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In vitro gas production, *in vivo* nutrient digestibilities, and metabolisable energy concentrations for sheep of fresh and conserved pangola grass

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ABSTRACT

In vitro gas production, nutrient digestibilities and metabolisable energy (ME) values of fresh and conserved pangola grass (*Digitaria eriantha* Steud., synonym *D. decumbens*) were studied in 16 cross-bred (Thai native × Merino) sheep. The study was designed as a completely randomized design with Napier grass (*Pennisetum purpureum*) as a control and pangola grass in fresh, hay and silage forms with the same cutting age (45 days growth) as treatments. Chemical composition of forages and faeces was determined and used to estimate nutrient digestibility. *In vitro* gas production was recorded at 3, 6, 8, 12, 24, 48, 72, 84 and 96 h of incubation and used to estimate the kinetics of gas production. Chemical composition was relatively constant across treatments. Likely due to the addition of 5% sugarcane molasses before ensiling, pangola grass silage had higher ($P < 0.05$) nutrient digestibilities and ME concentrations than the other forages when estimated from *in vivo* digestibility and *in vitro* gas production. Cumulative gas production at 12, 24, 48 and 96 h of incubation was highest ($P < 0.05$) in pangola silage followed by fresh pangola, pangola hay and Napier grass, in that order. In conclusion, pangola grass in fresh or conserved forms has a high potential to deliver energy and protein through forage and can be recommended as a nutrient source for small ruminants.

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1. Introduction

Ruminant livestock in the tropics and sub-tropics cover most of their dietary requirements from native pastures and crop residues. However, these feed resources are low in nutrient quality, e.g., they contain little crude protein (CP) and much fibre which is often of low digestibility. The most common problem facing smallholder farmers is the scarcity of good quality forages. These feed resources are either not available or attract very high prices during the dry season. One way to overcome this problem and to maintain adequate feed supply is to conserve surplus forage or crops during the rainy season as hay or silage for later use when the feed is in short supply.

Pangola grass (*Digitaria eriantha* Steud., synonym *D. decumbens*) is a high quality tropical grass (Cook et al., 2005) which may have potential to fill this gap. It is popularly grown in Thailand as pasture and utilized extensively

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for animal grazing, hay and silage making, mostly with N fertilization instead of using legumes as companion crops (Meeske et al., 1999). Its CP concentration ranges from 5 to 14% of dry matter (DM) and may exceed 15% of DM for young regrowths under intensive fertilization (Heuzé et al., 2011).

Pangola grass has been used as a ruminant feed for a long time (review by Tikam et al., 2013), however, evaluation of pangola grass in different forms (fresh, hay, or silage) at the same cutting age and harvested at the same location has not yet been investigated. Therefore, our objective was to evaluate *in vitro* gas production and *in vivo* nutrient digestibilities, and metabolisable energy (ME) values for sheep of pangola and Napier grasses (*Pennisetum purpureum*) harvested at the same regrowth age (45 days). The outcome of the present study could be used as baseline data to introduce and promote pangola grass in different forms to smallholder farmers in the near future.

2. Materials and methods

2.1. Experimental site

This study was carried out at the experimental farm of the Department of Animal and Aquatic Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai Province, Thailand (latitude 18°47′N and longitude 98°59′E). The average daily temperature during the study (in the dry season; October 2008 to January 2009) was 15 °C and the average daily relative humidity was 64%. The chemical analyses were conducted at the Department of Animal and Aquatic Science, Chiang Mai University, Thailand and the Institute of Animal Science, University of Bonn, Germany.

2.2. Forage management and harvest

Pangola grass and Napier grass were harvested from the same location at the same regrowth age at cutting (45 days) and were used to produce four forage treatments, namely Napier grass, fresh pangola, pangola hay and pangola silage. The 45 days of regrowth age at cutting were chosen in accord with Thai recommendations (Animal Nutrition Division, 2002). Common to all tropical grasses, nutritional value and chemical composition of pangola vary with several factors such as differences in stage of cutting, fertilizer, location and climate. Therefore, in 2002, the Thai government promoted forage production and supported farmers who produced fresh, hay, and silage at 45-day intervals instead of rice and other regular cash crops (Animal Nutrition Division, 2002). Pangola in Thailand typically contains 10% CP, 29% crude fibre and 59% total digestible nutrients (Animal Nutrition Division, 2002). The pangola grasses were planted in a rectangular plot of 40 m × 40 m (0.16 ha) in rows 50 cm apart with 50 cm spacing within rows. The area was subdivided into two parts (400 m^2 for fresh pangola and 1200 m^2 for hay and silage production). Napier grasses were planted in 400 m^2. Pastures were fertilized with 50 kg/0.16 ha of N-P-K (15-15-15) compound fertilizer before the start of the planting. Pangola stolons were used as planting material (300 kg/0.16 ha). Weeding of pastures was removed 2–4 weeks after planting. For fresh pangola and Napier grasses, their fields were divided into different plots already for the previous growth period so that their maturity could be controlled by cutting at different days in order to obtain fresh grass of 45 days regrowth duration and thus, similar quality, throughout the digestibility trial carried out in the following weeks. Grasses were harvested at approximately 5–10 cm above the ground. After harvesting, 20 kg of ammonium sulfate (46-0-0) per 0.16 hectare were used. Grasses were cut early every morning and chopped before feeding. For pangola hay, fresh pangola was harvested and sun-dried on the field for 2–3 days, then small square bales (0.9 m × 0.45 m × 0.35 m and weighing between 20 and 30 kg) were made and stored indoors. For pangola silage, grasses were chopped into pieces of 2–3 cm length, after which 5 kg sugarcane molasses per 100 kg fresh pangola were added. Molasses is the by-product of sugar production from sugarcane and contains on average 72.4% DM and 2.2% CP (Animal Nutrition Division, 2004). The material was then homogenized and filled in six 120-l plastic barrels (60 kg/barrel), compacted, sealed and ensiled for a minimum of 21 days. Each barrel was weighed before and after ensiling to determine the DM loss. At opening, silages were checked by sensory evaluation (organoleptic quality) and each barrel was sampled for determination of pH, ammonia-N and lactic, acetic and butyric acids. The barrels were opened one after the other during the digestibility trial where each was completely consumed within 3–4 days.

Ensiling of pangola is difficult to achieve without an additive providing extra water-soluble carbohydrates to promote a strong lactic acid fermentation. The supplementation of a fermentable carbohydrate source like molasses is seen as a practical solution to the problem of delayed fermentation or malfermentation in tropical silages (Tjandraatmadja et al., 1994). It was assumed that the inclusion of molasses represents a standard type of pangola silage and therefore, this forage type was simply referred to as pangola silage hereafter.

Forages (fresh Napier and pangola grass, pangola hay and pangola silage) were sampled twice every morning before being fed to the animals during the 7-day collection period ($n = 14$ for each forage) and pooled for chemical analyses.

2.3. Animals and in vivo digestibility trials

Sixteen cross-bred sheep (native Thai × Merino; 6 months; 18.5 ± 1.21 kg body weight) were placed individually in metabolism cages where faeces could be collected quantitatively. They were randomly assigned to four treatment groups comprising of Napier grass (control), fresh pangola, pangola hay and pangola silage with four animals per treatment. The sheep were fed twice daily at 08:30 and 16:30 h. Forages were offered in a metal feeding trough fixed to the front of the metabolism cage. Fresh water was available continuously during the whole experiment. The total experimental period was 21 days. The sheep were fed diets for *ad libitum* consumption during a 14-day adaptation period, followed by a 7-day collection period, during which each animal was fed 550 g DM/day (approximately 3% of body weight) divided into two equal portions. Forages and faeces of each animal were collected daily, weighed fresh and dried in an oven at 60 °C until constant weight was achieved.

2.4. Chemical analyses

Sensory silage quality (odour, colour and texture) was evaluated by an organoleptic test (Gross, 1982; score: 20–16 = very good-good; 15–10 = fair-good; 9-5 = fair; and < 5 = poor). The silage pH was determined by diluting approximately 50 g of duplicate samples with deionized water to 200 g in a blender jar. Samples were macerated for 30 s, macerated samples were filtered through two layers of cheesecloth, and pH was measured using a glass electrode pH meter (Bal et al., 1997). The concentrations of lactic, acetic and butyric acids were analyzed by distillation procedures as described by Zimmer (1966). Fermentation quality of the silages was assessed with the scheme of Deutsche Landwirtschafts-Gesellschaft (DLG, 2006), based on the concentrations of acetic acid, butyric acid and the pH. Ammonia-N concentration was determined by distillation using Tecator Auto-Kjeldahl analyzer according to Chen et al. (1994).

Feed samples (fresh, hay and silage) and faeces samples were weighed and oven-dried at 60 °C and then successively ground in mills with 1-mm sieves for use in chemical analyses. The DM content of samples was determined by oven-drying at 100 °C for 24 h. Crude protein (method ID 976.06), ash (method ID 942.05) and ether extract (hereafter denoted crude fat, method ID 920.39) analyses were carried out as described by AOAC (2000). Crude fibre, neutral detergent fibre (NDF) and acid detergent lignin (ADL) were determined according to the method of Van Soest et al. (1991). Acid detergent fibre expressed exclusive residual ash (ADFom) was analyzed using method 6.5.2 of the German Handbook of Agricultural Experimental and Analytical Methods (VDLUFA, 2007).

2.5. In vitro gas production measurement

In vitro gas production was determined according to Menke and Steingass (1988). The gas volume was recorded after 0, 3, 6, 8, 12, 24, 48, 72, 84 and 96 h of incubation. Data were fitted to an exponential model given by McDonald (1981):

$$y = B(1 - e^{-c(t-\text{lag})})$$

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