Tropentag 2009
University of Hamburg, October 6-8, 2009
Conference on International Research on Food Security, Natural Resource Management and Rural Development

In vitro Ensilability of Jack bean (*Canavalia ensiformis*) and Cowpea (*Vigna unguiculata*) Grains Sole or Mixed with Sorghum (*Sorghum bicolor*) Grains: an Alternative for Low Input Pig Feeding Systems

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Introduction

With an increasing interest in new feed sources, the seeds of under-utilized legumes receive currently more attention as they are better adapted to adverse environmental conditions, highly resistant to diseases and pests and of good nutritional quality. Jack bean (*Canavalia ensiformis* L. DC) has been identified as a legume adaptable to a wide range of agronomic and climatic conditions with a high potential for exploitation as a source of protein and energy for livestock. Grain yields are reported to be up to 6 t/ha (PROSEA, 1992). Cowpea bean (*Vigna unguiculata* L. Walp) is as well a warm-season crop well adapted to many areas of the humid tropics and temperate zones. Despite being a legume, sorghum (*Sorghum bicolor* L. Moench) is included in the group of feedstuffs adapted to a wide range of environmental conditions. For that reason it represents a good alternative to the use of conventional cereals in rations for animal feeding in low-input systems in areas that are too dry for maize. Storage of those legume and cereal grains is affected by high temperatures and humidity in the tropics, which often leads to the development of fungus and bacteria, affecting the nutritional quality of the feed. Ensiling is reported to be a valuable technique for both conservation and improvement of the feedstuffs' nutritive value (GOMEZ-BRENES *et al.*, 1988). The aim of the study was to investigate the ensilability of Jack bean and cowpea sole as well as in combination with sorghum by means of an *in vitro* method (Rostock fermentation test).

Material and Methods

Jack bean (*Canavalia ensiformis* L. DC), cowpea (*Vigna unguiculata* L. Walp.) and sorghum (*Sorghum bicolor* L. Moench) were hand harvested at the Agricultural Experimental Station "Las Antillas" at the Central University of "Las Villas". All grains were sun dried before being chemically analyzed. To carry out the *in vitro* method Rostock fermentation test (RFT) according to PIEPER *et al.* (1989) and ZIERENBERG (2000), grains were milled (4 mm mesh size) and 50 g were mixed with 200 ml of distilled water. RFT was performed in triplicate per treatment:

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Control without additive, molasses (4 % of fresh matter (FM)), *Lactobacillus plantarum* ($3x10^5$ cfu/g FM, LAB), molasses+LAB. As well sorghum was mixed with legume grains and proportions where calculated to reach 20 % and 24 % of crude protein in the mix. The incubation time was set at 30 ºC, pH was measured at 0, 14, 18, 22, 26 and 38 h. Ammonia as well as organic acids and ethanol (by HPLC and GC) were analyzed in filtrates after 38 h.

Results and Discussion

The chemical composition of the plant material is shown in Table 1.

Table 1. Chemical characterization of the grains used for RFT

	DM	CP	CF	NDF	ADF	ADL	EE	Ash
	(%)				(% DM)			
Jack bean	84,20	33,44	8,96	24,91	16,51	1,50	2,91	3,28
Cowpea	87,03	27,29	6,30	23,01	15,50	1,51	2,27	4,98
Sorghum	85,26	9,46	3,13	15,72	11,51	4,16	3,23	2,02

ADF-acid detergent fibre; ADL-acid detergent lignin; CF-crude fibre; CP-crude protein; DM-dry matter; EE-ether extract; NDF-neutral detergent fibre

The low quantities of water soluble carbohydrates (WSC), mainly glucose and saccharose, determined in all grains (Table 2) suggested poor ensilability qualities and the necessity of an alternative source of WSC.

Table 2. Contents of selected carbohydrate fractions and ensilability parameters in grains used for RFT

	WSC *(g/100gDM)*	**Starch** *(g/100gDM)*	**BC** *(gLA/100gDM)*	**WSC/BC ratio**
Jack bean	0,00	35,90	8,96	0,00
Cowpea	2,29	38,72	6,30	0,36
Sorghum	0,18	73,92	3,13	0,06

BC-buffering capacity; WSC-water soluble carbohydrates

Although higher buffering capacities (BC) were determined in legumes compared to sorghum, the WSC/BC predicts a low ensilability for all grains, with all ratios being below the required value of 2 for good silage quality (WEIßBACH, 1964).
In RFT of cowpea, inoculation with LAB had a distinct impact on the decrease of pH (Figure 1) without significant differences at 38 h among all the inoculated variants. Thus, it can be concluded that the content of WSC in cowpea is sufficient to expect good ensilability.

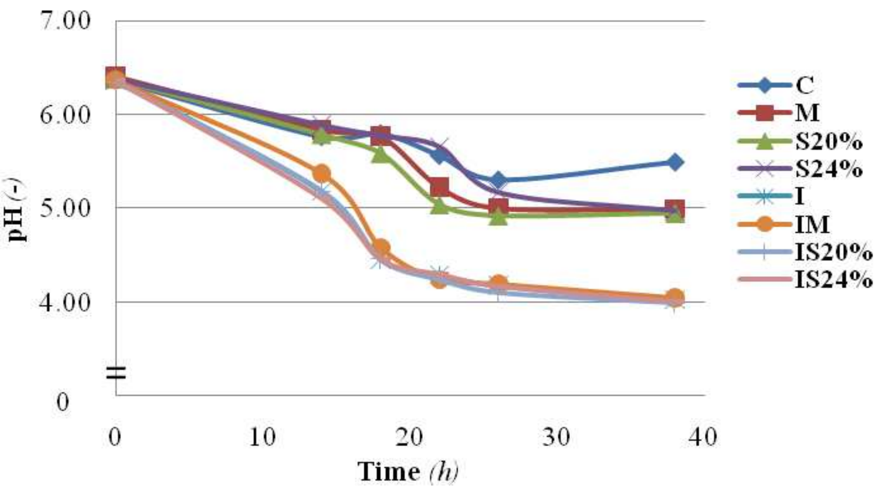

Figure 1: pH development during incubation of RFT for cowpea grains sole or mixed with sorghum

Variants with inoculant showed a significant higher production of lactic acid and lower contents of volatile fatty acids compared to those variants without the addition of inoculant (Table 3). Ethanol and NH_3 production were as well more pronounced in variants without inoculation. This suggests that with the addition of lactic acid bacteria it is possible to ensile cowpea grains even without an additional source of fermentable carbohydrates.

Table 3. Fermentation parameters after 38 h incubation in RFT of different variants with cowpea grains

	C	M	S20%	S24%	I	IM	IS20%	IS24%
Lactic acid	0.00^{a} ±0.00	2.40^{c} ±0.41	0.22^{a} ±0.12	1.95^{b} ±0.22	6.83^{f} ±0.04	6.85^{f} ±0.14	4.34^{d} ±0.04	4.75^{e} ±0.13
Acetic acid	1.76^{f} ±0.00	1.41^{e} ±0.11	1.04^{c} ±0.01	1.21^{d} ±0.03	0.67^{a} ±0.00	0.64^{a} ±0.05	0.62^{a} ±0.01	0.81^{b} ±0.05
Butyric acid	1.64^{c} ±0.16	1.20^{b} ±0.30	1.85^{c} ±0.16	0.93^{b} ±0.26	0.00^{a} ±0.00	0.00^{a} ±0.00	0.00^{a} ±0.00	0.00^{a} ±0.00
Ethanol	$1,53^{f}$ ±0.19	$0,99^{e}$ ±0.00	$0,52^{c}$ ±0.06	$0,74^{d}$ ±0.04	$0,16^{a}$ ±0.00	$0,15^{a}$ ±0.00	$0,30^{b}$ ±0.01	$0,34^{b}$ ±0.03
NH_3	$0,30^{f}$ ±0.03	$0,24^{e}$ ±0.01	$0,14^{c}$ ±0.01	$0,18^{d}$ ±0.00	$0,07^{a}$ ±0.00	$0,08^{a}$ ±0.01	$0,11^{b}$ ±0.00	$0,14^{c}$ ±0.00

[a,b] Mean values with different superscripts in the same row differ significantly (P<0,05); C *(control),* M *(molasses),* S20% *(with sorghum (20% CP)),* S24% *(with sorghum (24% CP)),* I *(inoculant)*

Contrary to cowpea, in Jack bean the effect of an inoculant on the reduction of pH was not as distinct as it was in cowpea (Figure 2). The addition of molassess had no effect on the reduction of pH in the first 14 h of incubation. Even in the inoculated variants pH values were well above 4.0 (38 h). It is likely that critical compounds of Jack bean, like antinutritional factors that are quite prominent in *Canavalia ensiformis*, hampered the development of lactic acid bacteria. This issue should be investigated in further studies especially for the case of silages.

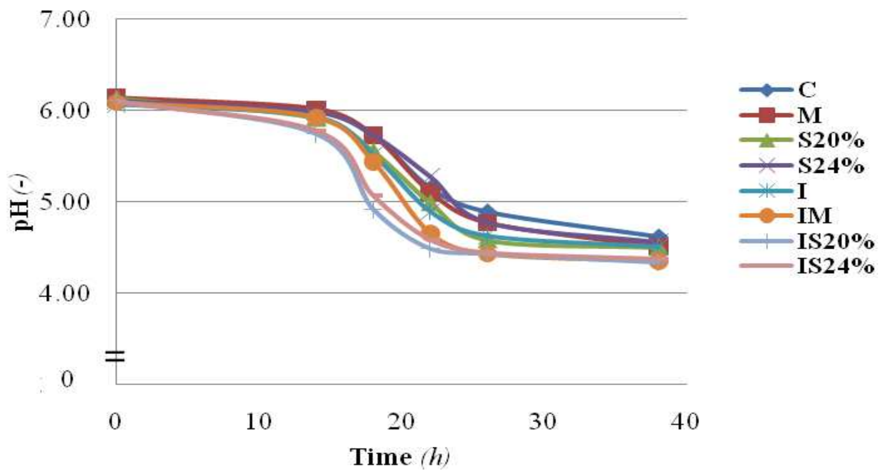

Figure 2: pH development during incubation of RFT for Jack bean grains sole or mixed with sorghum

The addition of an inoculant led to the highest lactic acid contents when sorghum was not included (Table 4). Molasses improved ensilability by enhancing the lactic acid production. Unfavorable fermentation parameters like acetic acid and butyric acid showed only low contents and were generally below critical values.

Table 4. Fermentation parameters after 38 h incubation in RFT of different variants with Jack bean grains

	C	M	S20%	S24%	I	IM	IS20%	IS24%
Lactic acid	2.26[a] ±0.24	2.80[c] ±0.00	2.23[a] ±0.02	2.36[ab] ±0.09	3.71[d] ±0.06	4.63[e] ±0.07	2.52[b] ±0.01	2.86[c] ±0.01
Acetic acid	1.14[bc] ±0.26	1.28[c] ±0.06	0.83[b] ±0.03	0.90[b] ±0.05	0.93[b] ±0.09	0.45[a] ±0.36	0.84[b] ±0.00	1.01[bc] ±0.00
Butyric acid	0.05[ab] ±0.04	0.01[b] ±0.03	0.05[ab] ±0.01	0.03[a] ±0.01	0.00[a] ±0.00	0.01[a] ±0.00	0.00[a] ±0.00	0.00[a] ±0.00
Ethanol	0.34[b] ±0.04	0.36[b] ±0.04	0.19[a] ±0.03	0.25[ab] ±0.01	0.18[a] ±0.066	0.15[a] ±0.00	0.19[a] ±0.02	0.22[a] ±0.00
NH_3	0.11[e] ±0.01	0.18[f] ±0.08	0.07[b] ±0.01	0.08[c] ±0.00	0.09[d] ±0.00	0.09[d] ±0.00	0.06[a] ±0.00	0.07[b] ±0.00

[a,b] Mean values with different superscripts in the same row differ significantly (P<0,05); C *(control),* M *(molasses),* S20% *(with sorghum (20% CP)),* S24% *(with sorghum (24% CP)),* I *(inoculant)*

In the variants without inoculation the production of ethanol was lower in most of the variants compared to cowpea, which is presumably due to a lesser yeast activity. Levels of NH_3 were generally low, providing evidence that proteolysis did not take place to a high extend.

Conclusions

Using the Rostock fermentation test (RFT) it is possible to evaluate the ensilability of cowpea and Jack bean grains sole or mixed with sorghum grains. RFT showed that in spite of a poor performance in respect to ensilability characteristics (content of water soluble carbohydrates, buffering capacity), it possible to produce good fermentation qualities using grains of Jack bean and cowpea.

It is generally recommended to apply lactic acid bacteria as inoculant to increase reduction of the pH value. Whereas for cowpea the content of fermentable carbohydrates in the grains seems to be sufficient, for Jack bean the addition of molasses is required. Mixtures with sorghum grains do not improve fermentation quality, but must be seen as an option to harvest sorghum at an earlier stage, reducing thus costs for drying and moreover be of advantage to form a complete diet for pigs in low-input farming systems. The results obtained with RFT should be validated by studies with model silages.

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