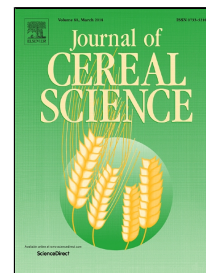


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Apparent Amylase Diffusion Rates in Milled Cereal Grains Determined *in vitro*;
Potential Relevance to Digestion in the Small Intestine of Pigs

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1 Apparent Amylase Diffusion Rates in Milled Cereal Grains Determined *in vitro*; 2 Potential Relevance to Digestion in the Small Intestine of Pigs

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8 Abstract

9 Starch digestion in grain particles depends on the diffusion of amylase into the particles.
10 Enzyme diffusion rate (EDR) is influenced by grain structure, and may be key in determining
11 the extent of grain digestion in the small intestine. EDR values of sixteen grains (wheat,
12 barley and sorghum) were compared with their ileal digestibility from pigs. Five fractions of
13 each hammer-milled grain were digested *in vitro* under conditions mimicking monogastric
14 digestion to obtain apparent amylase diffusion coefficients (ADC) from the inverse square
15 dependence of rate-coefficients on particle sizes. The ADC values in sorghum were lower
16 than in wheat and barley for samples grown under standard conditions. However, grain
17 differences such as sprouting or immaturity, resulted in higher ADC values that were
18 relatable to *in vivo* digestibility. Grain fibre had large effects on ileal digestibility, with an
19 apparent optimum neutral detergent fibre level of 10-20% that resulted in maximum starch
20 ileal digestibility. It is inferred that the true potential for efficient feed utilisation depends
21 both on fast grain digestion, and on an appropriate rate of passage, so that small intestine
22 residence time is long enough for starch in grains to be digested fully.

23 Key words: Apparent diffusion coefficient; ileal digestibility; starch-digestion; particle size.

24 Abbreviations: EDR – Enzyme diffusion rate, ADC – Apparent diffusion coefficient, PSD – Particle size
25 distribution(s), IDE – Ileal digestible energy, FDE – Faecal digestible energy, GI – glycaemic index, NDF –
26 neutral detergent fibre, SI – small intestine, LI – large intestine.

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28

29 1. Introduction

30 Cereal grains play a vital role in nutrition for many animals including humans and pigs. The
31 major component of cereal grains is starch, with its nutritional value being determined by its
32 site of digestion (Black, 2016). Starch that is completely digested before the end of the small
33 intestine (SI) provides the maximum amount of glucose from the grain to support growth in
34 pigs. However, complete digestion of starch can have negative consequences for human
35 health by providing excess energy and increasing risks of diabetes and obesity. Starch that is
36 not digested by the ileum (end of the SI) passes to the large intestine where it is fermented by

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