Starch Kinetics and Fibre Fermentation of Peas in Pigs

P. Leterme, R. Premkumar, and J.F. Patience

SUMMARY

The digestible energy content of peas in pigs is variable but not explained by their chemical composition. Laboratory techniques that mimic the digestive and fermentative processes in the pig's digestive tract were used here to try to find an explanation. The results showed a wide range of variation in starch hydrolysis in the small intestine but no variation in fibre fermentation in the large intestine between pea varieties grown in different conditions. Moreover, no correlations were established either between the chemical composition and the rate of starch hydrolysis or between starch hydrolysis and the digestible energy content.

INTRODUCTION

The digestible (DE) and net energy (NE) content of peas in pigs is very variable and that variability mainly depends on genetic and environmental factors. On the contrary, it can hardly be explained by differences in chemical composition (see other article in the present report). In order to find out an explanation, other factors such as the rate of starch hydrolysis in the small intestine or the rate of fibre fermentation in the large intestine were investigated here and the results were correlated to the DE content of the peas and their chemical composition.

MATERIALS AND METHODS

Different pea samples were collected in farms from Alberta and Saskatchewan in 2006. In order to mimic the digestive processes in the upper part of the intestines, the samples were first treated with pepsin (proteolytic enzyme of the stomach), pancreatic enzymes (mixture of enzymes from the pancreas, including an amylase) and a dextrinase (enzyme that hydrolyses small chains of glucose). The kinetics of starch hydrolysis was established for each variety by measuring the concentration in glucose of the solution. The pea residues were then isolated by filtration and incubated at 39 °C for 48h in a solution containing minerals and bacteria collected from pig large intestines. The rate of fibre fermentation was obtained by measuring the gas production generated by the carbohydrate fermentation. The values of DE and the pea chemical composition used for the correlations were obtained in another study (see other article in the present report).

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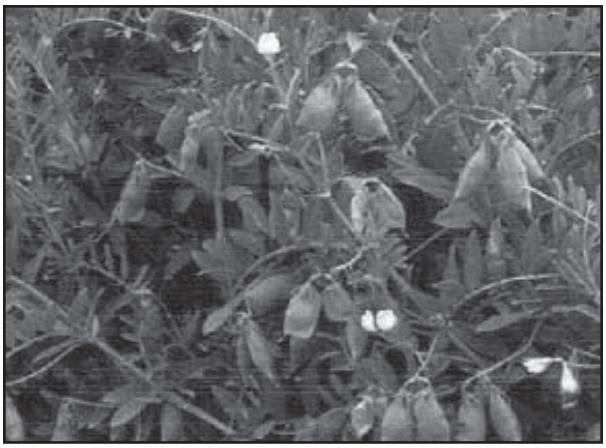
RESULTS AND DISCUSSION

Figure 1 illustrates the rate of starch hydrolysis obtained from 15 different pea varieties, as compared to corn starch. After 2h of incubation, important differences were already observed between varieties and these differences remained until the end of the incubation (6h). The final rate ranged from 70 to 92%. The reasons for



that high variation are not clear. All the varieties have the same quality of starch (amylose/amylopectin ratio and starch granule size and shape). Within the cells, the starch granules are mixed together with protein bodies (storage proteins). Starch hydrolysis will thus also depend on the rate of hydrolysis of the protein bodies and of the disruption of the cell walls. The disruption of the latter mainly depends on the grinding conditions. Previous work by the authors (J. Agric. Food Chem. 1998, 46, 1927) has shown that some cells are not disrupted even after fine grinding (< 1 mm) in lab conditions, which was the case here.

Whatever the reason can be, the question is to know if starch digestibility can be predicted and/or if there is a relationship between the latter and DE content or with the chemical composition.

The relationship between the NDF content and the rate of starch hydrolysis was low and not significant ($r = -0.48$; $P > 0.05$). The relationship with the ADF fraction was even lower ($r = -0.22$). The relationship with DE was not better ($r = -0.30$). Moreover, a negative relationship was not expected since starch is a net contributor of DE.

The variability between pea varieties in fibre fermentation was lower than that observed for starch hydrolysis (Figure 2). Fermentation was extremely fast and important: about 90% of the fibre carbohydrates were already fermented after 24h. The indigestible dietary compounds typically spend more than 40h in the large intestine. Their contribution to the total DE or NE content of the peas in the form of short-chain fatty acids is significant but must still be evaluated.

It can be suggested that the high variation in DE content of pea varieties grown in Western Canada can be ascribed more to variations in starch hydrolysis in the pig small intestine than to variations in pea fibre fermentation. Research continues at Prairie Swine Centre to understand the factors responsible for differences in starch hydrolysis and how these differences could be reduced. In particular, the effect of processing (grinding and pelleting) will be evaluated.

IMPLICATIONS

The variation in nutritional value observed between pea samples grown in different conditions seems to be related to the kinetics of starch hydrolysis in the pig small intestine but not to the rate of fibre fermentation in the colon. Further studies at Prairie Swine Centre will evaluate the consequences of processing (pelleting and grinding) on those parameters and on the DE contents of peas in pigs.

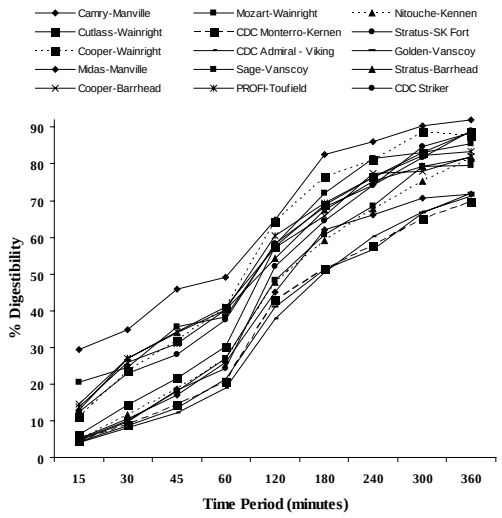


Figure 1. Kinetics of pea starch hydrolysis in the pig small intestine

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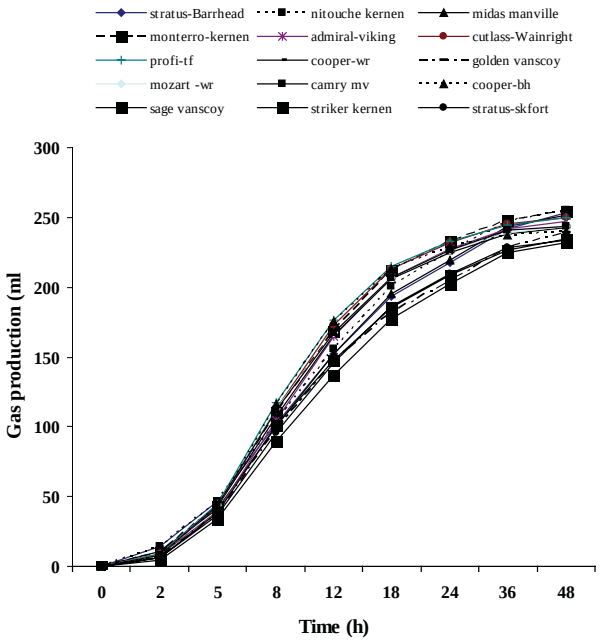

Figure 2. Kinetics of pea fibre fermentation in the pig large intestine.