Heat treatment of tropical multipurpose legume grains affects *in-vitro* digestion and fermentation in pigs

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Introduction

Tropical multipurpose legumes are an interesting protein source in pig nutrition, which could be used in small-scale pork production. However, the digestion of the nutrients of some of them in raw form is often poor. The thermal treatment has been widely used to improve the digestibility of proteins and to reduce antinutritional factors in legume grains. For this reason, the potential of *Canavalia brasiliensis* (CB), *Lablab purpureus* (LP) and *Vigna unguiculata* (white WVU, pink PVU, red RVU seed hull) legume grains as feed after different thermal treatments was evaluated.

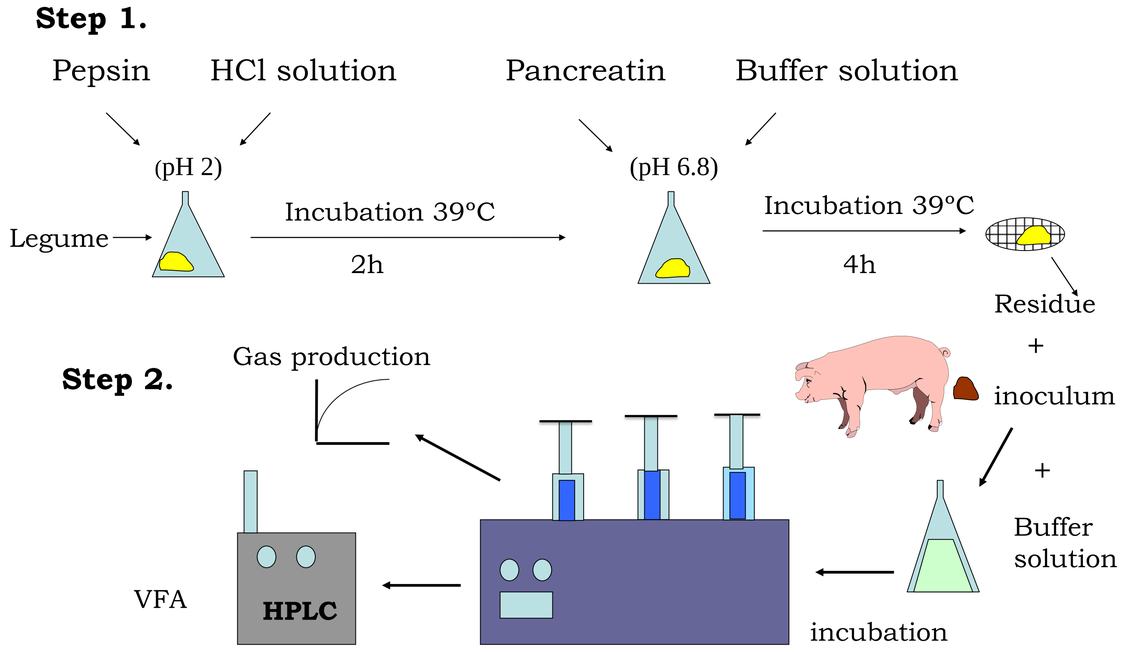
Objective

The aim of this study was to evaluate the effect of different thermal treatments on the *in-vitro* foregut enzymatic hydrolysis (or digestibility) of protein, dry matter and starch as well as the *in-vitro* hindgut fermentation of 5 tropical legume grains.

Materials and Methods

Legume grains of CB, LP, WVU, PVU and RVU were utilized to test the effect of the thermal treatment (raw, boiling and autoclaving for 5 and 20 min [B5, B20, A5 and A20 respectively]) in a factorial analysis (5 legumes x 5 treatments). Extruded full-fat soybeans (SB) (*Glycine max)* served as control, but were not included in the statistical analysis.

Enzymatic hydrolysis: Legume grains were incubated in buffer solution at 39°C with pepsin (120 min), followed by pancreatin (240 min). Aliquots were taken from the incubation medium at 0 and 360 min to determine protein digestibility. The digestibility of starch and dry matter was also determined at 360 min (step1).
Hindgut fermentation: The undigested residue of enzymatic hydrolysis was fermented for 72 h and gas production and volatile fatty acids (VFA) were measured (step 2).



Results and discussion

Table 1. *In-vitro* digestibilities of thermally treated tropical legume grains after pepsin and pancreatin hydrolysis.

Legume	Thermal treatment	*In-vitro* digestibility (%)		
		Protein	Dry matter	Starch
SB	-	76	77	30
CB	Raw	50.3^{h-j}	42.6^{l}	40.7^{hi}
	B-5	56.4^{e-i}	45.0^{kl}	51.3^{d-f}
	B-20	65.5^{ab}	44.1^{l}	35.4^{i}
	A-5	66.9^{a}	60.3^{c-f}	53.0^{c-f}
	A-20	62.0^{a-e}	43.0^{l}	43.2^{gh}
LP	Raw	46.0^{jk}	49.0^{jk}	42.0^{h}
	B-5	49.6^{ij}	49.2^{jk}	48.6^{fg}
	B-20	49.8^{ij}	52.5^{ij}	65.3^{a}
	A-5	56.9^{d-h}	56.3^{f-i}	54.6^{b-e}
	A-20	53.7^{f-i}	55.6^{g-i}	67.6^{a}
RVU	Raw	51.7^{g-j}	55.0^{hi}	52.0^{d-f}
	B-5	52.2^{g-j}	59.2^{d-g}	69.0^{ac}
	B-20	63.7^{a-d}	60.0^{c-g}	58.0^{bc}
	A-5	60.5^{a-f}	64.0^{bc}	67.3^{a}
	A-20	64.5^{a-c}	62.2^{b-d}	65.6^{a}
PVU	Raw	41.6^{kl}	46.0^{kl}	48.0^{fg}
	B-5	38.2^{l}	64.0^{b-d}	66.4^{a}
	B-20	57.8^{c-g}	58.0^{e-h}	50.2^{ef}
	A-5	61.4^{a-e}	60.0^{c-g}	65.0^{a}
	A-20	64.1^{a-c}	65.2^{ab}	70.0^{a}
WVU	Raw	54.0^{f-i}	55.0^{hi}	56.0^{b-d}
	B-5	57.0^{d-h}	61.0^{c-e}	65.6^{a}
	B-20	56.4^{e-i}	58.0^{e-h}	58.6^{b}
	A-5	65.2^{ab}	60.3^{c-f}	59.0^{a}
	A-20	59.7^{b-f}	69.0^{a}	70.0^{a}
Standard error		1.3	0.8	1
Legume		0.001	0.001	0.001
Thermal treatment		0.001	0.001	0.001
Legume* Thermal treatment		0.001	0.001	0.001

a,b,c Values with different letters in the same column differ significantly at P < 0.05.

The *in-vitro* protein digestibility of raw legume grains ranged from 42% (PVU) to 54% (WVU) compared to 76% for SB. This was significantly influenced by the interaction between the legume type and thermal treatment (P<0.001) (Table 1). The highest increases in protein digestibility were observed for PVU after A20 (+23%) and B20 (+16%) and the lowest for WVU after B20 (+2%) and A20 (+6%).

The *in-vitro* starch and dry matter digestibility were influenced by the interaction between the legume type by thermal treatment (P<0.001) (Table 1). The A20 thermal treatment had the highest increases in starch and dry matter digestibility for PVU (+19% and +22%) and WVU (+14% and +14%), but the lowest for CB (+0.4% and +2%) when compared to their raw form. In general, B20 had the lowest increases in starch and dry matter digestibility.

The gas production was influenced by "legume type x thermal treatment" interaction (P<0.01) (Table 2). This gas production increased or decreased depending on the legume and thermal treatment (e.g. +49, +33, -53 and -12 ml of gas/g dry matter incubated for LP, PVU, WVU and CB after A20). The concentration of VFA was only influenced by the legume effect (P<0.001), with CB presenting the lowest values when compared to the other grains (e.g. total VFA 49 vs. >60 mmol/l).

Table 2. *In-vitro* fermentation of thermally treated legume grains after 72 h of incubation with a faecal inoculum.

Legume	Thermal treatment	Gas production (ml/ g DM)	SCFA (mmol/L)			
			Acetic	Propionic	Butyric	Total
SB	-	382	27.3	12.0	4.7	54
CB	Raw	362^{c-h}	24.0	12.0	5.3	51
	B-5	347^{f-h}	24.0	11.2	5.0	48
	B-20	338^{gh}	19.0	11.0	5.6	44
	A-5	318^{h}	25.0	12.0	5.0	50
	A-20	350^{d-h}	24.4	11.4	5.0	50
LP	Raw	413^{a-f}	31.1	14.2	7.0	63
	B-5	425^{a-e}	33.0	14.0	5.0	64
	B-20	403^{a-g}	31.0	13.1	6.0	61
	A-5	378^{c-h}	34.2	15.0	6.3	67
	A-20	409^{a-g}	34.0	15.2	6.1	67
RVU	Raw	377^{c-h}	30.0	14.3	6.8	62
	B-5	429^{a-d}	31.4	14.4	6.3	65
	B-20	392^{b-g}	30.0	14.0	6.7	63
	A-5	348^{f-h}	26.1	13.0	5.4	54
	A-20	426^{a-e}	27.4	13.5	6.0	57
PVU	Raw	392^{b-g}	34.4	16.2	7.5	71
	B-5	356^{e-h}	33.1	15.0	7.0	68
	B-20	388^{b-h}	34.0	15.2	7.0	69
	A-5	370^{c-h}	35.0	15.7	6.5	70
	A-20	425^{a-e}	30.2	14.2	6.0	61
WVU	Raw	471^{a}	29.2	14.0	7.1	60
	B-5	459^{ab}	33.4	16.0	7.2	71
	B-20	400^{a-f}	34.0	17.0	7.0	71
	A-5	433^{a-c}	32.0	15.4	6.5	67
	A-20	418^{a-g}	29.5	14.0	6.6	61
Standard error		14.9	3.3	1.0	1.1	6.1
Legume		0.001	0.001	0.001	0.003	0.001
Thermal treatment		0.001	0.750	0.910	0.130	0.830
Legume* T. treatment		0.002	0.410	0.350	0.870	0.444

a,b,c Values with different letters in the same column differ significantly at P < 0.05.

Conclusions

The thermal treatment affected differently the *in-vitro* foregut digestibilities as well as the *in-vitro* hindgut fermentation for each legume. Therefore, the thermal treatment required to improve the foregut digestion and the hindgut fermentation would change depending on the tropical legume used to feed the pigs.