The voluntary intake in growing pigs of four ensiled forage species

Patricia I. Sarria B.[1] and Siriwan D. Martens[2]

[1]Universidad Nacional de Colombia, Facultad de Ciencias Agropecuarias, Carrera 32 No. 12-100, AA 237, Palmira, Colombia.[2] International Center for Tropical Agriculture (CIAT), Tropical Forages Program, Recta Cali-Palmira km 17, Cali, Colombia.

e-mail: pisarriab@unal.edu.co

Forage can potentially be food resource for pig feeding in the tropics. The palatability of silages by pigs may be better than that of fresh forage. Foliage silage contains more dry matter than green forage and has a pleasant smell. Thirty commercial pigs (47.0 ± 4.7 kg live weight LW), were used to assess the silage intake capacity of pigs when feeding the legumes *Clitoria ternatea*, *Centrosema brasilianum*, *Cratylia argentea* and the *Brachiaria* grass hybrid Mulato II. The silages were offered *ad libitum* as a supplement to a normal balanced diet based on maize and soy bean meal. A crossover design was applied comprising five treatments, Control and the four silage supplements respectively. Daily consumption of dry matter -expressed in g of DM kg^{-1} metabolic LW- were similar (p>0.05) for diets containing *C. argentea*, *C. ternatea* and the Control. Daily consumption of *C. brasilianum* and *Brachiaria* was significantly lower (p<0.001). In conclusion, *C. argentea* and *C. ternatea* silages have the potential to serve as feed supplement in pig diets.

Key words: dry matter intake, tropical forages, fibre, monogastric animals, silage

Introduction

In the tropics, conventional feed concentrates are mostly imported, often hardly available and quite expensive for smallholders; therefore, locally available alternatives are needed. Improved grasses and forage legumes integrated into smallholder tropical feeding systems can increase the benefits of livestock, for cattle, small ruminants, pigs, and/or poultry (Peters 2009). The humid and sub-humid tropics offer almost year-round growing conditions (Ly 2005), with seasonal water deficits and excesses; however these constraints are usually manageable (Martens et al. 2012). Forage crops like *Vigna unguiculata*, *Xanthosoma sagittifolium*, *Morus alba*, *Trichanthera gigantea*, among other examples, may offer an additional feed source for pigs due to their high protein content (particularly legumes), and yields of biomass (Leterme et al. 2005, Ly 2005 and Sarria et al. 2010). Though, the effect of the inclusion of these fibrous feed into the diets of growing pigs needs to be studied. The results of growing pigs receiving foliage as part of the diet, to date are highly variable according to different authors (Sarria et al. 1991, Leterme et al. 2005 and Ly 2005), and some food like forages, with elevated levels of fibre may have negative effects on food intake, digestibility and weight gain (Santomá 1997). Creative approaches are required to fit forage-based feed solutions for monogastric animals into existing smallholder systems. Furthermore, systematic research is required to define the actual value of some less-common forage species for different animal species (Martens et al. 2012). Ensiling forages allows the crops to be harvested at the optimal time and additionally preserve its nutritional quality. Moreover, in pigs, the palatability of ensiled forage may be better than that of fresh herbage (Artiles et al. 2012). In addition, wilting helps to reduce the volume and concentrate the nutrients. The higher the dry matter (DM) content, the better the consumption of forage by pigs: for instance pigs of around 100 kg LW consume 0.5 kg DM in the form of fresh leaves but one kg as dried leaves (Leterme et al. 2005). Silage making requires less energy and time with a target DM content of around 35% DM, in contrast to the production of herbage meal which comprises ≥ 90% DM. In a smallholder context in the sub-humid tropics this fact alone, along with the lack of a powerful mill, can make ensiling the preferred method of choice.

The objective of our study was to assess the palatability of ensiled herbage for its use in the fattening of pigs. Four species of forage silage were evaluated in this experiment (Table 1). Forage species and accessions with a high potential for feeding monogastric animals were selected based on the information available in the SoFT database (Cook et al. 2005) in the literature, in pilot experiments and expert knowledge.

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Materials and methods

Forages were grown in Southwest of Colombia: Herbaceous legumes *C. ternatea* (12 weeks growth, flowering) and *C. brasilianum* (17 weeks, pre-flowering) at CIAT Palmira (03°31’42” latitude N and 76°27’14” longitude W), the shrub legume *C. argentea* in Santander de Quilichao, (03°00’34” latitude N and 76°29’06” longitude W), and the *Brachiaria* sp. grass hybrid Mulato II (regrowth with high percentage of dead material) from Popayan (02°26’18” latitude N and 76°’47” longitude W).

Table 1. Tropical forage accessions of different species evaluated in the present experiment

	Clitoria ternatea L. CIAT 20692	*Centrosema brasilianum* (L.) Benth. CIAT 5234	*Cratylia argentea* (Desv.) Kuntze CIAT 18516/18668	*Brachiaria* sp. grass hybrid Mulato II CIAT 36087
Management and Production				
Continuity of production	Medium	Medium	Superior	Superior
Altitude, m above sea level	1600–2000	0–1000	0–1200	0–1800
Rain precipitation, mm/year	400–2500	600–3000	1000–4000	≥ 700
Adapted to low fertility soils	Medium	Superior	Superior	Superior
Yield leaf, dry matter/hectare/year	3–10	3–10	13–32	25
Nutritional value:				
Crude protein, %	17–20	12–20	18–30	12–15
Anti-nutritive compounds	Medium	Superior	Superior	Not determined
Ruminant digestibility, %	80	50–70	60–65	55–62
Ruminant voluntary intake	Medium	Medium	Medium	Superior
Countries were species are reported	Australia, Kenya, The Philippines and Mexico[1], Honduras, Mexico[2], East Africa, Uganda, India[3]	Colombia, Australia[2], Venezuela, Nigeria[3]	Costa Rica, Colombia and Nicaragua[2]	China, Thailand, Mexico, Central America countries, Panama, Colombia, Venezuela, Bolivia, Uruguay and Brasil[2]

[1]Villanueva et al. 2004, [2]Peters et al. 2011, [3]Cook et al. 2005

The forages were dried to a target DM of 350 g kg^{-1} fresh matter (FM) and chopped in a forage chopper. Subsequently, sucrose was applied at 20 g kg^{-1} FM and lactic acid bacteria were added (105 colony forming units CFU) g^{-1} FM of a strain of *Lactobacillus plantarum* (DSM 24624, CIAT S66.7). The material was compacted in 18.9 l plastic buckets which were closed tightly using lids with a rubber gasket. The herbages were ensiled between April and May, 2010, and stored at an ambient temperature of 22–33 °C, until February of 2011. Silage quality was determined considering DM, pH, NH_3-N and organic acids. The pH was determined by preparing an extract of 10 g FM with 100 ml distilled water and measured using a pH meter (MP 120 pH meter, Mettler-Toledo, Greifensee, Switzerland). After 2 h, DM was determined in duplicate at 105°C for 24 h (DIN 38414-S2, 1985). Ammonia was determined according to Voigt and Steger (1967). VFA, alcohols and lactic acid were detected by High Performance Liquid Chromatography (HPLC), column Rezex ROH-Organic Acid H+ (Phenomenex Ltd., Torrance, CA, USA), according to Siegfried et al. (1984). The standards used were lactic acid (LA) (Sigma, L-1750), acetic acid (Chem Service O-4), propionic acid (Chem Service O-25), isobutyric acid (Chem Service O-6), butyric acid (Chem Service O-5), valeric acid (Aldrich 240370), 1,2 propanediol (Emeral BioSystems, EBS-250), 2,3 butanediol (MP Biomedicals, 203774), and ethanol (absolute, Merck, 100983).

In February 2011, 30 commercial pigs (Landrace*Large white 47.0 ± 4.7 kg live weight (LW)), were housed in individual pens (2 × 1.5m), with cement floors, and open feeder and automatic water dispenser. They were used to evaluate the consumption of forage silage species. The experiment was carried out at the experimental farm of the National University in Palmira (Colombia) (03°32'22" latitude N and 72°18'13" longitude W).

A completely randomized experimental design was utilized including five treatments, three replicates and two periods of 14 days each, seven days for adapting and seven for measurements. The treatments were: Control, *Cratylia argentea, Centrosema brasilianum, Clitoria ternatea* and *Brachiaria* hybrid Mulato II silage supplement, respectively. The Control consisted of a balanced diet of maize and soybean meal (Table 2). Four other diets were prepared. They were composed of the Control diet supplemented with ad libitum access to silages of *C. argentea*, *C. brasilianum*, *C. ternatea* or *Brachiaria* sp. as specified below.

The animals were fed five times a day (8:00, 10:00, 12:00, 14:00 and 16:00 hours) in order to ensure a better consumption. Pigs of Control treatment received initially 80 g DM kg^{-1} $LW^{0.75}$/day. The animals of silage treatments receiving 50 g DM kg^{-1} $LW^{0.75}$/day of the Control diet and the silages ad libitum, starting with 20 g DM kg^{-1} $LW^{0.75}$/day. Silages and Control diet were mixed before being offered to the animals. In order to reduce refusal, the amount of silage distributed was adjusted every day according to the animal's appetite. Pigs were weighed each week to adjust the amount of food to provide. Refusals were collected after each feeding, and samples were stored at –20 °C, until analysis. The foods were analyzed for dry matter content using an oven at 105°C for 12 h, crude protein (Kjeldahl method) (AOAC 1990). The neutral acid detergent fibre (NDF and ADF) and acid detergent lignin were determined by means of an ANKOM fibre analyzer (Ankom Technology, Madecon, NY, USA) using nylon bags.

Table 2. Composition of the Control diet (g kg^{-1})

Yellow maize	593
Wheat bran	150
Soybean meal 46% crude protein	230
L-Lysine HCL 78%	2.5
D-L methionine 99%	3.5
Calcium carbonate	12.0
Bi-calcium phosphate	4.0
Salt (NaCl)	4.0
Mineral and vitamin supplement	1.0

Calculations and statistical analysis

The daily consumption was calculated as g DM offered – g DM rejected / pig / day.

The daily metabolic consumption was calculated as g DM consumed per day / kg $LW^{0.75}$.

The differences in both consumption variables were determined by analysis of variance using the GLM procedure followed by the multiple comparison test of Duncan, of the SAS version 9.1 for Windows (© 2002–2003 by SAS Institute Inc., NC, USA), using the following model:

$$Y_{ijk} = U + P_i + D_j + P_i \times D_j + E_{k(j)}$$

Where Y_{ijk} is the daily consumption or daily metabolic consumption, U the general mean, P_i the effect of the i period, D_j the effect of the j diet, $P_i \times D_j$ the interaction of the period i × diet j, $E_{k(j)}$ the effect of pig k within diet j as an error term.

Results and discussion

Chemical composition of the Control diet and the four silages is shown in Table 3. The pH of all 4 silages ranged between 4.0 and 4.3 with DM contents > 370 g kg^{-1} FM. The ammonia-N of total silage nitrogen was lowest in *C. brasilianum* and *C. ternatea* silages (44 and 45 g kg^{-1} N respectively) and slightly higher in *C. argentea* and *Brachiaria sp.* silages (60 and 74 g kg^{-1} N respectively). All silages were butyric acid free and the sum of acetic and propionic acid ranged between 4 and 11 g kg^{-1} DM.

The consumption of experimental diets is shown in Table 4. Pigs receiving *C. argentea* or *C. ternatea* silage consumed the same amount of dry matter as those fed only on the Control diet. In these feeding regimes, *C. argentea* and *C. ternatea* silage corresponded to 55 and 50% of total DM consumption respectively, the rest was Control diet. The consumption of *Brachiaria* sp. and *C. brasillianum* diets was lower than *C. argentea* and *C. ternatea*, possibly due to their poorer nutritional quality. The dry matter content was lower in the silages of *Brachiaria* sp. and *C. brasilianum* compared to the other two forage legume silages (*C. argentea* and *C. ternatea*) (Table 3).

Table 3. Composition of the Control diet, three legume silages and one grass silage (g kg^{-1} DM) and fermentation quality.

Parameter	Control diet	*Cratylia argentea*	*Clitoria ternatea*	*Centrosema brasilianum*	*Brachiaria* sp.
Dry matter	887	438	526	370	379
Crude protein	202	192	198	129	59
Neutral detergent fibre	188	476	490	463	732
Acid detergent fibre	74	349	380	349	468
Acid detergent lignin	29	157	109	113	200
NH_3-N (g kg^{-1} N)		60.4	45.1	43.6	74.1
Lactic acid		43.8	34.5	59.5	27.1
Acetic+propionic acid		10.5	7.4	4.7	4.0
Butyric acid		n.d.	n.d.	n.d.	n.d.
pH		4.3	4.5	4.0	4.1

n.d. not detected

Table 4. Consumption of the diets including tropical legumes or grass silage, by growing pigs.

Parameter	Control	*Cratylia argentea*[1]	*Clitoria ternatea*[1]	*Centrosema brasilianum*[1]	[1]*Brachiaria* sp.	CV%	SE	*p* value
Initial live weight (kg)	48.78	45.70	48.40	45.35	45.17	10.1	4.7	0.43
Consumption (g DM/ pig*day)	1752[a]	1642[a]	1710[a]	1395[b]	1358[b]	9.70	152	0.0003
Consumption (g DM kg^{-1} LW$^{0.75}$)[2]	94.67[a]	93.83[a]	90.00[a]	80.00[b]	78.18[b]	3.68	3.4	0.0006

[1]Control supplemented with the respective forage silage; [2]50g DM kg^{-1} LW$^{0.75}$ corresponded to Control diet and the rest to each silage, respectively. Different letters within rows indicate significant differences between treatments (p <0.05).

The consumption of the pigs on the Control diet (890 g DM kg^{-1} FM) was not significantly different from those on the *C. argentea and C. ternatea* silage diets, which had half of the DM content. The dry matter content of the silages was the factor that perhaps best explained the consumption by pigs, with a correlation coefficient of r=0.83 among silage treatments. Possibly growing pigs (≥ 45 kg LW), can ingest bulk food when the DM concentration is ≥440 g DM kg^{-1} FM without presenting physiological constraints for the animal. A review by Pérez (1997) indicates that the large intestine of pigs matures slowly; this explains why the pig tends to digest fibrous feeds better in direct relation to its age.

Results similar to those obtained in the present study were recorded by Leterme et al. (2005), who compared the intake of *Trichanthera gigantea* herbage in two forms: chopped and fresh or dried and ground. They reported twice the intake when forage was supplied in dry form. Most authors correlate the intake capacity of pigs with the fiber content of the feed. Campbell and Taverner (1986) observed less consumption in diets with high levels of fiber (120 g acid-detergent fibre (ADF) per kg DM) compared to those with low fiber (62 g ADF kg^{-1} DM), which decreased productive performance of the growing pigs. Díaz et al. (2005) recorded that the intake capacity of diets containing *Gliricidia sepium* herbage meal was correlated with the NDF content (r = –0.68). In the present experiment NDF, ADF and lignin contents of *Brachiaria* sp. were higher than of *C. argentea*, *C. ternatea* and *C. brasilianum*. Correlation coefficients between metabolic DM consumption and diet fibre content over all treatments were −0.73, −0.65 and −0.58 for NDF, ADF and acid detergent lignin (ADL), respectively.

However, Kyriasakis and Emmans (1995) registered that crude fibre or NDF content could not account for the effects on feed intake, with three bulky foods: wheat bran, citrus pulp and grass. They recommended using the water-holding capacity (WHC), which explained partially the effects on intake of feeds such as grass which appeared to limit intake through their bulk. Here, WHC was higher in *Brachiaria* sp. silage (5.7 g of water g^{-1} DM) than in *C. argentea* (5.1), *C. brasilianum* (4.5) and *C. ternatea* silage (4.1 g g^{-1}). Correlation coefficient between WHC and intake in our experiment was −0.61 among all treatments. Therefore, in this study, the factor that best explained the differences in consumption between the different species of silages by the pigs was the dry matter content.

Conclusions

It is concluded that *C. argentea* and *C. ternatea* silages of high DM and good quality have the potential to serve as feed supplement in growing pig diets. Inclusion rates up to 500 g kg^{-1} diet DM do not affect dry matter intake. Growth performance studies have to reveal the effect on live weight gain. Dry matter content followed by NDF, were the factors that best explained the capacity of metabolic consumption of forage silages in growing pigs.

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