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Effects of fermented and extruded wheat bran on total tract apparent digestibility of nutrients, minerals and energy in growing pigs

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ABSTRACT

A pig digestibility trial was conducted to investigate the effects of fermentation or extrusion of wheat bran included in a basal diet on coefficients of total tract apparent digestibility (CTTAD) regarding dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE), starch, energy (GE), phosphorus (P) and calcium (Ca). In the experiment, 9 growing pigs were allocated to a 3 × 3 Latin square design to measure the CTTAD of the basal diet containing different modified wheat bran variants, and therefore to demonstrate relative differences in the CTTAD among the diets as a result of wheat bran modification. The wheat bran was used in native form (NWB), as fermented bran ensiled with *Lactobacillus paracasei* and *Lactobacillus plantarum* (FWB) and as extruded wheat bran (EWB). Wheat bran variants were included at 200 g kg^{-1} in a phosphorus deficient basal diet. The obtained results show that the CTTAD of DM was increased when feeding the diet with FWB (+2%, $P<0.05$) instead of NWB (0.87). Likewise the CTTAD of OM was also increased with FWB (+2%, $P<0.05$), compared to NWB (0.88). Also the CTTAD of CF was improved with FWB and EWB (+9%, $P<0.05$), related to NWB (0.58). The CTTAD of ash was improved with FWB (+14%, $P<0.05$) compared to NWB (0.60). Correspondingly, the CTTAD values of P and Ca were also elevated when feeding the FWB diet. P-digestibility was increased in the FWB feeding group compared to those groups fed with NWB (+35%, $P<0.05$) and EWB (+53%, $P<0.05$). Regarding the Ca digestibility, similar results were obtained ($P<0.05$). While the CTTAD of energy was increased in the FWB (+3%, $P<0.05$) and EWB (+2%, $P<0.05$) feeding groups compared to that of NWB (0.85), the N-balance and the CTTAD of starch were not affected by the treatments. Nevertheless, the CTTAD of EE was enhanced in the FWB treatment group (+40%, $P<0.05$), and was also improved by extrusion (+30%, $P<0.05$) compared to the NWB (0.50) treatment. In conclusion, fermented and extruded wheat bran exert some significant influence on the apparent total tact digestibility of several essential nutrients,

Abbreviations: NWB, native wheat bran; FWB, fermented wheat bran; EWB, extruded wheat bran; CTTAD, coefficient of total tract apparent digestibility; EDDM, *in-vitro* enzymatic digestibility of dry mass; SME, specific mechanical energy; IDF, insoluble dietary fiber; SDF, soluble dietary fiber; CFU, colony forming units.

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minerals and energy when included in a basal diet, whereby fermentation seems to be the more potent strategy, as positive effects on the CTTAD of P and Ca could only be observed in the feeding group with FWB.

1. Introduction

Wheat can be regarded as the most frequently produced grain worldwide, after corn. However, besides its primary aim, the fabrication of flour, the agricultural production of wheat generates two major by-products: straw and bran. The outer protection layers of the wheat kernel are called bran, and represent about one fifth of its mass. They are separated from the kernel during the milling process. Today, besides its so far limited use in the food area, wheat bran has mainly been used in animal feeding (Rauter et al., 2010). It contains a high amount of total dietary fiber (451 g kg^{-1}). Other relevant compounds found in bran are protein (160 g kg^{-1}), fat (47 g kg^{-1}), available carbohydrates (177 g kg^{-1}) and minerals (61.5 g kg^{-1}) (Souci and Kirchhoff, 2008). Due to its valuable composition, wheat bran has been successfully introduced as a feed component for monogastric animals and is already used as ingredient in pig diets (Huang et al., 1999; Mwesigwa et al., 2013; Schedle et al., 2008; Wesendonck et al., 2013). However, its application in animal feeding shows some limitations due to a high amount of insoluble fiber which is very resistant to natural degradation processes in the gut (Noblet and Le Goff, 2001). It is well known that an increasing fiber content negatively correlates with digestibility and hence the energy content of the feed stuff (Dégen et al., 2009; Le Goff and Noblet, 2001). Not only the kind of fiber offered, but also the particle size, which can be modified by the processing technology, significantly influences the digestibility and therefore the digestible and metabolizable energy in growing pigs (Wesendonck et al., 2013).

Among the methodologies used for the modification of feed materials, extrusion technology is known to exert some major influence on the nutrient absorbance in the gut of pigs (mainly to break down starch), but strongly depends on the botanical source (Sun et al., 2006). This technology has been previously used to modulate the functionality of wheat bran, especially for the reduction of insoluble dietary fiber, either alone or in combination with enzymatic hydrolysis (Gualberto et al., 1997; Zhang et al., 2011). Although this technology is not capable of sufficiently destroying the polymer structure of dietary fiber, the mechanical and thermal energy input during the extrusion process aids in the partial transformation of the insoluble fraction into water-soluble polymers due to melting or breaking down connection keys (Hou et al., 2003). Alternatively, the method of ensiling is a traditional preservation method of plant materials and by-products utilizing lactic acid fermentation under anaerobic conditions (Ashbell and Weinberg, 2006; Gollop et al., 2005). Hence, lactic acid bacteria convert water-soluble carbohydrates into organic acids and thereby also influence nutrient as well as mineral digestibility in growing pigs (Humer et al., 2013). Taking into account these previous experiments, the aim of the present study was to investigate, how wheat bran could be modified by different treatments in order to enhance its digestibility in pigs when included into a basal diet.

2. Material and methods

2.1. Diets and raw material

For the experiment a basal diet was formulated based on potato starch, beet pulp, potato protein, egg white powder, cellulose and soy oil (Table 1). Hence the content of digestible phosphorus was adjusted suboptimal to meet the recommendation of the Society of Nutrition Physiology (GfE, 1994). Two hundred grams of wheat bran were added in different forms (native, fermented and extruded) to 800 g of feed. The raw material had a moisture of 103 g kg^{-1} and originated from

Table 1
Composition of the test diets (dry matter basis).

Ingredient	Amount
Potato starch (g kg^{-1})	514.4
Wheat bran (g kg^{-1})	200.0
Beet pulp, molasses added (g kg^{-1})	118.4
Potato protein (g kg^{-1})	68.0
Egg white powder (g kg^{-1})	52.0
Cellulose (g kg^{-1})	17.6
Soy oil (g kg^{-1})	13.6
Calcium carbonate (g kg^{-1})	6.4
Premix[a] (g kg^{-1})	9.6

[a] Per kg feed: L-Lysine-HCl (1.5 g), L-tryptophan (0.5 g), Na (1.5 g), Mg (0.3 g), Fe (50 mg), Cu (4 mg), Zn (50 mg), Se (0.2 mg), vitamin A (2000 I.U.), vitamin D2 (200 I.U.), vitamin E (11 mg), vitamin K3 (0.1 mg), thiamine (1.7 mg), riboflavin (2.5 mg), pyridoxine (3 mg), biotin (0.01 mg), cyanocobalamine (0.01 mg), nicotinic acid (15 mg), pantothenic acid (10 mg), choline chloride (350 mg).