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Comparison of the nutritional value of diets containing differentially processed blue sweet lupin seeds or soybean meal for growing pigs

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ABSTRACT

The current study aimed at determining the influence of both grinding intensity and expanding of blue sweet lupin (BSL) on the nutritive value of complex diets for growing pigs as compared with soybean meal-based diet. Four diets were formulated based on soybean meal (SBM, 21% in the diet) or differentially treated BSL (31% in the diet). Treatments of BSL were: ground to pass a 3 mm (CBL), 1 mm (FBL) sieve or ground to 1 mm and subsequently expanded (EBL). Twelve PIC x Danbred pigs (initial BW 20 kg), fitted with a T-cannula at the terminal ileum were used in an incomplete 3 × 4 Latin square design. Coefficients of ileal apparent digestibility (CIAD) and total tract apparent digestibility (CTTAD) of proximate nutrients and non-starch polysaccharides (NSP), and standardized ileal digestibility (SID) of amino acids were determined. The CIAD of organic matter, ether extract and starch was higher ($P < 0.05$) in SBM diet compared to CBL diet but similar to FBL and EBL diets. The CTTAD of CP was lower ($P < 0.05$) in CBL and FBL diets compared to SBM diet. The CTTAD of total NSP and their constituents (arabinose and galactose) was higher in all diets containing lupins. In addition, CTTAD of glucose and both, CIAD and CTTAD of glucuronic acids was the highest in EBL diets. The SID of methionine was higher in FBL compared to SBM diet. Similarly, SID of arginine was higher in FBL and EBL diets compared to CBL and SBM diets. The data show that fine grinding intensity and expander treatment can improve the digestive utilization of diets with BSL in growing pigs—at least to similar level as with SBM diet.

Abbreviations: AA, amino acids; BSL, blue sweet lupin; CBL, coarsely ground blue lupin; CF, crude fiber; CIAD, coefficient of ileal apparent digestibility; CP, crude protein; CTTAD, coefficient of total tract apparent digestibility; DM, dry matter; dMEAN, discrete mean particle size; EBL, expanded blue lupin; EE, ether extract; FBL, fine ground blue lupin; ME, metabolizable energy; NSP, non-starch polysaccharides; OM, organic matter; SBM, soybean meal.

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1. Introduction

Blue sweet lupins (BSL) are considered as a possible alternative for soybean meal in diets for monogastric animals (Van Barneveld, 1999; Jezierny et al., 2010). However, despite a relatively low concentration of anti-nutritional factors such as alkaloids in modern cultivars, the use of BSL over soybean meal (SBM) in swine diets may have some limitations due to their imbalanced amino acid (AA) profile, a lower proximate nutrient and AA digestibility and putative negative interaction between the relatively high concentrations of non-starch polysaccharides (NSP) and the digestion process of other nutrients (Jezierny et al., 2010). It can be assumed that mechanical and biological processing methods can help to improve the nutritional value of lupins for pigs (Jezierny et al., 2010; De Vries et al., 2012), or even affect the nutritive value of complex diets. For example, Batterham et al. (1986) reported that a diet with autoclaved lupins (5 min at 121 °C) had no negative effect on swine performance. More recent studies have shown that reduction of the particle size (Kim et al., 2009), germination (Chilomer et al., 2013) or hydrothermal treatment (Yang et al., 2007) can improve the ileal and total tract nutrient digestibility of lupins in pigs. Despite the above-mentioned information regarding the nutrient digestibility of differentially processed BSL, less is known regarding the breakdown of NSP structures and the resulting proximate nutrient, amino acid and NSP digestibility in complex diets along the pig gastrointestinal tract.

Therefore, the current study was performed to determine the effect of grinding intensity and hydrothermal (expander) treatment of BSL on the nutritive value of complex diets in growing pigs as compared with diet containing SBM as a commonly used standard.

2. Material and methods

2.1. Diets, animals and sampling

Blue sweet lupins var. Borlu was grown under organic farming conditions in north-east Germany in 2014 and contained 33 g kg^{-1} crude ash, 313 g kg^{-1} crude protein, 43 g kg^{-1} ether extact, 139 g kg^{-1} crude fiber, and 471 g kg^{-1} nitrogen-free extracts. Dry lupin seeds were processed in a hammer mill passing either a 3 mm sieve (coarse ground blue lupin; CBL), a 1 mm sieve (fine ground blue lupin, FBL), and ground to pass a 1 mm sieve and subsequent expanding (expanded blue lupin, EBL). For expander treatment, ground lupin seeds were introduced into a modified single screw extrusion-cooker TS-45 (ZMCh Metalchem Gliwice, PL) and processed at 110 (section I) to 120 °C (section II). The lupins exited the expander through round 8 mm-outlet nozzles. The expanded lupins (85–90 °C) were cooled to ambient temperature within 15 min. The moisture content was reduced at 35 °C for 3 h.

Four experimental diets were formulated to meet the requirements of growing pigs (NRC, 2012). The diets were based on wheat and barley and either soybean meal or lupin as main protein source (Table 1). The control diet (SBM) contained 210 g kg^{-1} soybean meal. For diets containing differentially processed lupins (310 g kg^{-1}), wheat and barley were also partially replaced. However, the final diets containing lupin had slightly lower crude protein but higher ME contents as compared to the SBM control diet (Table 1).

All procedures involving animal handling, surgery and sampling were approved by the Third Local Ethics Commission in Warsaw, Poland. Twelve PIC x Danbred castrated male pigs with an initial body weight of 20 kg were surgically fitted with a T-cannula (18 mm diameter) at the terminal ileum, approximately 10 cm anterior to the ileo–caecal valve as described by Horszczaruk et al. (1972). During the first ten days after cannulation, the animals were fed with increasing quantities of the basal diet. The recovery period was followed by 7-day periods of feeding the experimental diets in an incomplete Latin square design of 3 periods x 4 diets. During the feeding experiment animals were housed individually in metabolic cages with a slatted floor and plexiglas walls in a thermally controlled room (22–23 °C) and had *ad libitum* access to water. Pigs were offered the experimental diets in mesh form at 5% of BW, corresponding to about 90% of the approximate *ad libitum* intake. Animals were fed twice daily at 8.00 and 20.00 h with equal portions of meal mixed with water (1:1). During the last three days of the period, ileal digesta were collected from 8.00 to 20.00 h (between meals) using bags attached to the cannulas. The bags were changed approximately every hour and their content was immediately frozen at −20 °C. Faecal samples for determination of total tract digestibility were taken on day 4 over a time period of 12 h, immediately after voiding. After each collection period, samples were thawed, pooled per animal within each experimental period and subsequently freeze dried.

2.2. Feed and digesta nutrient analysis

Particle size was determined in processed lupins and complete diets by dry sieving as described previously (Röhe et al., 2014). Briefly, a representative 100-g sample of each diet sample was passed through a sieve stack for 10 min (Analysensiebe, Retsch GmbH, Haan, Germany) consisting of 9 sieves with screens of different mesh sizes (4, 2.5, 2.0, 1.6, 1.25, 1.0, 0.63, 0.40, and 0.15 mm). The discrete mean particle size (dMEAN) was calculated as described previously (Fritz et al., 2012). The extract viscosity of the diets was determined using a rotary viscosimeter (Brookfield Cone/Plate LVDL-II+, Brookfield, Lorch, Germany) as described previously (Vahjen et al., 2007).

Crude ash, crude protein (CP), crude fiber (CF), and ether extract (EE) in the feed and in the digesta samples were determined using standard procedures according to Naumann and Bassler (2004). The calcium content of the feed was determined