ARC, 1984)
SEM = standard error of means.

The present results indicate that local protein foliages from shrubs and trees can substitute imported feedstuffs such as SBM as protein supplement for dairy goat production.

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Paper 12

Enhancing Performance of Dairy Goat by Biscuit Feeding as Fibre Source

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Introduction

Dairy goat farming in Indonesia is an activity that has potential to be developed. The milk of dairy goats is of better quality than cow milk and fetches a higher price. The problem often encountered in the dairy goats is low milk yield of less than 2 L/head/day. Productivity of dairy goats is largely determined by the availability and quality of feed. The major constraints of ruminant feed are as follows: forage is bulky and perishable thus difficult to handle, distribute and process; inconsistent supply between dry and rainy seasons; low palatability and low digestibility. Therefore, it is necessary to develop suitable technologies to produce ruminant feed which is more durable, easier to handle, distribute and feed to animals.

Biscuit is a dry product that is relatively long-lasting under normal storage conditions and easy to handle (Whiteley, 1971). To date no research has been conducted on the processing of forage into forage biscuits which can be used during feed scarcity for dairy goats in the dry season.

Materials and methods

The process of making of corn leaf biscuit as described by Kitessa et al., (1999) was used to prepare biscuits of different treatments for this study. It includes chopping, grinding, mixing, pressing and heating at temperature of 100°C for 5 minutes and finally cooling at room temperature. The experimental design used was a completely randomised design with 6 treatments and 3 replications. The treatments were: R1 (100% field grass), R2 (50% field grass + 50% corn leaf), R3 (100% corn leaf), R4 (50% field grass + 50% corn husk), R5 (50% corn leaf + 50% corn husk) and R6 (100% corn husk). The results were subjected to ANOVA and contrast orthogonal test (Steel and Torrie, 1991). The biscuit parameters measured were water activity, moisture, water absorption, density and nutrient quality (ash, crude protein, crude fibre, crude fat and nitrogen free extract).

Results and Discussion

The nutrient composition of the different grass and corn plant waste biscuits is presented in Table 1. Results of this study indicated that the treatment of biscuit had a highly significant effect ($P<0.01$) on moisture where in biscuits R1, R2 and R6 it was lower than in biscuits R3, R4 and R5. The water absorption was significantly higher ($P<0.05$) for R1, R4 and R5 than biscuits R2, R3 and R6. Water activity and density were not significantly different between biscuits (Table 2).

Table 1. Nutrient composition of biscuits of field grass and corn plant waste

Biscuit*	Nutrient Composition (%)				
	Ash	Crude Protein	Crude Fibre	Crude Fat	Nitrogen free extract
R1	10.42	12.89	41.33	0.21	35.14
R2	9.78	14.51	31.90	0.20	43.60
R3	8.83	16.12	29.45	1.04	44.56
R4	8.45	13.51	42.49	1.31	34.24
R5	7.94	14.41	27.25	1.66	48.73
R6	9.59	13.69	38.12	1.86	36.74

- Please refer to text for composition of the different treatments

Based on this study it was shown that field grass plus corn leaf biscuits (R2) had the best physical characteristics. Corn leaf biscuit (R3) had the best nutrient quality among the different biscuits. It was concluded that field grass plus corn leaf could be processed to produce biscuits as a fibre source for ruminant feed.

Table 2. Physical characteristic of biscuits of field grass and corn plant waste

Biscuit	Parameters			
	Water Activity	Moisture (%)	Water absorption (%)	Density (g/cm^3)
R1	0.70 ± 0.05	11.23^{c} ± 0.60	492.34^{a} ± 40.90	0.45 ± 0.03
R2	0.69 ± 0.02	11.06^{c} ± 0.10	383.49^{c} ± 31.97	0.44 ± 0.03
R3	0.69 ± 0.02	12.85^{a} ± 0.37	438.00^{b} ± 15.69	0.45 ± 0.03
R4	0.69 ± 0.02	11.73^{b} ± 0.17	514.48^{a} ± 19.95	0.48 ± 0.06
R5	0.69 ± 0.03	11.80^{b} ± 0.09	504.27^{a} ± 5.59	0.52 ± 0.03
R6	0.70 ± 0.03	11.39^{c} ± 0.71	452.31^{b} ± 42.63	0.47 ± 0.01

Means with different superscripts within the same column are significantly different at P = 0.01

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Paper 13

Development of a New Quantitative Competitive PCR Assay for Rumen Butyrate-Producing Bacterium, *Butyrivibrio fibrisolvens*

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Introduction

Infusion of butyrate into the rumen of ruminants results in an increase of the concentration of milk fat and protein. Ruminal butyrate production can be increased by increasing the numbers of butyrate producing bacteria (Huhtanen et al., 1992). *Butyrivibrio fibrisolvens* strains are presently recognised as the major butyrate-producing bacteria in the rumen. They can be found in the digestive track of many animals and in the human gut. The aim of this study was to develop a powerful quantitative competitive polymerase chain reaction (QC-PCR) assay based on 16S rDNA for the enumeration of the strains belonging to *Butyrivibrio fibrisolvens* in rumen fluid.

Materials and methods

Species-specific PCR primers that amplify partial 16S rDNA region (213 bp as target DNA) were used in this study (Kobayashi et al., 2000). Two internal primers, bearing 5′ tails which contain two ~30 nucleotide sequences, unrelated to the target to be amplified and complementary to each other, were designed (Figure 1). To construct the homologous competitor with 50 bp insertion, a stepwise SOE-PCR (Splicing by Overlap Extension Polymerase Chain Reaction) in three separate amplifications using different primer pairs was carried out (Figure 2). For future applications and as the easiest way to determine competitor concentration, competitor fragment was cloned into a TA plasmid vector (pTZ57R/T), purified and quantified before use. The competitor was serially diluted and co-amplified by PCR with total extracted DNA from rumen fluid samples.

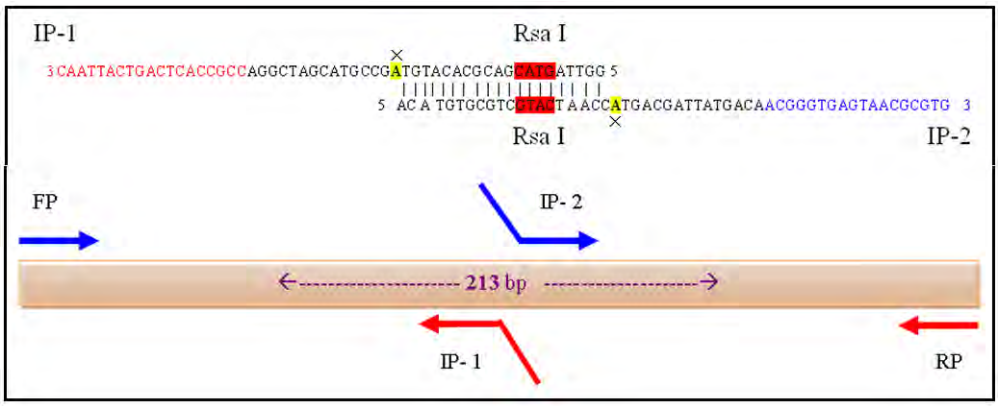

Figure 1. Design and sequence of internal primers (IP1 and IP2).

QC-PCR products were electrophoresed on agarose gel containing ethidium bromide, and photographed. Band intensities were measured using image analysis software (image J 1.42q) to determine if co-amplification had occurred with equal efficiency. The quantity of competitor against the ratio of amplified target to amplified competitor was plotted using log scale and evaluated by simple regression using the JMP® software (SAS Institute) and finally the R^2 was estimated as a criterion of competitive PCR performance.

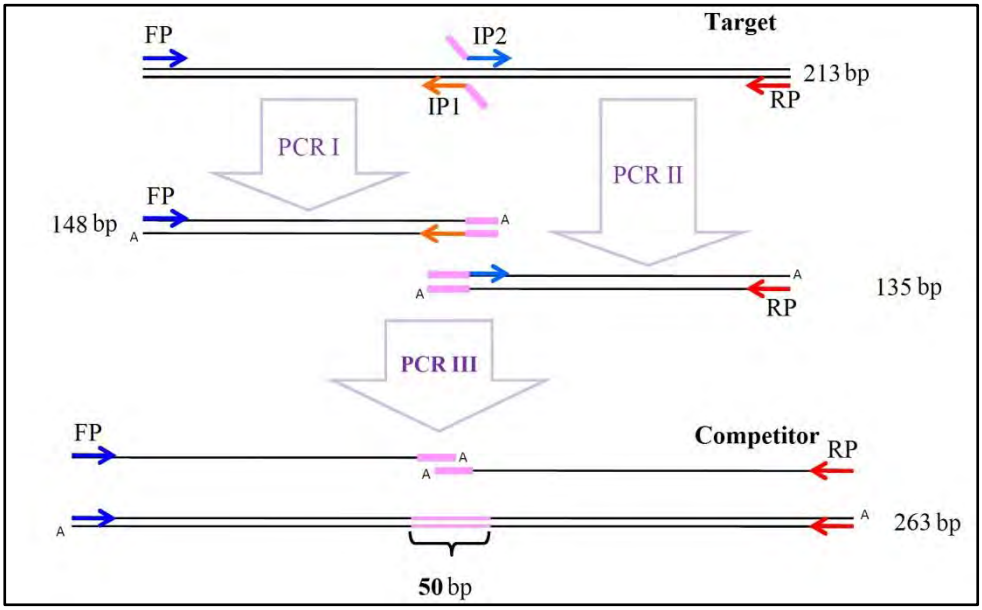

Figure 2. Splicing by overlap extension polymerase chain reaction (SOE-PCR) and used for constructing the homologous competitor fragment.

Results and Discussion

Butyrivibrio fibrisolvens species-specific primers successfully amplified a 213 bp amplicon. The log plot of the amount of amplified target DNA against the amount of amplified competitor DNA was highly linear (R^2 = 0.985) indicating that the homologous competitor can potentially represent the number of target fragments. As a result of our study a new quantitative competitive PCR (QCPCR) assay was developed for quantification and enumeration of *Butyrivibrio fibrisolvens* in rumen fluid samples. The developed QCPCR

method can be used for monitoring changes in the population of *Butyrivibrio fibrisolvens* in rumen fluid samples during nutritional treatments.

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Lead Paper 2

Reproductive, Production and Economic Performances of the Damascus (Shami) Goats in Cyprus

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Introduction

Damascus (Shami) goat is a large breed, measuring 78 cm at withers, having a body circumference of 97 to 99 cm and adult live weight of 65 ± 5 kg (female) and 75 ± 5 kg (male). The Damascus goat requires an improved management and feeding environment to express its full genetic potential (Mavrogeenis et al., 1984). The goat can be managed in small tethered or large size flocks (200 to 1000), if provided with housing, feeding and other necessary facilities. The breed combines high prolificacy with high milk production and growth rate (Constantinou, 1989). The main breeding season starts in late August and extends through mid December. Occasionally a heat wave occurs in late spring or early summer, but it is characterized by irregular oestrous cycles. This paper describes the reproductive, production and economic performances of Shami goats.

Materials and methods

This study involved collection of data in Cyprus for both reproductive and production parameters as well as economic performance of Shami goats (Mavrogenis and Papachristoforou, 1990; 2000). The reproductive characteristics included percent fertility, prolificacy, conception rate, mortality at birth and mortality at weaning. The production characteristics included live weight and growth rate (birth weight, weaning weight, pre-weaning growth, 15 week weight and post-weaning growth), carcass traits (carcass weight and percent dressing) and milk performance (total yield, lactation length, amount of milk suckled, fat content, protein content and total solids). Comparison of economic performance between Shami and other goat breeds (Boer, Jamnapari and Saanen) was made.

Results and Discussion

Reproductive characteristics

First oestrus occurred between 220 and 270 days of age at live weights from 42 to 54 kg, depending on type of birth. This characteristic allows for the early breeding of kids and the initiation of the productive life at the age of 13 to 16 months. Fertility was medium to high (80 to 90%), a characteristic of most goat breeds with high milk production. The prolificacy of the breed was among the highest in the region, averaging 1.80 kids per goat kidding.

Production characteristics

Birth weights were high ranging from 3.5 to 5.5 kg, depending on type of birth and sex. Weaning was practiced between 42 and 49 days post-partum. Kids during the suckling period had free access to a starter diet containing 18% crude protein (CP) and good quality hay (0.2 kg of Lucerne hay). Following weaning they were group-fed on concentrate diets containing 16 to 18% CP and Lucerne or Barley hay offered *ad libitum*. Males grew faster than females, and singles were faster in growth than twins or other multiples, both before and after weaning. Kid carcasses were lean with 47.3 to 49.5 dressing percentages, depending on age at slaughter.

The Shami goat is a dual-purpose animal (meat and milk). It is milked principally following weaning, but also during the suckling period, because a large quantity of milk remains in the udder without being utilized by the suckling kids. Total milk production, including milk produced until weaning, ranged between 450 and 850 kg per goat per lactation. Lactation lasted for approximately 7 months following weaning, although lactations up to a year were not rare. The fat and protein contents of the milk were characteristic for high yielding breeds, ranging from 3.8 to 4.5% for fat and from 4.0 to 4.8% for protein. The milking goat responded positively to high protein diets by increased milk output and longer maintenance of milk production at a high level.

Economic performance

Shami goats gave a higher income and faster return on investment (ROI) compared to other breeds such as Boer, Jamnapari and Saanen. A two-year comparison showed Shami goats gross profit was the highest (RM 32,660) compared with Boer (RM 7,320), Jamnapari (RM 6,400) and Saanen (RM 13,800) goats. RIO values among the four breeds, was 7.25 for Shami, 4.6 for Saanen, 2.44 for Boer, and 2.13 times for Jamnapari goats.

Conclusions

In conclusion, Shami goats possess high reproductive as well as production characteristics. With high milk production, Shami is an excellent breed of dairy goat and gives better and faster economic returns on investment compared to other breeds such as Boer, Jamnapari and Saanen. Therefore, it is apparent that Shami is a good candidate among the potential dairy goat breeds under consideration for strategic planning of the Malaysian goat industry..

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Paper 14

Genotypic Characterisation of Ardi Goats in Saudi Arabia

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Introduction

Adaptation of indigenous goat populations in the Kingdom of Saudi Arabia (SA) for low feed intake, harsh environmental conditions and limited water resources was reported by El-Nouty et al. (1990). The common native goat breeds in the Kingdom are Ardi, Bishi, Jabaly and Tohami. Ardi goat is black coloured with white leaf ears and horns present in both sexes (Fig. 1). Genetic characterisation is very useful and widely used to categorise animals in the world and important for conservation of genetic resources (Kevorkian et al., 2010). Thus, characterisation could enhance many attributes of breed traits such as resistance to diseases and fertility. Microsatellites are the markers of choice for genetic characterisation of livestock due to their various advantages (Baumung et al., 2004). The objective of the present study was to evaluate the genetic variability of Ardi goats in SA based on microsatellites.

Figure 1. Male (a) and female (b) goats of Ardi breed.

Materials and methods

Unrelated and randomly selected 43 Ardi goats were blood sampled (10 mL from the jugular vein) and the DNA was extracted using GFX Genomic Blood Kit and checked for quality and quantity using a spectrophotometer. Fourteen fluorescent labelled microsatellite markers, recommended by International Society for Animal Genetics (ISAG) were used to extract and amplify the DNA by PCR using an AB GeneAmp® PCR 9700. Amplified products were separated by ABI Genetic Analyser 3130. Microsatellite fragment sizing was performed by the GeneMapper® v.4.0. Statistical analysis was carried out using Cervus v.3.0.3 from Field Genetics Limited to assess the expected heterozygosity (H_e), observed heterozygosity (H_o) and polymorphic information content (*PIC*). Fixation Index (F_{is}) and Hardy Weinberg Equilibrium (HWE) were calculated by GenePop v.4.0.10., and Bottleneck was analysed using v.1.2.02. Popgene v.1.31.

Results and Discussion

All 14 microsatellites tested amplified well and were found to be polymorphic, containing a minimum of three alleles and a maximum of nine alleles. The highest observed heterozygosity was shown by locus *SPS113* (0.88), while the lowest was (0.26) by *MAF209.* Maximum H_e was given by *MAF70* (0.83) and the minimum was (0.35) by *ILSTS005.* Ten markers (Table 1) showed higher heterozygote alleles than the homozygote. All of the markers showed alleles which were within the expected sizes. HWE test indicated that seven loci: *ILSTS011*, *ILSTS005, SPS113*, *ILSTS029*, *SRCRSP3*, *MAF70* and *OarAE54,* were in HWE. All markers, except *ILSTS005*, showed acceptable informative capacity with PIC values higher than 0.5. Mean F_{is} value was 0.18. Ardi showed higher expected genetic diversity (0.69) when compared with some Asian goat breeds of southern Sri Lanka (0.48), Jamunapari (0.54) (Gour et al., 2006), and Korean goats (0.38) (Kim et al., 2002). On the other hand Ardi showed less genetic diversity when compared with some of the Indian breeds: Kutchi (0.80), and Mehsana (0.77) (Behl et al., 2003). The mean number of alleles and H_e detected were very good indices of the genetic polymorphism within breeds. The PIC values show the suitability of the markers for analysing the genetic variability. Kumar et al. (2009) reported the PIC mean of 0.65 for Gohilwaris. The high PIC values of the particular markers suggest their usefulness for genetic polymorphism related research and linkage mapping projects in goats. Mode shift indicator and Sign test, Standardised Differences test and Wilcoxon rank test showed that there was no bottleneck in Ardi goats. In general, from all of these indices, Ardi goats have a considerable amount of genetic polymorphism. Therefore, any unique alleles present in this breed may not have been lost.

Table 1. Genetic variability parameters of Ardi goats

Marker	n_a	n_e	H_o	H_e	*PIC*	F_{is}	HWE
ILSTS011	8	2.42	0.58	0.58	0.54	0.008	NS
OarFCB20	9	2.44	0.48	0.59	0.55	0.175	*
SPS113	7	4.08	0.87	0.75	0.70	-0.161	NS
ILSTS029	7	4.40	0.69	0.75	0.71	0.049	**
MAF209	3	1.99	0.25	0.49	0.43	0.490	NS
OarFCB48	8	4.31	0.39	0.76	0.72	0.488	**
SRCRSP3	3	2.37	0.61	0.57	0.50	-0.056	NS
ETH10	7	4.31	0.50	0.76	0.71	-0.056	**
MAF70	8	5.92	0.86	0.83	0.79	-0.044	NS
ILSTS005	5	1.54	0.26	0.35	0.33	0.025	NS
OarAE54	9	3.14	0.65	0.68	0.64	0.035	NS
BM6444	4	3.19	0.57	0.68	0.60	0.163	**
INRA023	8	5.47	0.63	0.81	0.78	0.226	**
TGLA53	7	4.39	0.34	0.77	0.73	0.000	**

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Paper 15

Effect of Estrus Synchronisation with Sponge and CIDR on Pregnancy Rate, Sex and Birth Type of Kids in Iranian Adani (Persian Gulf) Goats

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Introduction

Adani goat is a well-adapted dairy breed, which is raised in coastal areas of the Persian Gulf in the Bushehr province in southern Iran. In these areas, the climate is harsh with high temperatures and humidity and poor quality pastures. This breed of goat is well-adapted to these conditions and shortage of forage. Adani goat is maintained as household animal and has suitable litter size and high pregnancy rate. The average twinning rate is 0.7 and generally it has three pregnancies in two years. In goats, control of estrus and ovulation is a valuable tool to improve and maintain milk and meat production throughout the year. Therefore, estrus synchronisation together with artificial insemination (AI) is extensively applied in the reproductive management of goats (Leboeuf et al., 1998). Estrus synchronisation in livestock focuses on the manipulation of either the luteal or the follicular phase of the estrous cycle (Wildeus, 1999). During the breeding season, when goats are actively cycling, estrus can be synchronised with PGF2α or one of its analogues, such as cloprostenol (Bitaraf et al., 2007). The most widely used procedures for synchronisation and/or the induction of estrus are 12–21 days of intravaginal sponge treatments (Fonseca et al., 2005; Kausar et al., 2009). No study has been done on synchronisation and reproduction traits of Adani goats. The aim of this study was to investigate the effect of estrus synchronisation with CIDR and sponge on the pregnancy rate, gender and birth type of kids in Adani goats.

Materials and methods

A total of 333 dairy female Adani goats (aged 2.5 to 5 years) in seasonal breeding, were allotted to ten groups and synchronised by CIDR (EAZI-BREED, New Zealand) containing 0.3 g of progesterone (n = 127 and number of groups = 5) and sponges (EAZI-BREED, New Zealand) containing 45 mg of norgestomet (n = 206 and number of groups = 5). After 14 days the CIDR and sponge were removed and the animal injected with 2 mL PMSG and 2 mL pregnecol for the CIDR and sponge groups, respectively. After 36 hours male goats were added to the groups for 48 hours. One male goat was used to mate 6 to 7 does. The pregnancy rate was computed for each group and birth type and sex of kids recorded. The effect of CIDR and sponge on pregnancy rate was compared by *t*-test and the effect of CIDR and sponge on gender and birth type of kids was compared by Chi-Square test (via contingency tables). SAS ver. 9.1 Software was used for both analyses.

Results and Discussion

The effect of CIDR and sponge on pregnancy rate, gender and birth type of kids in Adani goats are shown in Tables 1 and 2. No significant difference was seen between sponge and CIDR (t = 0.03 and $P>0.05$) on pregnancy rate. Based on Chi-Square test, Sponge and CIDR had no significant effect on gender ($\chi^2 = 0.49$ and $P>0.05$) and birth type ($\chi^2 = 5.98$ and $P>0.05$) of kids. It can be concluded that either sponge or CIDR procedures can be used to synchronise estrus with a pregnancy rate of 49% in Adani does.

Table 1. The effect of sponge and CIDR on pregnancy rate in Adani goats (in percentage)

Treatment	n	Mean	t-value	*P*
Sponge	5	49.5[a]	0.03	0.9770
CIDR	5	49.2[a]		

[a]Means within column with different superscripts differ at $P<0.05$

Table2. The effect of sponge and CIDR on sex and birth type of kids (in percentage)

Treatment	Sex			Birth type			
	Male	Female	Total	1	2	3	Total
Sponge	63	68	131	66	31	1	98
CIDR	44	39	83	34	17	5	56
Total	107	107	214	100	48	6	154

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Paper 16

Estimation of Genetic Parameters for Growth Traits of Iranian Adani (Persian Gulf) Goats

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Introduction

Adani dairy goat is one of the most important breeds in southern Iran. This breed is reared in the coastal areas of the Persian Gulf in Bushehr province. In these areas, the climate is harsh due to high temperature and humidity and lack of good pasture. Adani goats are maintained as household animals under intensive systems. This breed adapts well to the harsh conditions of, and shortage of forage in, the coastal areas. It is a good breed for the export market. The goats are very quiet in behavior.

Growth is one of the important traits in animal production. Weight gain in animals is determined not only by their own genetics but by other factors as well (Zhang et al., 2008). Therefore, it would be important to determine the additive genetic, maternal and environmental effects of animals for production. Birth traits are often considered as an early indicator of growth and production because they correlate highly between them (Portolano et al., 2002). In fact several studies have estimated genetic parameters for growth traits in Asian goats (Zhang et al., 2008; Hermiz et al., 2009; Weng-Zhong et al., 2010). Gholizadeh et al. (2010) estimated genetic parameters for birth and weaning weights in Iranian Raeini goats. However, no such study has been done on Adani goats. The aim of this study was to estimate the genetic and phenotypic parameters for growth traits of Iranian Adani goats using a multiple-traits model.

Materials and Methods

Data consisting of growth traits of Iranian Adani goats born between 2006 and 2012 were obtained from the Adani Goat Breeding Centre of the Bushehr province. The growth traits obtained were birth weight (BW), weaning weight (WW), 3-month weight (W3), 6-month weight (W6), 9-month weight (W9) and 12-month weight (W12). The data consisted of 5934 growth records for 1349 goats and progeny of 79 sires and 366 dams. Heritability, maternal effect and genetic and phenotypic correlations between growth records were estimated using the multiple-traits model. The following model was used for growth records:

$$y_{ijkl} = C_i + T_j + S_k + a_l + M_m + \sum_{n=1}^{2} Damage^{n}_{ijklmn} + \sum_{n=1}^{2} b_{n+2} AGE^{n}_{ijklmn} + e_{ijlklmn}$$

where, y_{ijkl} = Body weight, a_l = random effect for animal, M_m = random maternal effect, C_i = fixed effect of contemporary groups, T_j = fixed effect of birth type, S_k = fixed effect of sex,

$Damage$ = fixed covariate of dam age, AGE = fixed covariate of age at recording time and e_{ijlk} = residual error.
Variance components were estimated by the restricted maximum likelihood (REML) method using the wombat software.

Figure 1. Iranian Adani goats

Results and Discussion

The heritability estimates, genetic and phenotypic correlations for body weight are presented in Table 1. Heritability estimates for body weight ranged from 0.18 to 0.55 and were highest in second half of lactation. Maternal effect ranged from 0.04 to 0.62 and was highest for weaning weight. Genetic correlations between body weights were highest between adjacent weights, which decreased as the distance between them increased. Phenotypic correlations followed a similar pattern but were lower than the corresponding genetic correlations.

Table 1. Heritability (main diagonal), maternal effect (in parenthesis main diagonal), genetic (above diagonal) and phenotypic (below diagonal) correlations for body weights

	BW	WW	W3	W6	W9	W12
[1]BW	**0.55 (0.1)**	0.90	0.81	0.69	0.60	0.51
WW	0.79	**0.18 (0.62)**	0.90	0.80	0.70	0.61
W3	0.79	0.74	**0.47 (0.09)**	0.90	0.80	0.69
W6	0.68	0.71	0.9	**0.43 (0.17)**	0.90	0.80
W9	0.61	0.6	0.82	0.9	**0.53 (0.11)**	0.90
W12	0.49	0.46	0.7	0.79	0.9	**0.48 (0.04)**

BW, birth weight; WW, weaning weight, W3, weight at 3 month; W6, weight at 6 month, W9, weight at 9 month; W12, weight at 12 month

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Paper 17

Effects of Synchronisation and Artificial Insemination with Alpine and Saanen Semen on Reproductive Traits of Iranian Goat Breeds

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Introduction

Yazd province is one of the driest areas in the central part of Iran. It receives less than 100 mm of rain annually. The Nodoshani and Rabati goats are the local breeds of the Yazd province and the Raeini breed is of Kerman Province (Ghorbanpor Dashtaki, 1993). The Nodoshani and Rabati breeds are dual purpose breeds (milk and cashmere wool) and Raeini breed is the most productive cashmere goats in Iran. All of these are raised under poor range conditions (Emami Mibody, 1990). Currently, goats of these breeds are raised in farms and farmers still aspire to get high producing breeds which can adapt to the environment.

This study was conducted to evaluate reproductive parameters of the Nodoshani, Rabati and Raeini breeds bred to Alpine and Saanen dairy goats to produce off springs which were reported to have high potential for milk production and reproductive performance (Abdul-Vahid, 1988; Carica and Bravo, 1987; Song et al., 2000).

Materials and Methods

Seventy does, each of the Nodoshani, Rabati and Raeini breeds, were selected and synchronised in the fall by CIDER (Horst, 1997). Teaser animals were used to detect does in heat followed by artificial insemination with Saanen and Alpine frozen semen (Whitley and Jackson, 2004.).

Heat detection rates, parturition records including sex, birth weight of kids and types of birth, were recorded and analysed by GLM procedure of the Statistical Analysis System (SAS, 1997; Song et al., 2000).

Results and Discussion

On average 94% of animals showed heat signs, with Nodoshani, Rabati and Raeini does showing 94, 97 and 91%, respectively. The average apparent pregnancy rate (parturition) was 36%: 40, 44 and 29% for Nodoshani, Rabati and Raeini does, respectively. The number of kids per parturition was 1.77 ± 0.65, 1.43 ± 0.57 and 1.58 ± 0.69 for Nodoshani, Rabati and Raeini does, respectively, with an average of 1.59 ± 0.64 kids for all breeds. The average total weight of kids in each parturition was 3.36 ± 1.3 kg for all breeds; the corresponding values being 3.93 ± 1.44, 4.05 ± 0.08 and 3.07 ± 0.87 kg for Raeini, Nodoshani and Rabati breeds, respectively. This study showed that the number of kids and their weight per parturition were highest in the Nodoshani breed.

The average gestation period was 149.74 ± 3.63 days for all breeds and 150.21 ± 2.57, 148.88 ± 1.9 and 148.93 ± 2.03 days for Raeini, Nodoshani and Rabati breeds, respectively. Raeini breed had a longer (P<0.05) gestation period than the other two breeds.

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Paper 18

Milk Production of Local Qomi and F_1 and F_2 Qomi × Saanen Goats in Iran

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Introduction

In Iran goats are kept primarily for meat production and they are not a significant source of milk. There is a great potential for development of milk production from goats in Iran and the projects for this purpose have already been initiated in recent years. Crossbreeding is a logical step to improve meat and milk production of local goats and has been practiced in many countries. Crossbreeding has been used for a number of reasons including the benefit of heterosis, as an initial stage of transition in establishing a breed (grading up) or for the development of a new breed (Donkin, 1997). The option of crossbreeding to introduce suitable genetic material for milk production is a much more rapid method than that of attempting to improve milk yield of local goat breeds by selection (Karua, 1989). The research project was concerned with evaluation of milk production from local and crossbred goats. This study is continuation of an earlier study (Hoseini et al., 2011) and is aimed at determining the milk production of local Qomi and Qomi × Saanen goats.

Materials and Methods

Milk production records at second, third, fourth and fifth month of lactation of local Qomi, F_1 and F_2 Qomi × Saanen crossbred goats were used in this study. Data were analysed using the GLM procedure in SAS. Estrus synchronisation and artificial insemination technology were used in the breeding of local Qomi and Qomi × Saanen F_1 and F_2 goats.

Results and Discussion

The mean daily milk yield was 0.48, 1.1 and 1.4 kg for local Qomi, F_1 and F_2 Qomi × Saanen goats, respectively. There were significant differences in mean daily milk yield between local and crossbred goats. Mean milk yields from second to fifth month of lactation of local Qomi, F_1 and F_2 Qomi × Saanen goats were significantly different ($P<0.05$) (Table 1). The results of this study are similar to those of previous researchers (Donkin, 1997; Dinh, 1998; Juan et al., 2001) who also showed significant difference between local with crossbred goats. This study showed that the milk production of F_2 Qomi × Saanen was higher than that of the Qomi local and the F_1 crossbreds.

Table 1: Mean daily milk yield of local Qomi and F_1 and F_2 Qomi x Saanen goats during lactation

Month of lactation	Milk yield (kg)		
	F_2 Qomi x Saanen	F_1 Qomi x Saanen	Local Qomi
2	1.85 ± 0.02^{c}	1.44 ± 0.12^{b}	0.64 ± 0.05^{a}
3	1.45 ± 0.23^{b}	1.13 ± 0.11^{b}	0.53 ± 0.03^{a}
4	1.21 ± 0.09^{b}	1.08 ± 0.08^{b}	0.39 ± 0.03^{a}
5	1.11 ± 0.53^{c}	0.77 ± 0.05^{b}	0.36 ± 0.03^{a}

[a,b,c] Means within row with different superscripts differ at $P<0.05$

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Paper 19

Serum Protein Polymorphism in Iraqi Local Goats Using Polyacrylamide Gel Electrophoresis: Transferrin (β-Globulin) Polymorphism

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The present study was conducted to determine the presence of polymorphism at transferrin (Tf) locus in local Iraqi goats using a polyacrylamide gel electrophoresis (PAGE) following the method developed by Khaertdinov and Gataulin (2000). This study was carried out at the Animal Farm, Hartha Research Station, College of Agriculture, Basrah University and in several farms in Basrah Province, Iraq. Gene frequencies were calculated by gene counting, because the mode of inheritance of each of the systems that does show variation is by co-dominant alleles at an autosomal locus. The allele frequencies in Tf locus were estimated by direct counting of the genotypes. To test differences between observed and expected genotype frequencies, a chi-square (χ^2) analysis was performed on the basis of the Hardy-Weinberg law.

Figure 1 shows the electrophoretical pattern of goat (*Capra hircus*) protein samples and the corresponding isolated Tf. PAGE at pH 8.6 gave a good separation of the four main goats serum blood fractions, i.e. prealbumin; albumin; Tf and γ-albumin. Two bands were detected when transferrin was stained with Amido Black. The goat transferrin types were named according to the nomenclature suggested by Irnazarow and Bialowas (1994) and Jurecka et al. (2009).

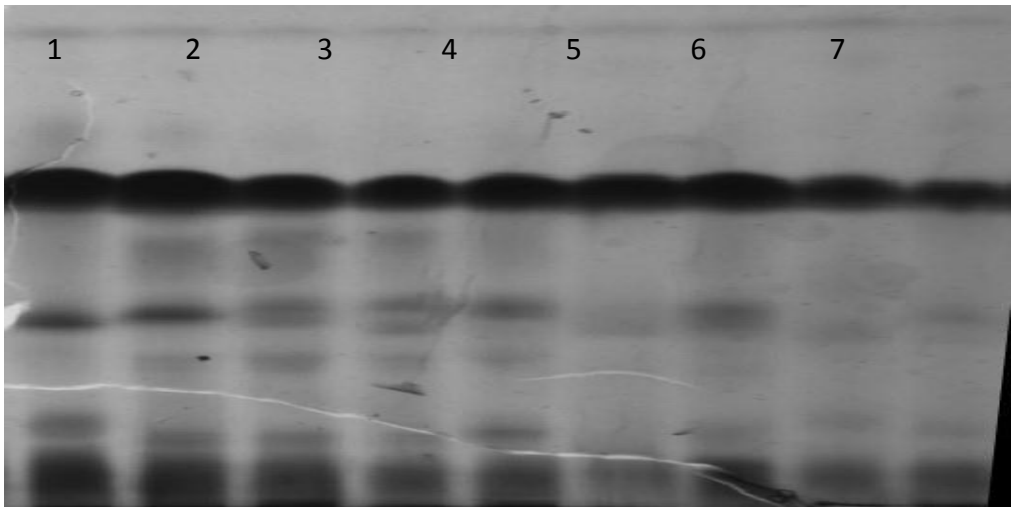

Figure 1. Transferrin genotypes detected by polyacrylamide gel disc electrophoresis patterns at pH 8.6 in local Iraqi goats

The results showed variation in the samples of goats (Table 1). The presence of transferrin genetic polymorphism with more than one allele was demonstrated. There were many genotypes (AA, BB, AB, AC and BC), in order of decreasing mobility in goats sera, from the

alleles (A, B and C) that could be inherited according to Mendelian laws. The genetic variants differed by only a few amino acid substitutions. The A allele was more predominant than B and C alleles (0.55, 0.36 and 0.10, respectively). The majority of Tf genotypes represented only AA and BB variants. These had affected all five genotypes. Homozygous genotypes AA and BB (45 and 27%, respectively) were predominant followed by the heterozygous genotypes AC (11%) and BC (9%). The CC genotype was not seen. Differences between expected number and observed number for transferrin genotypes were not significant on the basis of the Hardy-Weinberg law. Hence, the transferrin polymorphism is genetic and the goat population is genetically balanced for the Tf locus. This study showed that there is lack of selection or genetic improvement programme in these animals.

Table 1. Distribution of transferrin genotype frequency and gene frequency for transferrin locus in local Iraqi goats

	Transferrin genotypes (n = 100)					χ^2	Gene frequency		
	AA	BB	AB	AC	BC		A	B	C
Number	45	27	8	11	9	2.28	0.55	0.36	0.10
%	45	27	8	11	9				

To our knowledge, this is the first large-scale analysis on the genetic polymorphism of transferrin alleles in the local Iraqi goats (*Capra hircus*). The alleles discovered could possibly be used for the benefit of the genetic improvement programmes of domestic animals and conservation of bio-diversity.

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Paper 20

Phenotypic and Genetic Marker of Dairy Goat Performances Based on the Polymorphism of Acaca Gene

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Introduction

Etawa Crossbred goat or Peranakan Etawah (PE) is a popular dairy goat breed in Indonesia. In East Java, although the population of goats has increased from 2,384,973 in 2005 to 2,780,822 in 2009 (DGAHV, 2010), the performance of the Etawah Crossbred goat is still unknown. For this goat breed many aspects such as breeding, feeding, management and disease control need to be improved. Obviously superior animals can be obtained through good breeding programmes. These programmes could utilize Marker Assisted Selection (MAS) method based on the genotypic/genetic marker for a particular trait. The use of marker-based selection is very powerful because it can increase efficiency of selection according to the requirement. The aim of the study was to develop a method for breeding of Etawah crossbred goats through potential qualitative characteristic identification as a phenotypic marker for milk quality and a potential technology to determine the genetic marker in PE goat selection.

Materials and Methods

The research was conducted at Malang, East Java. Thirty-three female Etawa goats in their first to third lactation were used in the study. The parameters determined in the study were quantitative traits such as milk production, milk quality, body condition score (BCS) and qualitative traits such as head colour, ear type, and body colour. The research was conducted in two stages: field and laboratory studies.

Field study: This study involved phenotypic data collection, such as milk sample, BCS, head color, ear type, and blood sampling.

Laboratory study: This study involved milk quality and DNA analyses. DNA analysis was done by DNA and PCR and RFLP analyses. The PCR was done using primers F (5'–AGTGTAGAAGGGACAGCCCAGC–3') and R (5'–GTGGAATGACACATGGAGAGGG –3') to amplify 200 bp of ACACA gene in intron 3'. RFLP was done using Rsa1 restriction enzyme to examine base mutation. After digestion with Rsa1, the products were subjected to 2% agarose gel electrophoresis.

Based on the band pattern of the agarose gel, two alleles, G and T, were evident. By using the $PIC_i = 1 - \sum p^2_{ij}$ the resulting degree of polymorphism in ACACA locus was shown to be 43%. The relationship between qualitative and quantitative data was determined using ANOVA model One Way Layout *unbalanced design* using Genstat Release 7.22 TE 2008.

Results and Discussion

The results showed that the qualitative characters of ear type and head colour had no effect on milk fat and protein content. However the chest girth (CG), body length (BL), body height (BH) and BCS correlated well with the qualitative character such as body and head colour. Head width correlated with CG and BH, and head length with CG, BL and BH. Ear width correlated with CG and BL and ear length with BL. The BCS had significantly affected BL, while head colour significantly affected CG, BH and BL ($P<0.01$). The greatest influence on BH was on brown head followed by white, black and black-white with measurements of 76.0, 75.64, 72.72 and 67.57 cm, respectively.

Based on the agarose gel electrophoresis (Figure 1), the genetic polymorphism of ACACA gene in goat population was 43%, while the frequencies of G and T alleles were 31 and 69%, respectively. The genotypes that existed in the population were GT and TT. There is no significant effect of genotype on milk fat and protein content.

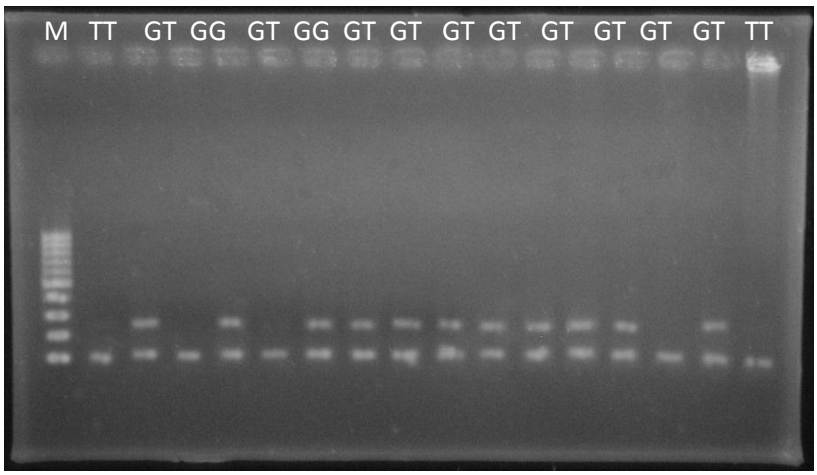

Figure 1. Agarose gel electrophoresis of PCR-RFLP products.
M = marker; GT, TT = phenotypes

Conclusions

The BCS is related with animal condition and describes the genetic potential and management implemented on the animals. It is concluded that qualitative traits have no effect on milk yield and milk quality, but have significant effect on the linear measurements of goat. Although only two genotypes of ACACA locus existed in the population, genetic polymorphism was high. The ACACA genotypes in the population could not be used as genetic marker for milk yield and milk production.

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Paper 21

Effect of Body Condition Score on Milk Yield, Protein and Fat Contents in Etawah Crossbred Dairy Goats

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Introduction

Etawah crossbred, one of dairy goat types in Indonesia, is distributed in almost all regions. This breed is a dual purpose goat – used both for meat and milk production. This goat is believed to be the result of undirected natural crosses between Etawah goats originating from India and the local goats, Kambing Kacang, with unpredicted genetic composition. At present, this goat contributes most to the population of goats in Indonesia and is more recognized as Etawah Crossbred (*Ind*: Peranakan Etawa, PE-goat).

In station, mature Etawah crossbred doe produces between 0.5 to 2.0 L milk/day (Sutama, 2011), indicating that this breed has high potential for selection and development as milk goat type. According to FAO (2011) Etawah goat in temperate region produced daily milk on the average of 1.725 ± 0.031 kg.

It is well-known that nutrition, live weight and body condition score (BCS) are important factors, which influence the phenotype and milk production of farm animals (Meyers-Raybon, 2010). Change in BCS should be used to assess the level and change of body fat stores and as an indicator of energy balance. The ideal BCS will support peak milk production during the negative energy balance of lactation. Many studies showed that BCS had a high correlation with milk production and composition (Zahraddeen et al., 2009, Ahmed et al., 2010; Pambu et al., 2011) and affected the reproductive performance of dairy goats (Suharto et al., 2008; Serin et al., 2010). The objective of present study was to evaluate the effects of BCS on yield, protein and fat contents of milk from the Etawah crossbred dairy goats.

Materials and Methods

The study was carried out under ASPENAS (National Etawa Farmer Association) in Blitar and Malang Regencies, East Java, Indonesia. Fifty-two Etawah crossbred goats were used in the experiment, conducted during period of March to December 2011. The BCS determination was carried out at lactation by the same person, according to Detweiler et al. (2011), who scored the body conformation by palpation. Scores were assigned a five-point scale from 1 = thin to 5 = grossly fat based on palpation of the body. Half scores were also included. Milk yield was recorded within the first 90 days of lactation, and protein and fat contents were determined biweekly by the Lactoscan Milk Analyzer. Milk yield was adjusted to energy corrected milk (ECM) of 4% fat and 3.3% protein (Hemme, 2010). The goats were

divided into 5 groups according to the BCS values. The data were statistically analysed by ANOVA (Genstat 12.2).

Results and Discussion

The daily milk yield increased significantly ($P<0.01$) with increase in BCS (Table 1). The animal with BCS 2 produced 1185.2 ± 399.5 mL ECM. The production was higher in the animal groups with BCS of 2.5, 3.0, 3.5 and 4.0 that recorded 1207.3 ± 366.5, 1691.9 ± 457.6, 1568.3 ± 340.1 and 1614.6 ± 396.6 mL ECM, respectively. The average milk yield in the present study was higher than that reported by Suranindiyah et al. (2009), which was 774 ± 291 mL/day for the same breed, but was lower than the Etawah pure breed goats (2.15 ± 0.30 kg/day)

Table 1. Daily milk yield, protein and fat content of Etawah Crossbred goat milk

	Body Condition Score (BCS)				
Parameter	2 (N = 7)	2.5 (N = 16)	3 (N = 21)	3.5 (N = 6)	4 (N = 2)
Milk Yield (mL ECM)	1185.2[a] ± 399.5	1207.3[a] ± 366.5	1691.9[b] ± 457.6	1568.3[ab] ± 340.1	1614.6[ab] ± 396.6
Protein (%)	3.03 ± 0.14	3.09 ± 0.13	3.06 ± 0.13	3.13 ± 0.09	2.84 ± 0.02
Fat (%)	6.37 ± 1.09	6.56 ± 0.98	6.85 ± 0.91	6.85 ± 1.06	6.09 ± 1.12

Values are means ± std errors
[a,b] Means within row with different superscripts were significantly different at $P<0.001$

Protein and fat contents in milk from the Etawah crossbred were not affected by BCS of the animals, although the does with BCS of 3.5 tended to have higher protein and fat contents in milk than the other groups. The BCS of the animal reflects the nutrient status, internal physiological condition and energy reserves in the body of animal. In the present study, increase in BCS significantly ($P<0.01$) increased milk production but did not affect protein and fat contents of milk.

Conclusions

Body condition score in an important indicator for predicting the potential milk production in Etawa Crossbreed goats. Goats with higher BCS, between 2 and 4 showed significant increase in milk production. However, BCS did not influence protein and fat content of milk.

Acknowledgements

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Paper 22

Detection and Identification of Pregnancy-Associated Glycoprotein as a Biomarker for Early Stage Pregnancy in Goats

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Introduction

In goat farming, does have to continue reproducing on regular intervals in order to increase livestock productive efficiency. Thus, early and accurate diagnosis of pregnancy is a useful management tool for improving efficiency of goat production so that expenses on feeding and vaccination could be reduced (Suguna et al., 2008; Padilla-Rivas et al., 2005). The main objective of the present study was to identify a potential early stage pregnancy biomarker, using Pregnancy Associated Glycoprotein (PAG) in the serum of Damascus goats.

Materials and Methods

Sixteen naturally bred Damascus does were used in this study. Blood was collected through jugular vein fortnightly from day 0 until day 42 of pregnancy. The day of mating was considered as day 0 of pregnancy. Out of the 16 animals, 12 animals were confirmed pregnant. Sera obtained were kept at -80^{o} C until analysis. Proteomics approach was used to seek and identify the significantly expressed proteins in the sera. To screen the serum protein for potential biomarkers, the sera were subjected to two dimensional gel electrophoresis (2DE) and the proteome maps obtained were analysed using the Image Master 2D Platinum 7.0. Any differentially expressed proteins were subjected to Maldi-Tof/Tof analysis for protein identification. In order to identify PAG spot on the proteome map, immunoblotting was performed and the spot was validated by LC-MS approach. Statistical analysis was performed using ANOVA where $P<0.05$ was considered significant.

Results and Discussion

From the 2DE proteome map, four proteins were detected as differentially expressed. Interestingly, the significantly expressed proteins with the Match ID of 196, 51, 223 and 239 were detected as early as week 2 of gestation. Compared to week 0 of pregnancy, these four proteins seemed to be upregulated by 2-fold of expression dynamic on the week 2 of pregnancy. However, these proteins were down regulated in week 4 of pregnancy. Pregnancy associated glycoprotein, which was detected using immunoblotting, only appeared in week 6 of gestation and was not detected in non-pregnant samples. Based on the LC-MS results, the protein spot was confirmed as PAG.

Four significantly expressed serum proteins (Match ID: 196, 51, 223 and 239) were successfully detected in pregnant Damascus goats using 2DE approach. Since the proteins could be detected in the second week of gestation, they have good potential to be used as a biomarker for early stage pregnancy in Damascus goats. However, a larger sample size is needed to determine the sensitivity and specificity of this biomarker. The PAG, which was detected using immunoblotting in the week 6 of pregnancy, appeared as a single spot with a molecular weight of 62 kDa and pI of 5.7. According to Sousa et al. (1998), the PAG concentration extracted from goat placenta significantly increased from week 5 to 7 before it began to fall again in week 9 of gestation. The molecular weight and pI of the protein spot were similar to those of placental PAG in other species. For instance, El Amiri et al. (1994) successfully isolated and characterised PAG from ovine placenta where the molecular weight of the ovPAG were reported to range from 55 to 66 kDa and the pI from 4.0 to 6.8. Whilst Sousa et al. (2002) also managed to extract PAG from zebu placenta, which possessed molecular masses of 51 to 69 kDa and pI of 4.4 to 6.7.

Conclusions

This study successfully detected four potential biomarkers for an early stage of pregnancy in Damascus goat. Pregnancy associated glycoprotein was also detected in goat sera where its molecular weight and pI were comparable with those of other species.

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Paper 23

West African Dwarf Goat Milk Production, Composition and Kid Growth during the Dry Season in Western Highland of Cameroon

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Introduction

The production potential of the West African Dwarf goats (WADG) in Cameroon in the Central African sub-region is very low because of lack of adequate nutrition (Pamo et al., 2006). Grass and crop residues which form a major part of their diet especially during the rainy season have very low nitrogen and fibre contents. Supplementation of these roughages is a promising way of alleviating nutrient deficiencies. Different types of supplementary feeding have been advocated to boost goat production (Leng, 2003) of which supplementing with leguminous tree leaves has high merit. The present study was undertaken to evaluate the effects of supplementary feeding of *Calliandra calothyrsus* and *Leucaena leucocephala* leaves on milk production and composition of WADG.

Materials and Methods

The study was conducted with WADG in the dry season (November 2001 to April 2002). The WADG grazed mixed pasture comprised of *Brachiaria ruziziensis* and *Pennisetum purpureum* between 0900 and 1700 h each day. After about a month, two bucks were introduced in the herd for a 2-month breeding period. The males were removed thereafter and 12 goats were subjected to supplementary feeding with *C. calothyrsus* and *L. leucocephala* leaves mixed in equal quantities by weight from three months prepartum up to three months postpartum. The mixture was left in the pens in the afternoon (1600 h) at the rate of 800 g per goat per night. The remaining 12 goats served as unsupplemented controls. The following observations were made: consumption of the supplements calculated from the residue every morning, kids' growth, and milk production and composition, and were analysed every two weeks from kidding up to three months. The data were analysed statistically (Steel and Torrie, 1980) and the effects of supplementary feeding on milk production and composition and on kids growth were evaluated.

Results and Discussion

On average the goats consumed between 700 to 800 g of the foliage supplement per head per day during the entire study period. The peak milk production was observed in the second week of lactation in the control group but the peak production occurred during the 3rd week in the group receiving supplement (Figure 1). Supplemented goats produced more milk (P<0.05) than controls during the entire period of the study. The average weekly milk

production during the period of the supplementation was almost double than that of the control animals (361 ± 11 vs 183 ± 43 g).

The supplementation has not significantly influenced dry matter, ash and lactose contents of WADG milk (Table 1). Milk protein content of supplemented WADG was higher (P<0.05) than of the control group, while lipids content in milk of the control group was higher (P<0.05). It appeared that the supplementation with the leaves of *L. leucocephala* and *C. calothyrsus* had variable influence on milk composition of WADG during the dry season.

The milk consumption index of the supplemented group (5.25 ± 0.47) was comparable with that of the control group (5.25 ± 0.38). A high significant correlation (r = + 0.96; P<0.01) was obtained between milk consumed and weight gain of kids of the supplemented group.

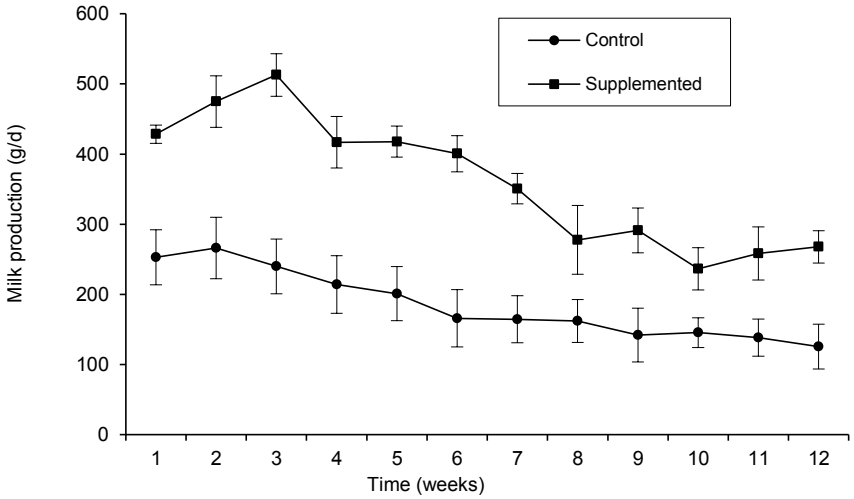

Figure 1. Weekly milk production of WADG.

Table 1. Average milk composition (g/100 g milk)

	Composition (g/100 g of milk)					
Group	DM	Protein	Lipids	Ash	^{2}P	Lactose
Control	14.7 ± 0.8	4.1^{a} ± 0.3	3.8^{a} ± 0.4	0.81 ± 0.04	0.09 ± 0.01	6.18 ± 1.18
Supplemented	14.21 ± 0.98	4.35^{b} ± 0.34	2.56^{b} ± 0.27	0.80 ± 0.05	0.09 ± 0.003	6.48 ± 0.82

^{ab}Means with different superscripts within column are significantly different (P<0.05). DM, dry matter; ^{2}P, phosphorus

Table 2. Weight of goats at kidding and weaning

Group	Weight at kidding (kg)	Weight at weaning (kg)	Total gain (kg)	Daily weight gain (g/d)
Control	1.12 ± 0.10^{a}	3.56 ± 0.46^{a}	2.44	29.0 ± 15.4^{a}
Supplemented	1.35 ± 0.08^{b}	5.95 ± 0.45^{b}	4.60	54.8 ± 26.3^{b}

^{a,b} Means with different superscripts within column are significantly different (P<0.05).

At kidding and weaning, the weight of kids born from supplemented goats was higher (P<0.05) than those of control (Table 2). At weaning, the total gain of kids of the supplemented group was almost double (4.60 kg) that of the control (2.44 kg). Also, the daily weight gain of kids from the supplemented group was higher (P<0.05) than that of the control.

Conclusions

Supplementary feeding with *L. leucocephala* and *C. calothyrsus* proved to be highly beneficial. It substantially increased the overall yield of milk per animal, milk protein content and growth of the supplemented animals during the dry season.

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Paper 24

Estimation of Genetic Parameters for Milk Production Test Day Records of Iranian Adani (Persian Gulf) Goats

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Introduction

Adani dairy goat is one of the most important breeds in southern Iran. This breed is raised in the coastal areas of Persian Gulf in Bushehr province. In these areas, the climate is harsh due to high temperatures and humidity and the pasture is poor. Adani goats are maintained as household animals in intensive systems. This breed has suitable milk production characteristics and litter size and is well adapted to the harsh conditions and shortage of forage in the coastal areas. The lactation period in Adani goats is approximately 4 months and total milk production is between 120 to 180 kg. In dairy animals, genetic evaluation is based on test day yields. The advantage of the test day yields for genetic evaluation over accumulated values is that it is a more accurate estimate of environmental effects, and defines the contemporary groups and evaluates production traits more accurately (Van der werf et al., 1998). Several Studies have estimated the genetic parameters for milk production in goats (Bagnicka et al., 2004; Torres-Vazquez et al., 2009; Menéndez-Buxadera et al., 2010) but studies on genetic parameters in milk goats in Iran are scarce. There is no information on the milk production traits of Adani goats. The aim of this study was to estimate the genetic and phenotypic parameters for test day records of Iranian Adani goats under a multiple-trait test day model.

Materials and Methods

The data consisting of milk test day records of Iranian Adani goats collected between 2006 and 2012 were obtained from the Adani Goats Breeding Centre of Bushehr province, Iran. Records collected at approximately 15-day intervals of six tests were used for this analysis. From the data, 4093 test day records of 397 goats and daughters of 20 sires were extracted. Heritability, genetic and phenotypic correlations between test day records were estimated using the multiple-trait test day model as follows:

$$y_{ijkl} = YST_i + T_j + a_K + \sum_{n=1}^{2} DIM_{ijkl}^{n} + \sum_{n=1}^{2} b_{n+2} AGE_{ijkl}^{n} + e_{ijlk}$$

where, y_{ijkl} = test day records on milk yield, a_K = Random effect for animal, YST_i = fixed effect of year – season of test (season defined as spring, summer, autumn and winter), T_j = Kidding type (number of kids in kidding), DIM = fixed covariate of days in milk at test, AGE = fixed covariate of age at kidding and e_{ijlk} = residual error.

Variance components were estimated with restricted maximum likelihood (REML) method using the Wombat Software.

Results and Discussion

Heritability, genetic and phenotypic correlations between test day records are presented in Table 1. Heritability estimates for test day records ranged from 0.07 to 0.58 and were highest in the second half of lactation. Genetic correlations between test day records varied from 0.67 to 0.98. Genetic correlations between adjacent test day records were high (>0.9, averaging 0.94) and decreased as the distance between tests increased. Phenotypic correlations followed a similar pattern but were lower than the corresponding genetic correlations.

Table1. Heritability, genetic and phenotypic correlations between test day records of Adani goats

	[4]TD1	TD2	TD3	TD4	TD5	TD6
[4]TD1	**0.18**[1]	0.97[2]	0.86	0.93	0.76	0.67
TD2	0.74[3]	**0.07**	0.98	0.88	0.83	0.73
TD3	0.66	0.68	**0.37**	0.91	0.76	0.77
TD4	0.59	0.6	0.69	**0.39**	0.90	0.84
TD5	0.62	0.58	0.65	0.75	**0.28**	0.94
TD6	0.49	0.42	0.58	0.67	0.74	0.**58**

[1]Heritability (diagonal), [2]genetic (above diagonal) and [3]phenotypic (below diagonal). [4]TD, test day (number indicated day)

Figure 1. A typical Adani doe

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Paper 25

Sexual Behaviour of Indigenous Does and Ewes under Mixed Flock System

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Introduction

Next to poultry, sheep and goats are the main source of animal proteins to the meat-eating population in India. Reproductive success is a must for production of viable offsprings and their subsequent growth to increase production of meat. Due to their capability to adapt to a wide range of climatic diversities, sheep and goats are traditionally being reared in Indian subcontinent under the mixed flock system. There is a paucity of published information on the goat and sheep sexual behaviour, although it plays a vital role in successful reproduction in these ungulates, specifically under mixed flock system. Therefore, in the present study, the sexual behavioural signs and activities were documented and compared in indigenous does and ewes maintained under mixed flock system.

Materials and Methods

A total of 265 mating sessions were meticulously observed, both manually and videographically, in goats (n = 3 bucks and 30 does) and sheep (n = 3 rams and 27 ewes). All experimental animals were apparently healthy and showed general appearance and vigour favourable for successful sexual activity. The feeding and management during the observation period (3 months) were kept identical. The overt physical signs shown and behavioural activities accomplished by females (Hafez, 1969) during courtship, mating and post-mating were recorded and the data analysed for comparison between does and ewes.

Results and Discussion

Among the six prominent overt signs of female courtship, swollen vulva was the most common in both does (93.8%) and ewes (96.9%). More does moved away from the male on first male exposure (65.6 vs. 20.0%; $P<0.01$), while more ewes rubbed their necks and bodies with males (37.5 vs. 88.4%; $P<0.01$) and placed their noses under males' flank (31.3 vs. 76.5%; $P<0.01$). The morning hours (05:00–09:00 h) were the most preferred time for mating for both does and ewes. The highest frequency of pre-mating activities was tail fanning (59.8 vs. 4.2; $P<0.01$) in does and turning head back (6.2) in ewes. During mating, standing still to allow mounting was the most frequent activity for both does and ewes (2.2 vs. 3.3). Post-mating urination was the most frequent activity in does and ewes (1.4 vs. 1.2). The longest pre-mating activity was clustering of male for both goats and sheep (17.2 sec vs. 83.7 sec; $P<0.05$). The longest pre-mating activity recorded was urination for both does and ewes (1104.5 sec vs. 1616.0 sec). Becoming stationery to allow males to mount was found to have

the longest activity during mating for both does and ewes. After mating, squatting was the longest activity for both does and ewes.

It is concluded that does and ewes showed similar sexual behaviour patterns during pre-coital, coital and post-coital stages under mixed flock system.

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Paper 26

Genetic and Phenotypic Parameter Estimates for Birth Weight in Iranian Indigenous Goats

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Introduction

Goat production is one of the key elements contributing to the economy of farmers living in the arid and semi-arid regions of Iran. Rapid growth during the early period can minimise the cost of rearing and thus provide more profit to the farmer. The birth weight and early growth rate of animals are determined not only by genetic potential but also by maternal and environmental factors (Mandal et al., 2006). The objective of this study was to examine the factors affecting birth weight in Iranian indigenous breed.

Materials and Methods

Data on performance and pedigree information used in this study were collected from Iranian indigenous Cashmere goats. Initially records without date of birth or weights were eliminated. Finally, the birth records of 814 goats, having the information of pedigree were used for the analysis. Breeding values for birth weight were estimated for all 814 animals using the best linear unbiased prediction (BLUP) based on an animal model with a relationship matrix. To identify fixed effects to be included in the models, a least square analysis was conducted using the General Linear Model (GLM) procedure (SAS Institute Inc., 2001). This was performed with a model which included the fixed effects of year of birth (7 classes), litter size (3 classes), sex (2 classes) and kidding parity (4 classes). All of these fixed effects were significant ($P<0.001$) for birth weight, and were then included in the model (Table 1). Estimation of variance and covariance components was obtained by restricted maximum likelihood (REML) using a derivative-free (DF) algorithm by fitting an animal model (Meyer, 1989). Convergence was assumed when the variance of likelihood values was less than 10^{-8}. In addition, a restart of each analysis was performed with different starting values to attempt to avoid convergence to local maxima. The general representation of the animal model used was as: $Y = Xb + Zu + e$, where Y was a n × 1 vector of records, b denoted a vector of fixed effects in the model with an association matrix X, u was the vector of direct genetic effects with an association matrix Z and e denoted the vector of residual (temporary environment) effects. The variance-covariance structure for the model was as follows,

$$V\begin{pmatrix} u \\ e \end{pmatrix} = \begin{pmatrix} A\sigma_u^2 & 0 \\ 0 & Ie\sigma_e^2 \end{pmatrix}$$

where A was the numerator relationship matrix, σ_u^2 was direct genetic variance and σ_e^2 was variance due to residual effects.

Results and Discussion

All fixed effects studied in this study had significant effect on birth weight of kids. Litter size had significant effect on birth weight and mean birth weight declined with larger litter size. Due to maternal effects, dams with higher kidding parity had heavier kids. Male kids were significantly heavier than female kids. The high variation in birth weight among the kidding years might have been resulted from the changes in management, climate and sample size. These findings are in agreement with the results reported in other goat breeds (Valencia et al., 2007; Zhang et al., 2009). The estimate of direct additive heritability of 0.23 ± 0.12 for birth weight in Iranian indigenous Cashmere goats found in the present study was lower than the reported estimates in other goat breeds (Zhang et al., 2009). This study had a smaller sample size and fitted a model which did not consider the maternal genetic effect and permanent maternal environmental effect.

As a conclusion, the fixed factors such as kidding parity and litter size of dam, kidding year and sex of kids are important for birth weight trait in Iranian indigenous Cashmere goat breed, and should be fitted in the models.

Table 1. Birth weight for litter size, kidding parity, sex and year of birth of kids of the Iranian indigenous Cashmere goats

Fixed effect	N	LSM ± SE	Fixed effect	N	LSM ± SE
Litter size			Sex		
1	507	2.30 ± 0.027[a]	Female	407	1.85 ± 0.033[a]
2	261	1.96 ± 0.031[b]	Male	407	2.04 ± 0.031[b]
3	46	1.57 ± 0.062[c]	Year of birth		
Kidding parity			2000	119	1.77 ± 0.050[e]
1	375	1.82 ± 0.029[a]	2001	177	2.11 ± 0.042[a]
2	268	1.92 ± 0.030[bcd]	2002	228	1.91 ± 0.034[cde]
3	145	1.99 ± 0.040[bcd]	2004	33	1.89 ± 0.072[cde]
4	26	2.04 ± 0.079[bcd]	2005	91	2.05 ± 0.049[abc]
			2006	119	1.99 ± 0.040[bcd]
			2007	47	1.88 ± 0.058[cde]

[abcde]Means with different superscripts within each fixed effect were significantly different at $P<0.05$. N, number of records; LSM, least-square means; SE, and standard errors

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Lead Paper 3

Taurine-Rich Goat Milk

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Introduction

Traditionally goat milk served as part of daily diet for the rural family but has fast becoming a health food for the sick and wealthy in the cities. Goat milk is reported to contain significant quantity of various immune-protective proteins, essential minerals, omega acids and large quantities of vitamins (Tommaso et al, 2004; Belewu and Adewole, 2009). In addition, the presence of free amino acids in goat milk, not required for protein synthesis of the host animal is also important for human health. Many of the free amino acids are integral part of several life processes and one of such free amino acids is Taurine. Taurine is a sulfur-containing amino acid and is chemically known as 2-aminoethanesulfonic acid. The concentration of taurine in goat milk is 20-fold higher than in cow milk and almost equal to that in human milk. Although colostrum from cows contains high concentration of taurine, it is still lower than that in goat milk. As a result, commercial milk formula is often enriched with taurine to increase its content. On the other hand, newborns and infants fed on goat milk do not need additional taurine since its content in the goat milk is almost similar to that in mothers' milk (Park et al., 2007).

Taurine is well-recognised to be beneficial to almost all life processes in the body, it is increasingly becoming an important component of food and nutraceuticals (Gupta and Kim, 2003; Gupta et al., 2005; Gupta et al., 2009).

Taurine content in Goat Milk Products

Goat milk at all stages of lactation has a high content of taurine. Among the dairy products from goat milk, whey has the highest taurine content, while cheese contains 12.5 to 16.5%. Taurine in milk products is not affected by high temperature treatment as cheese from the Cacioricotta goat milk produced by heating milk to 95 °C remained higher in taurine. In addition, taurine content in milk products does not vary with fermentation and storage period (Pasqualone et al., 2003).

Taurine Biological Action and as Components of Functional and Nutraceuticals

There is increasing evidence that sulfur amino acids (SAAs) play an important metabolic and functional role in human health and disease prevention. The SAAs also provide elemental sulfur required for growth and development, and are good sources of energy and nutrient need for various life processes.

It is possible and feasible to modulate body functions for better health by consumption of food rich in taurine. Taurine can contribute to many aspects of health, for example it has liver protection, cardio protection, retino protection and bone loss prevention

activities. In addition it could act as anti-cancer, anti-bacteria, anti-diabetes, anti-aging, anti-inflammatory, anti-hypertension, anti-oxidant, anti-craving agents. It also contributes to bile salt formation. The mode of action by taurine in the prevention of diseases is suggested to be as follows:

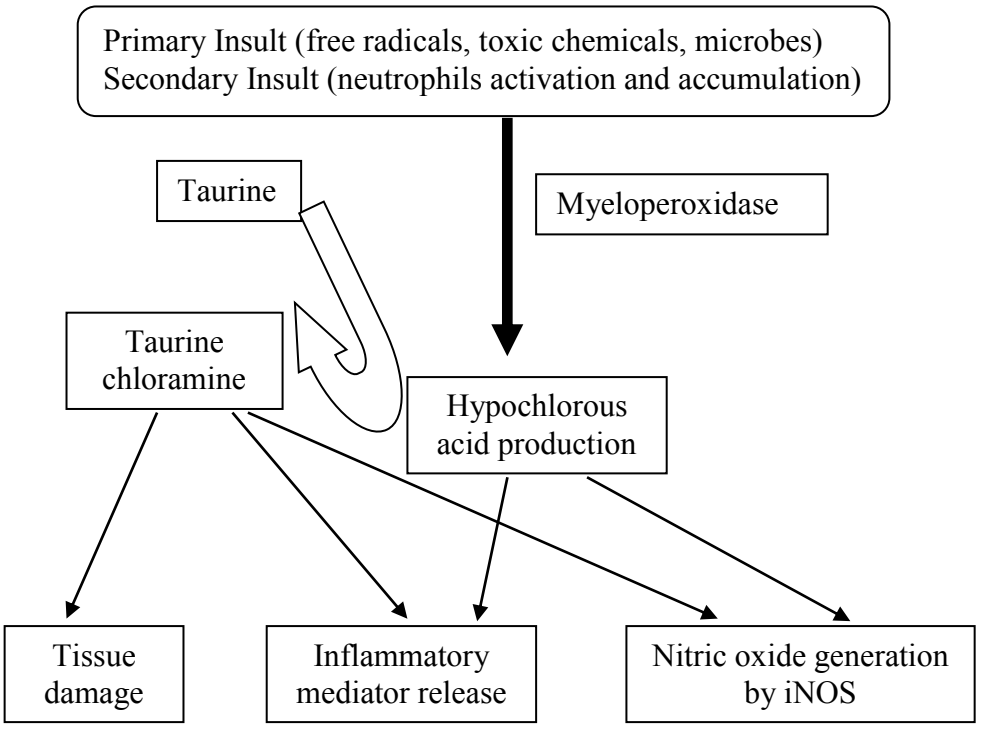

Figure 2: Role of taurine in disease prevention.

Conclusions

Goat milk riched in taurine or taurine- supplemented food and formula can provide long term beneficial effects to general health of humans.

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Paper 27

"Feed less Food" – Effect of a Low Concentrate Diet on Milk Quality, Milk Fatty Acid Composition and Performance of Dairy Goats

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Introduction

More than a third of the world's grain harvest is used to feed animals. According to the environmental agency of the United Nations, losses of calories by poor conversion efficiency of grain into animal food could theoretically feed 3.5 billion people (McIntyre, 2009). This shows that the production of animal protein is very energy consuming, especially when concentrates are fed to ruminants. Consequently, a major goal is to explore the potential of dairy goats for producing high quality milk in an extensive system but in an ecological friendly way.

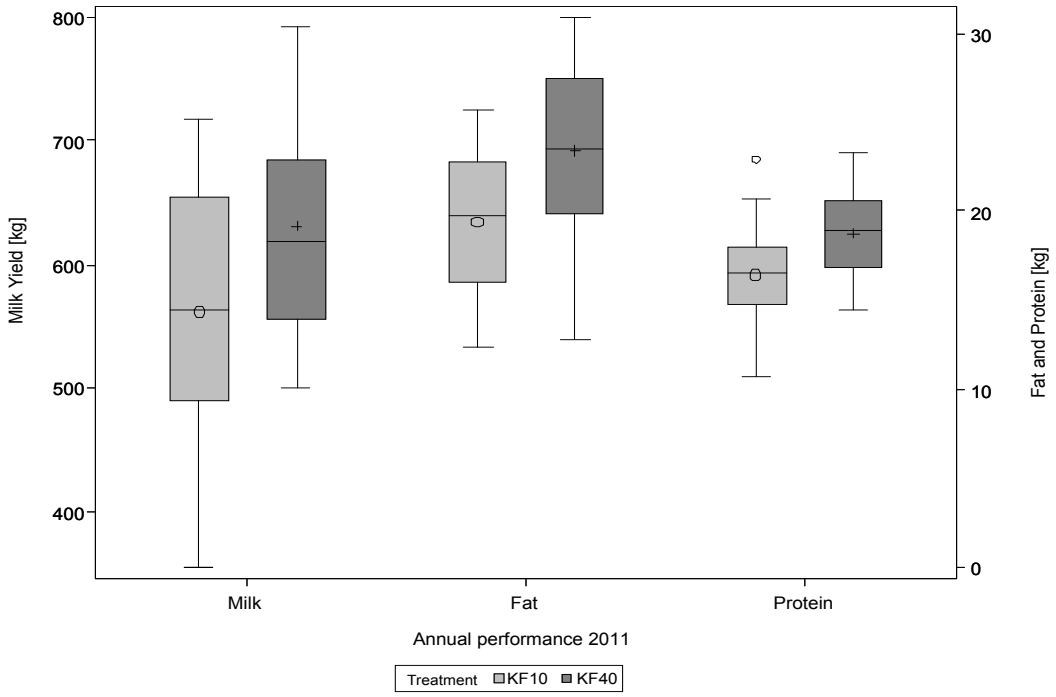
Ruminants can be divided into three categories based on their feeding behaviour: concentrate selectors (CS), grass and roughage grazers (GR) and intermediate feeders (IM) (Hofmann, 1989). CS feeders include deer and elk, whereas cattle and sheep are all grazers. Goats together with chamois, red deer, fallow deer belong to the IM feeders. IM feeders are able to browse bushes and even trees besides consuming traditional ruminant diets. Goats are generally very selective in choosing feed of the highest quality, thereby optimising the quality of their roughage diet. Due to their anatomical advantages and excellent roughage conversion efficiency, goats are destined to produce high quality milk at a minimum amount of concentrates in their ration. Thus, the objective for this study was to measure the effects of a low concentrate diet on fatty acid composition and milk yield of dairy goats.

Materials and Methods

In 2011, 50 dairy goats of our experimental herd were divided into two homogenous groups of 25 goats each based on parity, milk yield and body weight. One group (KF10) was fed according to the Bio Suisse guidelines with 10% concentrate and the other group (KF40) in accordance with the requirements of the EC regulation on organic farming with a 40% concentrate in the ration. The concentrate consisted of 100% wheat grist. Mineral licks were made available to the animals. Limited grazing was offered to both groups during the growing season. During the entire lactation period, the herds were extensively monitored, which include recording of monthly milk production and bodyweight change, biweekly feed sampling (concentrate, hay and fresh grass). In addition, milk samples were taken weekly to assess milk composition. Data were statistically analysed using SAS 9.3 (SAS Institute Inc.). Test of normality was done by calculating Shapiro-Wilk-test (proc univariate). Where appropriate, Student's *t*-test or non-parametric test procedures were used to compare group means, box-whisker plots were created to illustrate data distributions.

Results and Discussion

Figure 1 shows the annual milk yield, fat and protein contents. The fatty acid compositions are of monthly samples. Milk yield of KF10 was 68.8 kg, and fat and protein contents were 4.1 and 2.4 kg, respectively lower compared to those of KF40. The annual amount of concentrates for KF10 was 66 kg/goat, whereas it was 259 kg/goat for KF40.



Suisse guidelines (KF10) and EC regulation on organic farming (KF40)

Conjugated linolenic acid (CLA, C18: 2 c9t11), as an example of fatty acids analysed in this study, was higher in KF10 throughout the whole lactation period (Figure 2). Body weight was significantly lower for KF10 during the last three months of lactation. Health status, checked regularly for both groups, did not show any difference. The results indicate that less concentrate feeding is feasible. Future studies should quantify selective abilities of goats as a base of breeding selection.

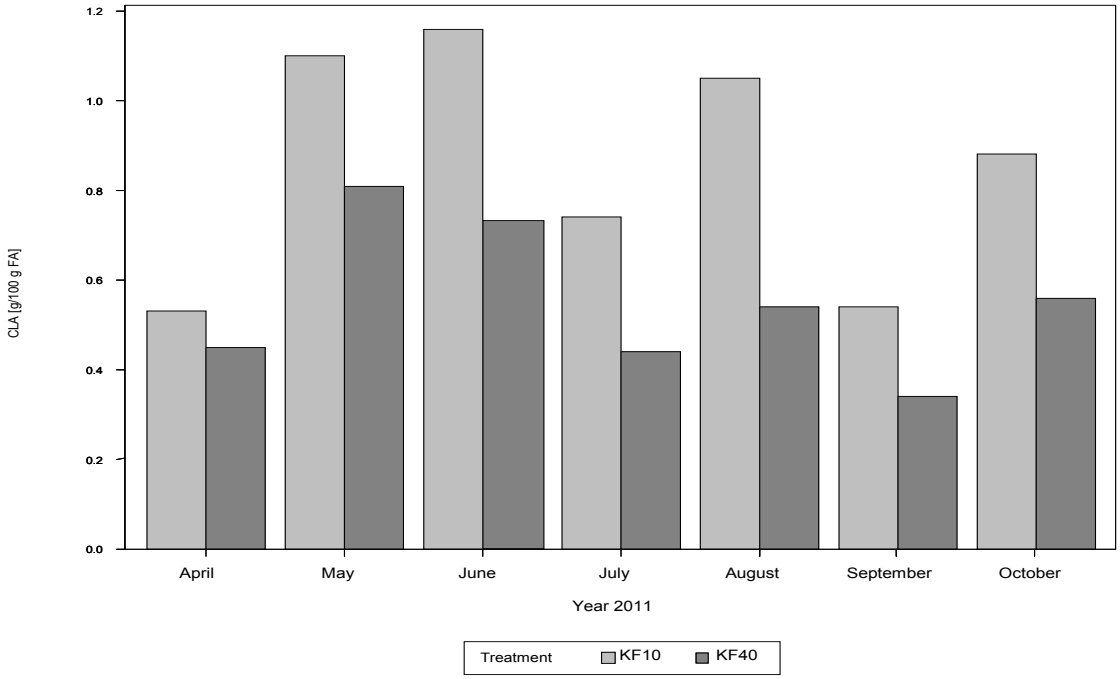


Figure 2. Conjugated linolenic acid content in milk of goats fed according to Bio Suisse guidelines (KF10) and EC regulation on organic farming (KF40)

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Paper 28

Comparative Studies of Milk Components of West African Dwarf Goats and Sheep

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Introduction

Dairy and dairy products are important food components especially for infants, school children and other protein vulnerable population. Unfortunately these products are in short supply in under-developed countries. In Nigeria less than 20% of protein intake is of animal origin compared to about 70% in the United States (Onu and Okongwu, 2006). In Nigeria, cow is the traditional dairy animal while goats and sheep are kept for meat, hide and skin. There are 12.2 million cattle, 13.2 million sheep and 26.0 million goats in Nigeria (Olukunle and Agbede, 2010). Despite all these, Nigeria continues to depend on imported dairy products which continue to deplete her limited foreign reserves. A viable solution is to exploit local resources to enhance dairy production. Information on milk composition in Nigeria deals largely with cattle (Adeneye, 1989) with limited information on goat milk (Akinsoyinu et al., 1977). The objective of this study was to compare the milk composition of West African Dwarf goats and sheep with a view to popularising goat milk consumption among the low income earners in peri-urban cities of Nigeria.

Materials and Methods

Four lactating West African Dwarf (WAD) does and four ewes between 1½ to 2½ years old of unknown parity were used for the study. The animals were allocated to the trial at 3 weeks after parturition and were raised on a semi-intensive system provided with cassava peels supplemented with *Morus alba*. Hand milking was done at 06.00 h thrice per week on the designated milking days to collect milk samples for 10 weeks. The milk samples collected were immediately stored at -5^{o}C prior to analysis. Milk samples were analysed for total solids, fat, crude protein, lactose and total ash while the solid-not-fat (SNF) were calculated as the difference between the total solids and fat composition of the milk. The concentrations of Ca, Mg, P, Na and K were determined and all data collected were subjected to Student's *t*-test.

Results and Discussion

Milk composition of the WAD goats and sheep are presented in Table 1. There were no significant (P>0.05) differences for any of the parameters measured between goats and sheep except for K concentration. However, total solid, solid-not-fat, fat and lactose contents in goat milk were numerically higher than those in sheep milk, thus suggesting that goat milk could be of better source of dietary energy but not for protein than sheep milk. The present

data were comparable to those reported for other breeds of goats and sheep (Akinsoyinu et al., 1977). The results also indicated that among all the minerals analysed, only K concentration was significantly (P<0.05) influenced by species effect. Generally, the values of the macrominerals recorded in this study compared favourably with those reported for goat milk by Akinsoyinu and Akinyele (1979).

Table 1. Milk composition of WAD goat and their interrelationships

Parameters	WAD goat	WAD sheep
Total Solid (g/kg)	156.1 ± 2.05	147.2 ± 1.41
Solid Not Fat (g/kg)	114.2 ± 2.12	112.3 ± 1.21
Protein (g/kg)	42.7 ± 1.01	48.8 ± 0.41
Fat (g/kg)	40.2 ± 1.02	36.9 ± 1.38
Lactose (g/kg)	56.6 ± 1.30	55.5 ± 1.18
Ash (g/kg)	7.9 ± 0.97	8.3 ± 0.14
Fat/SNF ratio	0.35 ± 0.13	0.33 ± 0.15
Protein/Fat ratio	1.06 ± 0.31	1.32 ± 0.21
Calcium (mg/100 mL)	128.41 ± 12.40	128.51 ± 12.01
Magnesium (mg/100 mL	22.11 ± 10.31	24.7 ± 7.37
Phosphorus (mg/100 mL)	69.97 ± 5.11	69.81 ± 7.12
Sodium (mg/100 mL)	71.31 ± 8.12	61.66 ± 3.13
Potassium (mg/100 mL)	126.13[a] ± 10.31	115.66[b] ± 10.81

[ab]Means in the same row with different superscripts differ significantly (P<0.05)

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Paper 29

Introduction of Goat Milk Pasteurisation Equipment to the Etawah Crossbred Dairy Goat Farmers in East Java Province, Indonesia

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Introduction

An important characteristic of goat milk is the unique ‚goaty' flavour which is attributed to the different fatty acids and the relatively higher proportions of short and medium chain fatty acids in goat milk (Tziboula-Clarke, 2003). Jandall (1996) reported that the composition of goat milk as: 3.80% fat, 8.68% solid-non-fat, 4.08% lactose, 2.90% protein, 2.41% casein, 0.43% whey proteins, 0.79% total ash, 0.194% Ca, and 0.270% P, while recently Pall et al. (2011) showed that goat milk contained 4–4.5% fat, 3.2% lactose, 4.6% protein, 0.129% Ca, and 0.106% P.

In East Java, goat milk has not been fully utilised because of the lack of milk processing equipment at farm level; hence almost all the milk produced is for the consumption of the kids. It is often that the kids are unable to consume all the milk, resulting in incomplete milk let down and retention in the udder. Also goat milk has short shelf life and therefore availability of proper processing and storage equipment at the farm level is needed to preserve its quality to market it for human consumptions (Susilorini and Sawitri, 2002). The objective of this study was to determine the effect of introducing milk pasteurisation, simple cup-sealer equipments and training of the goat farmers on the production of pasteurised goat milk. Capacity building of farmers in Ngambe Ngawi district to produce dairy products from goat milk was also conducted.

Materials and Methods

Training on milk pasteurisation was held for the Etawah crossbred dairy goat farmers in the Ngambe Ngawi district, East Java Province, Indonesia. Twenty-five farmers, having a total of 70 heads of Etawah crossbred goats with an average milk production of 1.05 (0.75 to 1.25) litre/head/day, were selected for the study. Milk pasteurisation equipment, cup-sealer and training in handling the equipment and in dairy goat management were provided to the above farmers.

The milk pasteurisation equipment had a capacity of 30 litres per batch and this equipment was easy to operate because it is regulated using several simple keys. It is also easy to maintain. The main function of this equipment was to pasteurise goat milk to produce a "commercially sterile" product (Winarno, 1994). Goat milk was pasteurised at a temperature of 65–70^{o}C for 30–40 minutes. Participants were trained to operate and maintain the milk pasteurisation equipment. Functions of each component and on how to use them were explained. To increase the income of farmer, the participants were also trained to make different dairy products such as beverages, candy, “dodol” and caramel.

Results and Discussion

All participants were able to use the milk pasteurisation equipment and the cup sealer but only 25% of the participants could make dairy products. In order to increase milk production and farmers' income and to enhance the flavour of milk as demand by the community, it was suggested that goat milk must be pasteurized and dairy products such as "dodol", ice cream and candy milk should be introduced (Winarno and Fernandez, 2007). The study showed that after the training, the participants were capable to use the milk pasteurisation equipment properly and made dairy products from goat milk.

Conclusions

Introduction of milk pasteurisation equipment and training on making goat milk products had shown to be beneficial to the farmers. After taking the training, the farmers were able to create new businesses. In addition to pasteurised milk, farmers could produce fruit syrup, "dodol", ice cream and candy from goat milk.

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