A low concentration of rice distillers' byproduct, or of brewers' grains, increased diet digestibility and nitrogen retention in native Moo Lath pigs fed ensiled banana pseudo-stem (*Musa* spp) and ensiled taro foliage (*Colocasia esculenta*)

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Abstract

Six native Moo Lath pigs with initial live weight of 29.3 kg, fed a basal diet of (DM basis) ensiled banana pseudo-stem (10%), ensiled Taro foliage (70%) and broken rice 20%, were allocated to a 3*3 double Latin Square Design in which the treatments were (DM basis): 4% of brewers' grains (BG), 4% of rice distillers' by product (RDB) or no supplement (CTL). The feeds were offered at 3% of live weight (DM basis).

Both supplements improved feed intake, digestibility and N retention, with indications of greater responses in N retention and in the biological value of the protein, for the rice distillers' byproduct. It is suggested that the beneficial effect of both supplements may have been due to the presence of ?-glucan, a component of the cell wall of both cereal grains and yeasts, that is known to have immunological, health-benefitting effects in humans and animals.

Key words: *forages, indigenous breeds, prebiotics*

Introduction

Brewers' grains have been widely used as protein supplements in diets of pigs and cattle. However, recent research (Binh et al 2017) suggests that they may also provide other benefits, as a source of "prebiotics". The evidence for this idea is from an experiment in which cattle were fed a basal diet of cassava pulp-urea and either sweet (low-HCN) or bitter (high-HCN) cassava foliage as the bypass protein supplement. Growth rate was only 30 g/day with bitter cassava foliage compared with 600 g/day for sweet cassava foliage; and urine thiocyanate excretion was twice as high for the bitter compared with sweet cassava foliage. However, when 4% brewers' grains were added to the bitter cassava diet, the growth rate increased to 500g/day and urine thiocyanate was reduced by half. It was concluded that the effect of the small supplement of brewers' grains was to assist the immune system in the detoxification of the HCN (Binh et al 2017).

Further evidence for a "prebiotic" effect of a yeast-fermented grain byproduct is: (i) in the report of

Vor Sina et al (2017) that supplementing 4% of brewers' grains to goats fed cassava foliage doubled the weight gain from 80 to 160 g/day and reduced urinary excretion of thiocyanate; and (ii) of Sengsouly and Preston (2016) of a 100% increase in growth rate of Yellow cattle fed ensiled cassava root, urea and cassava foliage when the diet was supplemented with 4% rice distillers' byproduct (Quilao), the residue from yeast fermentation of rice to make “ rice wine”. The dramatic improvement in growth rate from supplementation with 4% brewers' grains or "Quilao" cannot be explained as being due to improved supply of nutrients.

The above experiences were the basis of the hypothesis that small amounts (4% of diet DM) of either brewers' grains or rice distillers' byproduct (Quilao) would support increased growth rate in local Moo Lath pigs.

Materials and methods

Location and climate

The experiment was conducted in the livestock farm of the Faculty of Agriculture, National University of Laos, Vientiane Capital, Lao PDR, from 14 September to 31 November, 2016. The average daily temperature during the experiment was 27 ?C (range from 24 to 30 ?C). The site of experiment was located 32 km to the south of Vientiane city.

Treatments and experimental design

Six pigs (Moo Lath breed) with average initial live weight of 29.3 kg were individually housed in metabolic cages (Photo 1) and randomly allocated to 3 diets:

CTL: Ensiled banana pseudo stem, ensiled taro foliage and broken ric.

BG: CTL + 4% of brewers' grains

RDB: CTL + 4% of rice distillers' byproduct.

The treatments were arranged according to a double 3*3 Latin Square Design with periods of 10 days: 5 days for adaptation to the change of diet and 5 days for measurement of feed intake and collection of feces and urine.

Photo 1. Metabolism cages for feces and urine collection

Feeding management

The control diet was a mixture (DM basis) of 10% ensiled banana pseudo-stem, 70% ensiled taro foliage and 20% broken rice. Rice distillers' by-product and brewers' grain were added at the 4% level (DM basis) to the BG and RDB treatments. Feeding times were 7:00 am and 4 pm. Feed offer level was 3% of live weight (as DM). Water was supplied automatically through nipple drinkers.

Feed resources

The banana pseudo-stem (left over after harvest of the fruit) was brought from the gardens of villagers surrounding the experimental area. Taro foliage (leaves + petioles) was harvested from the banks of ponds in the local village where waste water was stored. Broken rice was purchased from a rice mill in Vientiane capital. Rice distillers’ by-product was purchased from households in the nearby

village. Fresh (ensiled) brewers' grains were purchased from a feed shop in Vientiane city (the source was a local brewery).

The inner part of the banana stem was chopped by hand into small sizes around 1-2 cm of length (Photo 2). Taro foliage (leaves and petioles) was processed by machine into particles of 0.5 cm. Both forages were wilted under black netting for a day to reduce moisture content to about 80%, and then stored in closed polyethylene bags for 7-14 days, prior to mixing with the broken rice and supplements (Photos 3 and 4).

Photo 2. Chopped banana pseudo-stem **Photo 3.** Rice distillers' byproduct **Photo 4.**

Data collection

Amounts of feed offered and refused were recorded daily and sub-samples retained for analysis (stored at -20?C). Urine and feces of each pig were collected every morning, were weighed and samples (20 % of total) stored at -20 ÂºC. Urine was collected in a bucket via a funnel below the metabolism cage with 50ml of 30% H_2SO_4 to maintain pH below 4. At the end of each experimental period, the daily collections of urine were bulked and representative samples were stored at -20 ÂºC. The feces collections were also mixed and representative samples dried at 70ÂºC for 48 h.

Chemical analysis

The samples of feeds, offered and refused, and feces were analyzed for dry matter (DM), nitrogen (N), crude fiber (CF) and ash according to AOAC (1990) methods. The pH of the mixed feed was measured with an electronic meter. Urine was analyzed for N (AOAC 1990).

Statistical analysis

The data were analyzed using the general linear model in the ANOVA program of the MINITAB software (Minitab 2014). Sources of variation were treatments, pigs, periods and error.

Results and discussion

Chemical composition of diets

The values for proximate constituents of brewers' grains, rice distillers' byproduct, banana pseudo-stem and Taro silage (Table 1) were in accordance witt those in the literature (Feedipedia.org; Luu Huu Manh et al 2003; Manh et al 2009). The crude protein in the broken rice (12.3%) was higher than the average (10.2%), but within the range of values (7.8-13.2% in DM), reported in Feedipedia.org. The low pH of the brewers' grains and rice distillers' by-product indicates that both products were well preserved.

Table 1. Proximate composition of diet ingredients

Diets	DM, %	% in DM				pH

		CP	Ash	OM	CF	
Brewers' grains	24.1	23.5	17.6	96.4	16.1	3.28
Rice distillers' by-product	16.8	22.3	13.9	96.6	3.71	3.21
Ensiled banana pseudo stem	9.93	2.94	1.56	98.4	35.7	4.11
Ensiled taro foliage	10.8	17.2	3.28	96.7	30.0	3.77
Broken rice	88.5	12.3	2.68	97.3	3.00	-

Table 2. Composition of diets (DM basis)

	% **DM basis**	
	CTL	**BG**
Brewers' grain	0	4
Rice distillers' byproduct	0	0
Ensiled taro foliage	70	66
Ensiled banana pseudo stem	10	10
Broken rice	20	20

Proximate analysis, % in DM, except for DM which is on air - dry basis

Dry matter#	12.3	14.1
Crude protein#	12.6	12.9
Crude fiber	18.8	18.3
Ash	1.9	2.0
Organic matter	*98.2*	*98.0*
pH	3.92	4.00

 # Average of 18 samples of complete feeds offered during the experiment

Feed intake

DM intake was increased 19 and 29%, respectively, by inclusion of BG and RDB in the diets (Table 3; Figure 1). The crude protein in the diet DM consumed (12.6-12.9%) was only slightly higher than was found to be optimum (12% in DM) in an earlier experiment with a similar basal diet (Sivilai and Preston 2017).

Table 3. Mean values for DM intake and % CP of the diet consumed by Moo Lath pigs without (CTL) or with supplements of BG or RDB

	CTL	**BG**	**RDB**	**SEM**	***p***
DM intake, g/d	703[b]	777[a]	805[a]	13.4	<0.001
CP in DM, %	13.1	13.2	13.1	0.07	0.411

[ab] *Mean values within rows with different superscript differ at P<0 . 05*

Apparent digestibility

Apparent digestibility coefficients for DM, organic matter, crude fiber and crude protein were increased by both supplements (Table 4; Figures 2-4). The highest relative increases were for crude fiber (8.4 and 11.6 %, respectively for BG and RDB).

Table 4. Mean values for apparent digestibility by Moo Lath pigs fed diets without (CTL) or with supplements of BG or RDB

	CTL	BG	RDB	SEM	*p*
Apparent digestibility, %					
Dry matter	84.5[b]	87.5[a]	89.6[a]	0.84	<0.001
Crude protein	75.6[b]	79.4[ab]	80.7[a]	1.41	0.032
Crude fiber	79.5[b]	86.2[a]	88.7[a]	1.11	<0.001
Organic matter	84.7[b]	87.8[a]	89.9[a]	0.81	<0.001

[ab] *Mean values within rows without common superscript differ at P<0.05*

Figure 1. Effect of rice distillers' by-product and brewers' grain on DM intake by Moo Lath pigs

Figure 2. Effect of apparent

Figure 3. Effect of rice distillers' byproduct and brewers' grain on apparent digestibility of crude protein by Moo Lath pigs

Figure 4. Effect of r apparent dig

Nitrogen balance

N intake and N retained was greater on the BG and RDB diets as a consequence of the increases in DM intake induced by the supplements (Table 5). When the N retained was corrected for differences in N intake, there was no advantage from supplementation with BG; however, the RDB supplement increased N retention by 11% (Table 5; Figure 5). The N retained as a percent of N digested, indicating the biological value of the protein, was increased by both BG and RDB (Table 5; Figure 6).

Table 5. Mean values for N balance by Moo Lath pigs fed diets with or without (CTL) supplements of BG or RDB

	CTL	BG 4 %	RDB 4 %	SEM	*p* - value

N balance, g / d					
Intake	14.5[b]	16.2[a]	16.7[a]	0.28	<0.001
Feces	3.2	3.4	2.9	0.19	0.196
Urine	2.2[b]	2.1[b]	1.5[a]	0.10	0.174
N retained					
g/day	9.00[a]	10.7[b]	12.3[c]	0.35	<0.001
g/day#	10.2[a]	10.3[a]	11.3[b]	0.27	<0.001
% of digested N	73.8[a]	83.1[b]	87.2[b]	1.91	<0.001

[ab] *Mean values within rows with different superscripts are different at P<0.05*
 # Corrected by covariance for differences in N intake

Figure 5. Effect of rice distillers' byproduct and brewers' grains on N retention (#corrected by covariance for differences in N intake)

Figure 6. Effe
grains on

Discussion

Previous research with brewers' grains (eg: Amaefule et al 2006) and rice distillers' byproduct (Luu Huu Manh et al 2003) have used these supplements in pig diets as sources of protein replacing conventional protein sources such as fish meal. As far as we are aware, this is the first report on the use of these supplements at low levels in the context, not of sources of protein per se, but as sources of prebiotics (Fuller 1989; Vanbelle et al 1990). Thus in our experiment the diets were compounded to contain the same amount and source of protein, shown previously to be optimum for a diet based on ensiled banana stem and Taro foliage (Sivilai and Preston 2017).

It is suggested that the effect of both brewers' grains and rice distillers' byproduct, in supporting improved feed intake, digestibility and N retention, could be explained by the presence in both the supplements of ?-glucan, a carbohydrate component of the cell wall of cereal grains and fungi including yeasts. The beneficial effect of ?-glucan on growth rate and health in weaning pigs was recently reported by Nguyen Thi Thuy (2017). The immune-modulating effects of ?-glucans, with beneficial health effects in humans and animals are well known (see Novak and Vetvicka 2008;

Waszkiewicz-Robak 2013).

Brewers' grains

Barley has been reported to contain ?-glucan, on average at 40 g/kg (HavrlentovÃ¡ and Kraic 2006**);** and 1 kg of barley, processed for production of beer, is estimated to give a residue (brewers' grains) of 0.6 kg. The concentration of ?-glucan in brewers' grains could then be of the order of 70 mg/g DM. In 1 kg of diet fed to the pigs, there were 40 g of brewers' grains, that could contain 2.8 g of ?-glucan thus the diet fed to the pigs would have contained a maximum concentration of 2.8 g glucan/kg DM. This is similar to the level of "extracted" ?-glucan fed to weaning pigs by Nguyen Thi Thuy (2017), with reported increases in growth rate of the order of 10%. Thus 4% of brewers' grains in the diet may be a reasonable indicator of the amount needed to promote benefits to the animal's immune system leading potentially to better growth performance.

Rice distillers' byproduct

Rice distillers' byproduct is almost always made from milled rice which at most contains 4% crude fiber so rice cell wall fiber is unlikely to contribute more than a minimum amount of ?-glucan to the diet supplemented with rice distillers' byproduct. However, rice distillers' byproduct is rich in yeast (Dang Thiep, personal communication) and yeast cell walls are reported to contain 7.7% ?-glucan (Waszkiewicz-Robak 2013). The report by this author that bakers' yeast (*Saccharomyces cerevisiae*) was as effective as pure preparations of ?-glucan in reducing cholesterol levels in mice fed a "cholesterol-inducing" diet, lends support to the idea that in rice distillers' byproduct, it is the yeast that is responsible for the apparent prebiotic effect.

Conclusion

- Brewers' grains and rice distillers' byproduct, each at concentrations of 4% of diet DM, improved feed DM intake and apparent digestibility of DM, crude protein ad crude fiber in native Moo Lath pigs fed a basal diet of ensiled banana pseudo-stem (10%), ensiled Taro foliage (70%) and broken rice (20%).

- N retention (corrected for N intake) was increased by rice distillers' byproduct but not by brewers' grains.

- The biological value of the protein was increased by both supplements.

- It is suggested that the positive effects on pig performance, of both brewers' grains and rice distillers' byproduct, may have been due to the presence of ?-glucan, a component of the cell wall of both cereal grains and yeasts.

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