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SHORT COMMUNICATION

Pelleting increases the metabolizable energy of de-hulled sunflower seed meal for broilers

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ABSTRACT

The study examined the effects of two methods of processing de-hulled sunflower seed meal (SFM) from the same batch of sunflower seeds. Sunflower seed meal was fed to broilers as meal (MSFM) or after it had been pelleted (PSFM) at 75 °C and 360 kPa pressure to pass through a 3 mm mesh. Three diets were prepared, namely a balancer feed (BF) and two diets containing 200 g/kg MSFM or 200 g/kg PSFM. They were fed to 30 pens (two birds each) with male Ross 308 broilers, from 8 to 21 days old, following randomization. Data were analysed by ANOVA. Two pre-planned orthogonal contrast tests were performed to compare overall differences between the diets containing SFM and BF and between diets containing the MSFM and PSFM. The BF had a very different nutrient composition from the complete feeds containing SFM so, as expected, there were differences in growth performance and nutrient retention. The diet containing PSFM had greater apparent metabolizable energy corrected for N retention (AMEn) and dry matter retention (DMR) than that containing MSFM. The use of the substitution method showed the PSFM had AMEn that was 18% greater than the MSFM (8.79 vs 7.47 MJ/kg DM). Under the conditions of the current study, incorporating PSFM in a mash broiler feed increased dietary AMEn compared with the same feed containing MSFM. Further studies are needed to identify whether the benefits of pre-pelleting SFM remain after this product has been incorporated in complete pelleted broiler feeds.

Keywords: high protein sunflower meal, ileal nitrogen digestibility, growth, nutrient retention.

In many countries, the poultry industry relies heavily on imported soybean meal (SBM) as a protein source in feed. Although soybean is a major oil crop that is planted on a rapidly expanding number of hectares, the encroachment of soybean plantations into forests is contributing to deforestation and climate change (Liu & Dai, 2020). Demand for sustainable feed ingredients has increased recently, motivating the development of alternative protein sources for modern poultry production (Abdulla *et al.,* 2016; 2020; Whiting *et al.,* 2017, Watts *et al.,* 2019). Sunflower *(Helianthus annuus)* is also grown as an oilseed in temperate and subtropical climates worldwide. High-protein sunflower meal (SFM) is a by-product of oil production (Kaya *et* al., 2016). The high dietary fibre content, low metabolizable energy (ME) and lysine contents, and presence of chlorogenic acid in SFM are the main challenges to its use in poultry diets (Alagawany *et al.,* 2017; Ditta & King, 2017). However, recent advances in engineering have improved the de-hulling process to allow further processing of SFM to produce a high-protein product with a crude protein content greater than 40% and a crude fibre content lower than 10% (Waititu *et al.,* 2018; Chobanova, 2019; Karkelanov *et al.,* 2020). After production, the SFM is usually in the form of a very fine meal, which may increase its bulkiness and make it difficult for transportation. To alleviate the problem, SFM is often pelleted. Pelleting also creates opportunities to use materials that are unpalatable, difficult to handle, and that vary in density to create uniform and easy to handle pellets. However, pelleting involves an increase in temperature and pressure, which may further break down the cell structure of the sunflower seed meal (and provide greater accessibility of nutrients that were previously encapsulated within the endosperm sub-aleurone) to digestive enzymes and release more energy and nutrients to the chickens (Abdollahi *et al.,* 2013; Pirgozliev *et al.,* 2016). Information about this comparison is scarce. The objective of the study was to compare the impact of feeding two de-hulled SFM samples in a complete diet, one fed as a meal (MSFM) and the other pelleted (PSFM), on dietary apparent metabolizable energy corrected for N retention (AMEn), retention of dry matter (DMR) and nitrogen (NR), and fat digestibility (FD) and ileal nitrogen digestibility (ND) coefficients. The MSFM and PSFM samples were obtained from the same batch of sunflower seeds, and diets were fed in meal form to male Ross 308 broiler chickens from 8 to 21 days old.

The study procedures were reviewed and approved by Harper Adams University Animal Research Ethics Committee (Project number 0515-201906-STAFF).

Commercial sunflower seeds (Pioneer P64LE25) harvested in 2018 were purchased from the Trakia region of Bulgaria. The two sunflower seed meals used in this study were from the same batch of sunflower seeds. All procedures were carried out in Tivatrade Ltd (Sofia, Bulgaria). In brief, the seeds were initially de-hulled until only about 50% of hulls remained, milled in a roller mill, conditioned at 3% humidity and 114 °C, and the expeller was then pressed at 105 - 114 °C and 3 - 3.5% humidity. The product of this preliminary phase contained about 10% fat, which was then hexane extracted. The resulting SFM usually contains about 37% crude protein (CP) and 0.1 - 0.5 % crude fat. The SFM was further de-hulled to reduce the fibre content and have 43 - 45% CP. During the process, including mechanical separation and milling, the SFM is in a meal form with particle sizes of which the predominant fraction is 250 microns. The SFM is usually incorporated in diets in meal form. However, to reduce bulk when transported, the SFM is further pelleted without preconditioning at 75 °C and 360 kPa to pass through a 3 mm mesh.

Prior to analyses, the SFM and basal feed samples were milled to pass through a 0.5 mm sieve (Cyclone mill twister, Retsch, GmbH, Haan). Dry matter (DM) was determined by drying the samples until they reached a permanent weight in a forced draft oven set at 105 °C (AOAC 2006, method 934.01). The Dumas combustion method (Leco FP-528 N, Leco Corp., St. Joseph, MI) was used to determine total nitrogen (N) content with EDTA as a calibration standard (AOAC 2006, method 968.06). Crude protein (CP) was calculated as N χ 6.25. The gross energy (GE) of the samples were determined by bomb calorimetry (Model 6200, Parr Instrument Co., Moline, IL) with benzoic acid as an internal standard. Acid insoluble ash was quantified following the method by Van Keulen and Young (1977). Ether extract was determined by Soxhlet extraction with petroleum ether using a Soxtec system (Foss UK Ltd.). Non-starch polysaccharides (NSP) contents in the SFM and basal feed samples were determined according to the methods of Englyst *et al.* (1994).

A control diet was formulated to meet breeder specifications (Table 1) when mixed with 200 g/kg SFM. All ingredients of this diet were ground to pass through a 5 mm screen and augmented with a feed-grade diatomaceous earth (Multi-Mite®, Wiltshire, UK) to provide 20 g/kg of acid insoluble ash. Two experimental diets were then formulated by mixing 200 g/kg of MSFM or PSFM with 800 g/kg of the control diet. The only difference between the two SFM diets was the form of the sunflower meal. The diets did not contain coccidiostat or other feed additives.

Day-old male Ross 308 broilers were purchased from a local hatchery (Cyril Bason Ltd, Craven Arms, UK). During the pre-experimental period, that is, 0 to 7 days old, birds were allocated to a single floor pen bedded with wooden shavings. Fresh drinking water and a proprietary broiler starter feed were provided ad libitum. Throughout the trial, environmental conditions and the lighting regime conformed to breeder recommendations (Aviagen Ltd., Edinburgh, UK). At eight days old, 60 healthy birds were randomly transferred in groups of two to raised floor pens (0.160 m^2 floor area) and weighed on a per-pen basis. All pens had a removable solid floor and were equipped with individual feeders and drinkers. Each of the three diets was weighed and allocated at random to ten replicate pens. At 17 days old the solid floor was replaced with a wire mesh. For the last four days of the experiment (from 17 to 21 days old) excreta was collected daily and dried immediately at 60 °C to minimise N losses. Dried excreta were quantified and milled to pass through a 0.75 mm sieve. On the final day of the experiment birds and feed were weighed to determine feed intake and weight gain during the experimental period. The birds were then stunned electrically and killed by cervical dislocation. The ileal digesta were collected, pooled into pots on a per-pen basis, and freeze dried. Chemical composition of excreta and digesta was determined as described for the feed. The AMEn of the diets and the coefficients of nutrient availability were determined (Hill & Anderson, 1958; Dei *et al.,* 2008; Abdulla *et al.,* 2016; Whiting *et al.,* 2017). The AMEn values in the two SFM samples were determined by a substitution method (Abdulla *et al.,* 2020).

Data were analysed using analysis of variance (ANOVA) in GenStat® (19^{th} edition, VSN International, Rothamstead, Hertfordshire, UK). Two pre-planned orthogonal contrast tests were performed to compare overall differences between the diets. Differences were reported as significant at P <0.05.

The experimental SFM sample contained 932 g/kg DM, 441 g/kg CP, 4 g/kg fat and 17.65 MJ/kg GE. The carbohydrates in various sugar fractions of the SFM samples and the BF, based on duplicate analyses, are presented in Table 2.

The chemical composition of the SFM, including proximate analysis and carbohydrates, was in the expected range for de-hulled SFM (Waititu *et al.,* 2018; Karkelanov *et al.,* 2020). The growth of the birds fed BF alone was included in the table so that the derivation of the substitution could be inspected. The BF had a different nutrient composition from the complete feeds containing SFM so, as expected, there were significant differences in growth performance and nutrient retention (Table 3).

Dietary AME, AMEn, DMR, NR, and fat retention (FR) coefficients were determined based on total excreta collected when the birds were between 17 and 21 days old. The ND was based on digesta collected when they were 21 days old.

The overall average AMEn for the two SFM diets was 12.87 MJ/kg DM. Using the substitution method, this indicated that the overall AMEn of the SFM was 8.13 MJ/kg DM. This estimate agreed with published reports for the metabolizable energy of de-hulled SFM (Pereira & Adeola, 2016; Waititu *et al.,* 2018; Karkelanov *et al.,* 2020). The diet containing PSFM had greater AMEn (P <0.001) and DMR *(P* =0.001) than that containing MSFM. Using the substitution method, this indicated that the PSFM had an AMEn that was 1.32 MJ/kg DM greater than the MSFM (8.79 vs 7.47 MJ/kg DM).

To reduce bulk when SFM was transported, it was pelleted at 75 °C and 360 kPa pressure to pass through a 3 mm mesh. This suggested that because of the heat and mechanical pressure applied during the pelleting, there might have been a further breakdown to the cell structure of the SFMP (Abdolahi *et al.,* 2013), thus more energy and nutrients were exposed to digestive enzymes and were available to the chickens (Pirgozliev *et al.,* 2016; Huang *et al.,* 2017). This may explain the improvement in ME and DMR, and the positive tendencies observed in growth performance and nutrient availability coefficients when feeding PSFM in comparison with MSFM. This agrees with Ditta and King (2017), who reviewed the benefits of various processing techniques, including pelleting, on the nutrient availability of SFM when fed to poultry.

The only differences observed between the PSFM and MSFM were in AMEn and DMR. The pelleting process includes some heat treatment, so a small effect on nitrogen digestibility was expected, but perhaps it was counteracted by the physical effect of processing on nutrient availability. The feeding period was too short to assess potential differences in growth performance as a result of the improvement in AMEn.

This study has shown that pelleting of SFM gives an 18% increase in its AMEn. Energy is a major cost component factor in diets of high-performance animals such as broilers. Consideration of ME in feed formulation for broiler chickens is critical to increase the efficacy of energy utilization. One of the major problems of incorporating SFM in practical broiler feed is its low ME content, therefore pre-pelleting may be an important technique to improve the acceptability of this ingredient for use in broiler diets. Research by Colovic *et al.* (2015), however, demonstrated that changes in the protein and the crude fibre contents in SFM samples and pelleting conditions could change pellet quality variables, affecting the SFM nutrient value for poultry (Abdolahi *et al.,* 2013). This experiment studied only one SFM sample, thus research is warranted that involves a variety of samples from various sunflower cultivars and produced in different plants. In this study, the SFM samples were fed as part of a mash diet. However, the vast majority of broilers around the world are fed pelleted diets, thus if milled-only SFM is incorporated in a diet that is later pelleted, the benefit from the pre-pelleting observed in the reported study is unknown. Further studies are needed to identify whether the benefits of pre-pelleting SFM remain when this product has been incorporated in complete pelleted broiler feeds.

It can be concluded that under the conditions of the current study, incorporating pelleted sunflower meal in a mash broiler feed increased dietary ME compared with the same feed containing non-pelleted sunflower meal. Further research is needed to study the impact of pelleting on the ME of whole diets containing already pelleted sunflower meal as opposed to milled only sunflower meal.

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Authors' Contributions

NK and SC conceived the idea, and VP and SPR designed the study. NK conducted the trial and collected the samples. IMW, KD and NK performed laboratory analysis. VP and SPR analysed the data and in collaboration with NK, IMW, KD and SC wrote the article.

Conflict of Interest Declaration

Authors have no conflicts of interest regarding the work reported in this article.

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