

# Novel Swine Feeding Programs to Enhance Competitiveness and Pork Differentiation: Feedstuffs and Carbohydrates

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## ■ Introduction

This topic is broad. Therefore, the emphasis is on parts of the program funded by the Canadian Swine and Research Development Cluster and industry partners that is focussed on changes in diet formulation that: 1) alter the profile of feedstuffs to less grain and more co-products from processing of crops or 2) alter the profile of dietary carbohydrates (starch and fibre). These two parts are linked: the changes in feedstuffs by default will change dietary profile of carbohydrates to more fibre and less starch. Dietary feedstuffs play an important role in feed costs and thus competitiveness. Functional characteristics of carbohydrates, digestion patterns of starch and fermentation patterns of fibre, play an important role in value-added attributes such microbial profile in the gut and thus intestine health; however, such characteristics are not used widely yet in feed formulation.

## ■ Dietary Feedstuffs

The increase in price of grains and increasing processing of crops in Canada has gradually reduced dietary content of feed grains and increased the content of co-products from crops. A major component of the increase in crop processing is increased canola crushing (Beltranena & Zijlstra, 2012, these proceedings) but also processing of flaxseed, ethanol production or flour milling, etc. increases the availability of co-products. General trends by feeding diets that contain more co-products and less grain are that growth performance of pigs as measured by average daily gain (ADG), feed intake (ADFI), and feed efficiency as not necessarily reduced (**Table 1**). However, co-products contain more fibre that stimulates development of visceral organs; therefore, carcass weight at identical slaughter weight declines (**Table 1**). If co-products contain residual oil, fatty acid profile in pork products can be

altered. For example, increasing dietary flax co-products increases the content of  $\alpha$ -linolenic acid, an omega-3 fatty acid, in jowl fat (**Table 1**). Therefore, co-products that contain fat may provide opportunities to alter pork fat quality.

**Table 1. Growth performance, carcass weight and  $\alpha$ -linolenic as percentage of jowl fatty acids of grower-finisher pigs fed diets containing increasing levels of dietary co-products including from flax<sup>1</sup>**

Variable	Co-products (%)					Pooled SEM	P value
	2	12.5	25	37.5	50		
ADG, kg/d	1.06	1.07	1.05	1.05	1.04	0.02	0.182
ADFI, kg/d	3.14	3.16	3.13	3.11	3.12	0.04	0.337
G:F	0.337	0.341	0.338	0.338	0.334	0.005	0.569
Carcass, kg	99.8	100.1	100.0	98.8	99.0	0.4	0.012
$\alpha$ -Linolenic, %	3.61	2.44	4.78	6.63	7.82	0.85	<0.001

<sup>1</sup>Adapted from Jha et al. (2011).

## ■ Enzymes and Co-Products

Co-products are normally higher in fibre than cereal grain. Increased fibre is known to reduce energy digestibility (Zijlstra et al., 1999). Hence, a logical thought is that co-products provide opportunities for fibre-degrading enzyme to improve nutrient digestibility (Zijlstra et al., 2010). Indeed, fibre-degrading enzymes improve nutrient digestibility of co-products from flour milling (Nortey et al., 2008; Shrestha, 2011; **Table 2**). However, such improvements do not appear to be consistent across feedstuffs such as DDGS, a difference that might be related to modification of fibre during the specific production process (Yáñez et al., 2011).

**Table 2. Impact of fibre-degrading enzymes on apparent energy digestibility of grower pigs fed a diet with wheat or wheat plus wheat millrun<sup>1</sup>**

Energy digestibility, %	Wheat		Millrun		Pooled SEM	P value Diet
	C	E	C	E		
Ileal	79.4 <sup>a</sup>	80.4 <sup>a</sup>	70.6 <sup>c</sup>	74.2 <sup>b</sup>	0.90	<0.001
Total tract	87.7 <sup>a</sup>	89.0 <sup>a</sup>	74.4 <sup>c</sup>	78.0 <sup>b</sup>	0.53	<0.001

<sup>1</sup>Adapted from Shrestha et al. (2011).

## ■ Dietary Carbohydrates

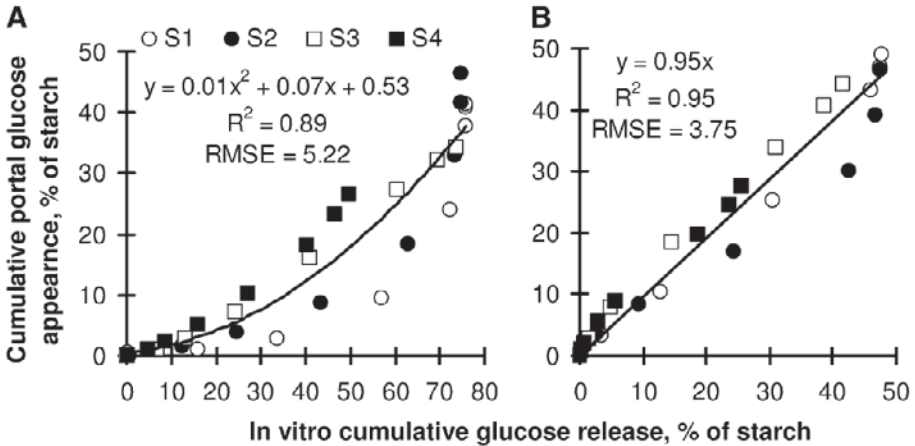
A novel aspect in describing the energy value of feedstuffs for swine is a description of the kinetics of breakdown of carbohydrates, the main energy-contributing macronutrient. For starch, the kinetics of digestion is important, whereas for fibre the kinetics of fermentation is important.

### Starch Digestion

Among macronutrients, starch content is generally the largest in swine diets and starch is thus an important contributor of energy. Starch, via kinetics of glucose absorption in the small intestine, also influences production of gut hormones and pancreatic insulin and thereby protein and fat deposition and feed intake responses (Van Kempen et al., 2007). Starch that is resistant to digestion might be fermented and thereby influence gut health.

In vitro (lab-based) glucose release reflects in vivo (animal-based) starch digestion and therefore the kinetics of in vivo glucose absorption in swine. To test, in vitro starch digestion was compared to portal glucose appearance in pigs (Van Kempen et al., 2010). Portal catheterized pigs (Hooda et al., 2009) were fed diets containing 70% purified starch ranging from slowly to rapidly digestible, and net glucose flux was measured. After a pepsin-pancreatin-amyloglucosidase hydrolysis, glucose release was measured in vitro. Data were modeled after correction of in vitro glucose release for gastric emptying.

**Figure 1.** Prediction of modeled net portal glucose appearance in pigs fed 4 starch diets using in vitro cumulative glucose digestion (A) and in vitro cumulative glucose digestion corrected for predicted gastric emptying (B). From van Kempen et al. (2010).



In vitro glucose release and in vivo net portal glucose flux had a strong linear relation (**Figure 1**;  $R^2 = 0.95$ ; Van Kempen et al., 2010; **Figure 1**). In vitro starch digestion kinetics can thus accurately predict portal glucose appearance.

## Fibre Fermentation

Fibre may play an important role in improving gut health. The hypothesis is that gas produced and fermentation kinetics during in vitro fermentation reflects the same kinetics as in vivo fermentation of fibre in the large intestine of swine. Fibre in concentrated form such as oat  $\beta$ -glucan has a prebiotic effect in pigs (Metzler-Zebeli et al., 2010), similar to natural  $\beta$ -glucan (Pieper et al., 2009). In vitro fermentation characteristics have been measured in an array of feedstuffs (Williams et al., 2005). The fermentation characteristics of hull-less and hulled barley, oat, field pea fibre and DDGS samples have been studied in vitro and in vivo (Jha et al., 2010a,b; 2011a,b,c) and had similar fermentation characteristics and metabolites produced. After a pepsin-pancreatin hydrolysis, the ingredients were incubated in a buffer solution containing minerals and pig feces as inoculum. The accumulated gas production, proportional to the amount of fibre fermented, was measured for 48 h and modeled. The results indicated that better fermentable substrates have a higher rate of degradation and produce more gas and beneficial metabolites such as SCFA and lactic acid than less fermentable substrates. In conclusion, inulin, hull-less barley and field pea fibre have a better fermentation potential than other feedstuffs evaluated to stimulate large intestine fermentation and therefore modulate gut microbiota and gut health.

## Future

The principle that starch digestion and fibre fermentation profile have an impact on intestine microbial profiles and gut health is clear. These profiles must be related to feed formulation and future crop development.

## ■ Conclusions

The pork industry in western Canada remains under severe competitive pressure, in part due to high feed costs. Dietary co-products may be part of a package of solutions to improve competitiveness. Increasing co-products increases dietary fibre content that might be managed with fibre-degrading enzymes. Dietary carbohydrates fibre and starch possess a range of fermentation and digestibility patterns.

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