In vitro evaluation of fermentation characteristics of two types of insects, as potential novel protein feeds for pigs

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Introduction

Novel protein sources such as insects are suggested for pig nutrition.

BUT protein availability might be impacted:

(i) by the nature of the insect ;
(ii) by the thermal treatment applied to sanitize this ingredient.

Objective of this experiment:

Study of the influence of the nature of the insect (house crickets or mealworms larvae) and the cooking procedure (raw, oven-cooked or autoclaved) on protein availability and on colonic fermentation by comparison with grain legumes.

Materials and Methods

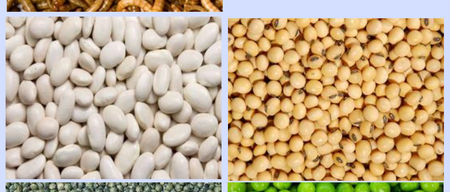
Test ingredients:

House crickets
Acheta domesticus

- Raw
- Oven-cooked at 150ºC for 30 min.

Mealworms larvae
Tenebrio molitor

- Oven-cooked at 200ºC for 10 min.
- Autoclaved (25 min.)



Beans
Soybean

- Raw
- Vapor-cooked (60 min.)

Lentils
Peas

- Raw
- Vapor-cooked (30 min.)

***In vitro* simulation of the pig digestive tract:**

Raw and cooked ingredients + casein as positive control

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Pre-digestion with pepsin (2h) and pancreatin (4h) (Boisen and Fernandez, 1997)

↓

Residue of hydrolysis → Weight of residues ↳ *Determination of the in vitro dry matter digestibility (IVDMD)*

Residue of hydrolysis → Dosage of nitrogen ↳ *Determination of the in vitro crude protein digestibility (IVCPD)*

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In vitro fermentation of hydrolysis residue (200 mg) by pig faeces in glass bottles (Bindelle *et al*., 2007)

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Residue of fermentation → Analysis of SCFA production after 12h, 24h and 72h of fermentation by HPLC

Results

Digestibilities of DM and CP with enzymatic hydrolysis

- As shown on Table 1, IVDMD and IVCPD for both insects sources are reduced by cooking *(P<0.05)*.
- For mealworms larvae, this reduction is higher when a severe thermal treatment is applied (autoclaving) (*P*<0.05).
- Except for soybean, cooking grain legumes positively influences IVDMD but does not affect IVCPD (*P<0.05*).
- IVCPD of raw mealworms (72.5%) equaled that of the best grain legumes (72.5 to 76.3%) while crickets were less digestible (*P<0.05*).

Table 1. *In vitro* dry matter (IVDMD) and crude protein digestibility (IVCPD) of test ingredients (insects and grain legumes) submitted to an hydrolysis with pepsin and pancreatin (values are means of 15 values obtained from 5 independant experiments).

Ingredient	Treatment	IVDMD (%)	IVCPD (%)	Ingredient	Treatment	IVDMD (%)	IVCPD (%)
House crickets	Raw	56.1^{e}	65.5^{b}	Beans	Raw	27.2^{h}	68.5^{b}
	Oven-cooked at 150°C	46.1^{f}	59.3^{c}		Vapor-cooked	46.9^{e}	68.8^{b}
	Oven-cooked at 200°C	47.3^{f}	61.1^{bc}	Lentils	Raw	32.6^{g}	68.8^{b}
	Autoclaved	48.7^{f}	59.5^{c}		Vapor-cooked	60.2^{c}	72.5^{ab}
Mealworms larvae	Raw	76.2^{b}	72.5^{a}	Peas	Raw	37.1^{f}	74.1^{ab}
	Oven-cooked at 150°C	69.8^{c}	64.1^{b}		Vapor-cooked	63.4^{b}	76.0^{a}
	Oven-cooked at 200°C	69.4^{c}	63.9^{bc}	Soybean	Raw	49.6^{d}	60.8^{c}
	Autoclaved	63.8^{d}	59.5^{c}		Vapor-cooked	46.2^{e}	76.3^{a}
Casein	-	92.5^{a}	78.5^{a}	Casein	-	92.5^{a}	78.5^{a}
SEM		1.31	0.79	SEM		1.62	0.78
P-value		<0.0001 ***	<0.0001 ***	P-value		<0.0001 ***	<0.0001 ***

a-h: different letters within a column indicate significant differences (*P*<0.05)
SEM, standard error of the mean.

SCFA and BCFA productions by *in vitro* fermentation

- The Figure 1 shows that both insects sources display higher proportion of butyrate and branched-chain fatty acids (BCFA) but lower molar ratio of propionate as compared to grain legumes (*P*<0.05).
- The *in vitro* fermentation of house crickets produces 50% as much BCFA as mealworms larvae (23.5 to 26.9% for house crickets *vs*. 16.7 to 20.6% for mealworms, *P*<0.05)
- The application of a thermal treatment to both insects sources leads to a reduced proportion of propionate (*P*<0.05). For crickets, this is compensated by a higher butyrate molar ratio in raw crickets against the heat-treated ones (13.3% *vs.* 10.9 to 11.5%, *P*<0.05).

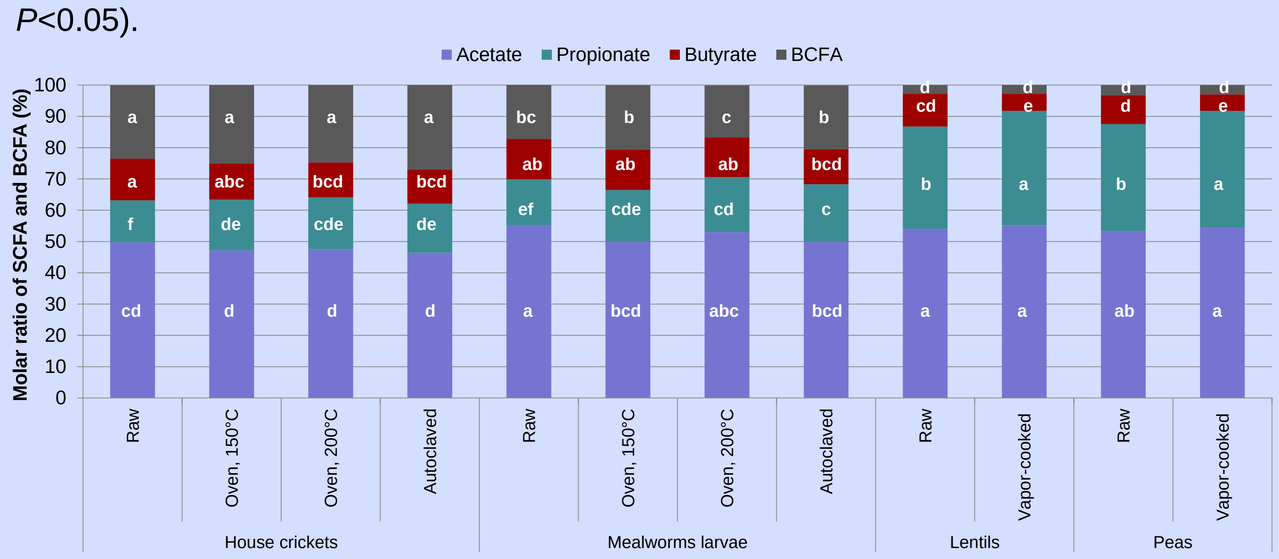

Figure 1. Production of SCFA (acetate, propionate and butyrate) and BCFA (isobutyrate, isovalerate and valerate) according to the ingredient and the cooking procedure used as substrate for *in vitro* fermentation by pig inoculum (n = 9).
a-f: different letters for a given SCFA or for BCFA indicate significant differences (*P*<0.05)
SCFA, short-chain fatty acids ; BCFA, branched chain fatty acids.

The nature of the insects and the thermal treatment applied have significant incidence:
(1) on IVDMD and IVCPD. Mealworms larvae show a higher IVDMD than crickets and, for both insects sources, IVDMD and IVCPD are reduced by cooking.
(2) on metabolites production. Crickets produce more BCFA than mealworms and the cooking of an insect source modifies the ratio of propionate and butyrate.

Feeding insect-sourced protein requires a careful choice of the species as well as the thermal treatment to avoid possible detrimental consequences on intestinal health in pigs.

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