# In vitro fibre fermentation characteristics of specialty ingredients with varying non-starch polysaccharides levels

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*"Fermentable fibre modulates the gut environment, extends health-promoting properties and reduces ammonia excretion"*

**SUMMARY**

The objective of this study was to use a laboratory technique that mimics what happens in the intestimes of pigs to evaluate the fermentation characteristics of some non-conventional feed ingredients with varying fermentable fibre and their possible influence on intestinal environment and nitrogen excretion. We concluded that fibre fermentation characteristics in the pig gastrointestinal tract are extremely variable from one ingredient to another. Of the feed ingredients evaluated, peas and pea fibres had higher fermentability and bacterial protein synthesis capacity.

**INTRODUCTION**

The pork industry is looking for alternative feed ingredients that have functional properties to improve gut health and a positive impact on the environment. The intestinal fermentation of dietary fibre results in the formation of short-chain fatty acids (SCFA), which in turn stimulate the growth of beneficial bacteria such as lactobacilli and bifidobacteria and limits the activity of proteolytic microbes in the pig intestine. This might positively affect gut health. In addition depending on the fermentation kinetics, the nitrogen excretion pathway may be shifted from urine to faeces, reducing ammonia emission from swine facilities. However, there is limited information available on these properties of feed ingredients.

**MATERIALS AND METHODS**

Eight ingredients (wheat bran (WB), solka floc® (SF, wood cellulose), peas, pea hulls fibre (PHF), pea inner fibre (PIF), sugar beet pulp (SBP), flaxseed meal (FSM) and corn distiller dried grains with solubles (DDGS)) with diverse carbohydrate composition were selected for the study (Table 1).

The ingredients underwent an in-vitro pepsin-pancreatin hydrolysis. The hydrolyzed ingredients were then fermented in-vitro with minerals and buffer, using pig feces as the inoculum (Bindelle et al., 2009). The gas production kinetics during fermentation were modeled (Figure 1 and Table 2) according to France et al. (1993). Bacterial nitrogen incorporation (BNI) in fermented substrates was determined using 15N as a marker (Bindelle et al., 2009) (Table 3). Fermented residues were analyzed for SCFA content (Figure 2). There were 2 replications of 8 ingredients and 6 blanks in each of 4 batches. The influence of the ingredient on the fermentation kinetics, SCFA and BNI was compared in the statistical analyses.

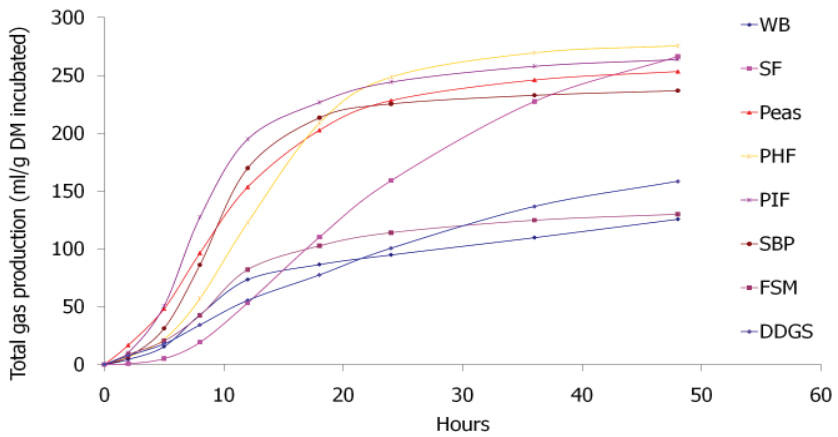


**Figure 1.** Gas production kinetics of different ingredients studied in vitro (in test tube)

*Representative of kinetic parameters of gas production curve (Gf, L, T/2 and μ) modeled according to France et al (1993)

**RESULTS**

The source of fibre affected the in-vitro dry matter degradability (IVDMD), the fermentation kinetics and the gas production profile ($P<0.05$). The highest ($P<0.001$) IVDMD values were observed for peas (0.80) and FSM (0.70), whereas SF was essentially undegraded (0.06), as would be expected. The fractional rate of degradation appeared to be lower ($P<0.001$) for WB and DDGS (0.07 and 0.05/h, respectively) and highest for SBP (0.20/h). Peas started to ferment rapidly (lag time 1.3 h). Half gas production (T/2) was achieved sooner for PIF (8.4 h) and was the longest for

DDGS (19.8 h). The total gas production was the highest for PH, followed by SF, PIF and peas (276, 266, 264 and 253 ml/g DM incubated, respectively) and lower for FSM and WB (130 and 124 ml/g DM incubated, respectively). There was no difference (P>0.05) in SCFA production after the fermentation of SF, P, PH, PIF and SBP (ranging from 3.8 to 4.5 mMol/g DM incubated) while WB and FSM yielded lower (P<0.05) SCFA. The bacterial nitrogen incorporation (BNI), both at T/2 and after 48 h of fermentation was the highest (P<0.001) for PIF (18.5 and 15.6 mg/g DM incubated, respectively) and the lowest for DDGS and WB.

**IMPLICATIONS**

peas and pea fibres had higher rates of fermentability, produced more SCFA and had high bacterial protein synthesis capacity. They thus have the potential to be included in pig diets as a source of fermentable fibre to modulate the gut environment, extend health-promoting properties and reduce ammonia excretion.

**CONCLUSIONS**

Fibre fermentation characteristics in the pig gastrointestinal tract are extremely variable between ingredients. Pea and pea fibres have high fermentability and bacterial protein synthesis capacity and thus have potential to be a source of fermentable fibre when included in swine diets.

**ACKNOWLEDGEMENTS**

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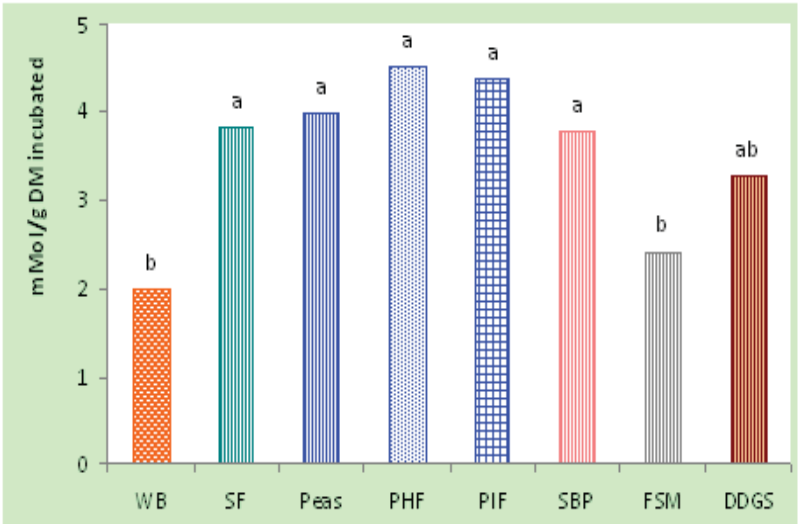


**Figure 2.** Short chain fatty acid production of different ingredients studied in vitro (in test tube)

**Table 1.** Chemical Composition of the Ingredients and the Hydrolyzed Substrates used in the Experiment

| | Raw Samples | | | | | | Hydrolysed samples | | |
|---|---|---|---|---|---|---|---|---|---|
| **Ingredients** | **DM** | **CP** | **NDF** | **ADF** | | **S** | **CP** | **NSP** | **S** |
| Wheat bran | 884 | 221 | 382 | 125 | 401 | 186 | 103 | 347 | 7 |
| Solka floc ® | 953 | 16 | 995 | 901 | 989 | 0 | 0 | 487 | 0 |
| Peas | 879 | 257 | 214 | 81 | 265 | 441 | 50 | 254 | 80 |
| Pea hull fibre | 922 | 176 | 400 | 350 | 524 | 184 | 17 | 380 | 31 |
| Pea inner fibre | 890 | 48 | 213 | 134 | 449 | 540 | 12 | 245 | 71 |
| Sugar beet pulp | 913 | 97 | 425 | 271 | 563 | NA | 32 | 286 | NA |
| Flax seed meal | 906 | 381 | 245 | 165 | 394 | NA | 72 | 222 | NA |
| Corn DDGS | 883 | 271 | 366 | 177 | 365 | 59 | 147 | 215 | 21 |
| Feed# | 887 | 220 | 172 | 80 | NA | 384 | NA | NA | NA |

* NSP, non starch polysaccharides; S, total starch; NA, not analyzed'
# Feed sample of pig used as donor of faeces used as inoculum for in vitro fermentation

**Table 2.** Fitted kinetics parameters (means) on the gas accumulation recorded for different hydrolyzed substrates incubated with faecal inoculums of pig

| | Per g DM | | | | | Per g CHO fermented | | |
|---|---|---|---|---|---|---|---|---|
| Ingredients | | L[2] | T/2[3] | μ[4] | $G_f$[5] | N[1] | μ[4] | $G_f$[5] |
| Wheat bran (WB) | 8 | NA | NA | NA | 126$^{f}$ | 8 | NA | 639$^{de}$ |
| Solka floc ® (SF) | 8 | NA | NA | NA | 266$^{b}$ | 8 | NA | 608$^{e}$ |
| Peas | 8 | 1.33$^{d}$ | | 0.10$^{b}$ | 253$^{c}$ | 8 | 0.11$^{c}$ | 1040$^{b}$ |
| Pea hull fibre (PHF) | 8 | 3.59$^{a}$ | | 0.10$^{b}$ | 276$^{a}$ | 8 | 0.11$^{c}$ | 713$^{cde}$ |
| Pea inner fibre (PIF) | 8 | | 8.38$^{d}$ | 0.11$^{b}$ | 264$^{b}$ | 8 | 0.14$^{b}$ | 1050$^{b}$ |
| Sugar beet pulp (JBP) | 8 | 2.91$^{b}$ | 9.39$^{c}$ | 0.20$^{a}$ | 237$^{d}$ | 8 | 0.16$^{a}$ | 834$^{c}$ |
| Flax seed meal (FSM) | 8 | 1.75$^{c}$ | | 0.10$^{b}$ | 130$^{f}$ | 8 | 0.11$^{c}$ | 753$^{cd}$ |
| Corn DDGS | 8 | NA | NA | NA | 158$^{e}$ | 8 | NA | 1199$^{a}$ |
| SEM | | | | | 1.9 | | | 32.6 |
| P-Value | | | | | | | | <0.001 |

* N, number of observations in fermentation; L, lag time (h); T/2, half-time to asymptote (h); μ, fractional rate of degradation at t = T/2 ($h^{-1}$); $G_f$, maximum gas volume (ml per g DM incubated / CHO fermented); CHO, fermentable carbohydrate (NSP + Starch)
* NA, not available as these parameters did not fit in the model used
* Means with different superscripts within the columns are significantly different (P < 0.05)

**Table 3.** Bacterial Nitrogen Incorporation (BNI) of Different Fibre Sources Measured after One-Half the Final Gas Volume was Produced (T/2) and 48 h of Fermentation.

| | T/2 | | | 48 h | | |
|---|---|---|---|---|---|---|
| Ingredients | N[1] | mg/g DM incubated | mg/g CHO fermented | N[1] | mg/g DM incubated | mg/g CHO fermented |
| Wheat bran | 8 | 6.5$^{d}$ | 52.9$^{cd}$ | 4 | 4.1$^{d}$ | 22.2$^{d}$ |
| Solka floc ® | 8 | 10.9$^{c}$ | 30.6$^{d}$ | 4 | 12.7$^{b}$ | 29.1$^{cd}$ |
| Peas | 8 | 11.9$^{c}$ | 106.0$^{b}$ | 4 | 9.5$^{c}$ | 39.6$^{bc}$ |
| Pea hull fibre | 8 | 14.4$^{b}$ | 60.0$^{c}$ | 4 | 13.6$^{ab}$ | 36.0$^{bc}$ |
| Pea inner fibre | 8 | 18.5$^{a}$ | 133.9$^{a}$ | 4 | 15.6$^{a}$ | 62.6$^{a}$ |
| Sugar beet pulp | 8 | 14.7$^{b}$ | 79.3b$^{c}$ | 4 | 12.2$^{b}$ | 43.4$^{b}$ |
| Flax seed meal | 8 | 7.6$^{d}$ | 72.2$^{c}$ | 4 | 6.3$^{d}$ | 37.0$^{bc}$ |
| Corn DDGS | 8 | 5.6$^{d}$ | 78.3b$^{c}$ | 4 | 5.2$^{d}$ | 40.1$^{bc}$ |
| SEM | | 0.86 | 7.53 | | 0.82 | 2.98 |
| P-Value | | <0.001 | <0.001 | | <0.001 | <0.001 |

[1] N[1] . number of observations in fermentation
* DM, dry matter; CHO, fermentable carbohydrate (NSP + starch)
* Means with different superscripts within the columns are significantly different (P < 0.05)