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Effects of rapeseed variety and oil extraction method on the content and ileal digestibility of crude protein and amino acids in rapeseed cake and softly processed rapeseed meal fed to broiler chickens

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ABSTRACT

We examined the effects of rapeseed variety and oil extraction method on crude protein (CP) and amino acid (AA) content in rapeseed co-products, and determined their coefficient of apparent (AID) and standardised ileal digestibility (SID) in broiler chickens. Sixteen rapeseed samples were de-oiled; four were cold-pressed producing rapeseed cake (RSC) and twelve were mild processed and hexane-extracted producing soft rapeseed meal (SRSM). One batch of the variety Compass, grown on the same farm, was processed using both methods obtaining Compass RSC and Compass SRSM. DK Cabernet rapeseed variety, grown on three different farms, was used to produce two SRSM batches and one RSC batch. All rapeseed co-products were ground through a 4 mm screen and mixed into semi-synthetic diets at a level of 500 g/kg. Day-old Ross 308 male broilers were fed a commercial diet for 14 days. A total of 96 pairs of birds were then allotted to 1 of 16 dietary treatments ($n = 6$) and fed a test diet for 8 days. Birds were then culled allowing removal of ileal digesta from Meckel's diverticulum to the ileal-caecal junction. Digestibility of CP and AA was determined using titanium dioxide as an inert marker. The SRSM samples had an increased content of CP (419–560 g/kg DM) compared to RSC samples (293–340 g/kg DM). Both AID and SID of lysine, and SID of arginine, histidine and threonine were greater in Compass RSC compared to its SRSM counterpart ($P < 0.05$). However, AID and SID of AA did not differ in both DK Cabernet SRSM, cultivated in two different farms ($P > 0.05$). The SID of lysine was on average 0.03 units greater ($P < 0.001$) in RSC than in SRSM. The SRSM produced from variety PR46W21 showed similar or greater AID and SID of individual AA than the RSC from four other rapeseed varieties. It is concluded that selection of rapeseed varieties, and extraction method have a potential to deliver high-protein dietary ingredients with a good digestibility value.

Abbreviations: AA, amino acid; AID, coefficient of apparent ileal digestibility; Arg, arginine; *B. napus*, *Brassica napus*; CP, crude protein; DM, dry matter; DMI, dry matter intake; FI, feed intake; GLS, glucosinolates; His, histidine; Ile, isoleucine; Leu, leucine; Lys, lysine; Lys:CP, lysine:crude protein ratio; M + C, methionine and cysteine; NDF, neutral detergent fibre; Phe, phenylalanine; RSC, rapeseed cake; RSE, rapeseed expeller; RSM, rapeseed meal; SBM, soybean meal; SEM, standard error of the difference mean; SID, coefficient of standardised ileal digestibility; SRSM, soft rapeseed meal; TAA, total amino acids; Val, valine.

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1. Introduction

The strong dependence of the British livestock sector on imported protein-rich feeds such as soybean meal (SBM), is prompting investigations into the nutritional value of home-grown protein alternatives for animal production. As the European Union is the greatest producer of *Brassica napus* (*B. napus*) rapeseed worldwide (USDA, 2015), rapeseed co-products are of considerable interest as a protein source in animal diets. Compared to SBM, rapeseed meal (RSM) contains considerably less lysine but more sulphur-containing amino acids (AA) (Khajali and Slominski, 2012). The indices for the quality of rapeseed protein may be as high as those of animal protein (e.g. eggs) and far higher than those of other legume or cereal sources (e.g. peas and wheat, respectively) with a high content of indispensable AA (Thompson et al., 1982; Friedman, 1996).

Rapeseed traditionally contains high contents of erucic acid, glucosinolates and fibre, but plant breeding improvement has delivered varieties of *B. napus* with low levels of erucic acid (<20 g/kg) and glucosinolates (<30 μmol/g) in defatted co-products in recent decades (Maison and Stein, 2014). These varieties are called "double-low" or "double zero" rapeseed in Europe, and "canola" in Australia and North America (Newkirk, 2009).

Rapeseed co-products are currently used as a protein ingredient in animal diets; however the nutritional value, measured by protein digestibility, varies and is often reported as being lower than that of SBM (Adedokun et al., 2008). The low digestibility of protein in rapeseed has been associated with components such as enzyme inhibitors, phenolic compounds, glucosinolates and dietary fibre (Rayner and Fox, 1976; Bell, 1993). Moreover, the nutritional value of rapeseed protein is influenced by many different factors that are closely related to the concentration of components and the processing technology employed. The concentration of components in rapeseed co-products (e.g. protein, fibre and oil) might differ considerably depending on the seed cultivars, growing conditions, harvesting time, seed storage conditions, seed drying temperature and further processing such as de-hulling, heat treatment, oil removal method and pelleting (Bell, 1993; Newkirk et al., 2003a; Liu et al., 2014).

Rapeseed co-products are commercially produced using two main de-oiling methods: hexane extraction producing RSM and cold-pressing producing rapeseed cake (RSC). Hexane extraction involves processing at a high temperature (up to 130 °C) that supports greater extraction of the oil and results in a RSM with less than 50 g residual oil/kg (Woyengo et al., 2010; personal communication, Patrick Carre). Cold-pressing involves crushing of rapeseeds without additional heat supply, delivering a virgin oil and co-products with a high residual oil content (>170 g/kg) (Leming and Lember, 2005). The majority of the crop is crushed, heat treated and then hexane extracted in large industrial complexes, whereas a small proportion of the crop is processed by cold-pressing, mainly on farms by growers or small to medium enterprises.

Mixed varieties of rapeseed are often collected and processed by hexane extraction, which produces rapeseed co-products with potentially differing AA and crude protein (CP) digestibility. Thus, commercially available rapeseed co-products vary in digestibility of AA and CP due to the variation depending on rapeseed co-product origin including cultivar and processing, but also on the level of substitution of RSM/RSC into a diet as well as animal species tested (Zhou et al., 2013; Qaisrani et al., 2014). Therefore, a lack of consistency in selection of rapeseed varieties leads to difficulties in estimation of nutritional value of rapeseed co-products in animal diets.

A recent investigation at a rapeseed pilot plant (CREOL, Pessac, France) showed that decreasing the residence time (RT) in the desolventiser/toaster during the hexane extraction led to production of RSM with a greater content and digestibility of lysine, measured in pigs (Eklund et al., 2015). The reduction of heat treatment in rapeseed processing has the potential to improve digestibility of AA in the final co-products. The aim of the present study was to compare the effects of soft processing by hexane extraction or cold-pressing of Western rapeseed varieties on content and digestibility of CP and AA in rapeseed co-products fed to broiler chickens.

2. Material and methods

2.1. Rapeseed co-products and diet formulation

Thirteen varieties of oilseed rape were grown in four South Eastern counties of the United Kingdom (UK) and harvested in 2013. Seven rapeseed varieties were grown in Cambridgeshire (Ability, Avatar, DK Cabernet, NK Grandia, PR46W21, Quartz and Sesame), three in Lincolnshire (Excalibur, Trinity, V2750L), two in Norfolk (Compass and Incentive) and one in Suffolk (Palmedor). Eleven varieties were characterised as double low varieties, of which ten were winter, and one was spring (Ability). Further diversity was derived by the inclusion of a single-low, high erucic acid oil variety (Palmedor) and a relatively new variety with high oleic and low linolenic oil composition with a high glucosinolate content (V2750L). Twelve rapeseed batches were de-fatted by mild hexane extraction producing a soft rapeseed meal (SRSM), and four batches were cold-pressed producing a RSC.

The hexane extraction was performed at a pilot plant (CREOL, Pessac, France). Each of the rapeseed batches was subjected to conditioning. The seeds were dried to a moisture content of approximately 70 g/kg in a static dryer with movable containers of 1.6 × 1.2 m surface connected to a warm air generator using air at 70 °C. Unlike standard industrial processing, the seeds were softly processed by excluding the cooking step before the pressing and heat supply during the seed crushing. After conditioning, the seeds were cold-pressed at a rate of 250 kg/h using a MBU 75 press (La Mécanique Moderne, France) with a gap between pressing each batch 20 min, in order to avoid mixing the varieties. The expeller meal was then pelletized in 6 mm pellets to prevent possible differences in percolation during the extraction. Pellets were transferred immediately