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Use of poultry pre-cooked slaughterhouse waste as ruminant feed to prevent environmental pollution

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ABSTRACT

The generation of poultry slaughterhouse waste from poultry production is not only unavoidable but the amount and kinds of waste can cause environmental problems. In the present study, the potential rumen digestion of poultry slaughterhouse waste which consists of protein-rich organic residues was evaluated. The chemical composition, amino acid profile and Cornell Net Carbohydrate and Protein System fractions of these wastes was determined. Rumen digestion of poultry slaughterhouse waste was compared with two common protein sources (fish meal and roasted soybean). Three poultry slaughterhouse waste samples were collected from industrial poultry slaughter-houses and the *in situ* degradation was done using rumen cannulated sheep. The protein (50–63%), ether extracts (18–27%) and ash (9–15.5%) contents of different poultry slaughterhouse waste samples were different ($P < 0.05$). Methionine and lysine contents were similar among different poultry slaughterhouse waste sources. Difference were observed for cystine (1.2–1.7%), threonine (1.9–2.2%), arginine (3–3.5%), leucine (3.5–4.1%) and valine (2.8–3.3%) ($P < 0.05$). Ruminal degradation rate for dry matter, organic matter and protein were different among poultry slaughterhouse waste, fish meal and roasted soybean. The degradation parameter for protein degradation was 76% for poultry slaughterhouse waste, 79% for fish meal and 98% for roasted soybean ($P < 0.05$). Results revealed that there was great variation in chemical composition, protein fractioning, and amino acid profiles of different poultry slaughterhouse waste sources. Poultry slaughterhouse waste is slowly-degraded protein in the rumen and thus can be an economical and rich source of rumen undegradable protein in ruminant nutrition. This implies that the use of poultry slaughterhouse waste in ruminant nutrition has a huge potential as a cleaner product of animal feeding and prevention environmental pollution. However, further studies are warranted to evaluate the digestibility of poultry slaughterhouse waste amino acids escaping the rumen into the intestine in ruminants and to compare the biological values for the amino acids in these waste material with common ruminant feedstuffs.

1. Introduction

The waste products from the slaughter of poultry might be useful feedstuffs for protein supplementation in ruminant diets as a cleaner product for animal feeding while safeguarding the environment (Lallo and Garcia, 1994; Knaus et al., 1998). Yoon et al. (2014) reported that the amount of nitrogen obtainable from the slaughterhouse wastes was 22.4 kg per 1000 heads of poultry

Abbreviation: PSW, Poultry slaughterhouse waste; FM, fish meal; RSB, roasted soybean; CNCPS, Cornell net carbohydrate and protein system; DM, dry matter; CP, crude protein; AA, amino acid; EE, ether extract; OM, organic matter; PBSN, phosphate buffer soluble nitrogen; NDIN, neutral detergent insoluble nitrogen; ADIN, acid detergent insoluble nitrogen; TVN, total volatile nitrogen.

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which could be an excellent biological source of nitrogen (protein) in animal nutrition. However, the use and disposal of poultry slaughterhouse wastes (PSW) is difficult because it has not been adequate characterized biologically, its potential pathogenic contents and because of its high moisture and organic matter contents.

In Iran, the waste materials from poultry slaughterhouses is about 12.6 thousand tons per year (Geshlog-Olyayee et al., 2010). In addition to the different industrial uses of livestock wastes such as biogas production (Li et al., 2016) or electricity (Billen et al., 2015), including different waste materials from the livestock industries for evaluation in animal nutrition is a worthwhile endeavor. Some of the waste materials which have been evaluated in animal diets include bone and hydrolyzed feather meal in cattle (Knaus et al., 1998); meat and bone meal in steers (Klemesrud et al., 1998); poultry litter in Friesian steers (Muia et al., 2001), slaughter-house blood in steers (Ayangbile et al., 1993) and feather meal in juvenile tench diets (González-Rodríguez et al., 2014).

Among the different animal waste materials, PSW is one of the most important rendering by-product with a high protein content for use to feed ruminants (Meeker and Hamilton, 2006). Klemesrud et al. (1998) evaluated the protein efficiency of numerous sources of PSW in growing steers and found that the protein efficiency of PSW was greater than that of meat and bone meal. Similarly, Lallo and Garcia (1994) reported that including PSW as protein substitute for soybean meal (i.e., SBM) could decrease feed costs in growing hair lambs. However, a better understanding of the chemical composition and protein degradation patterns of PSW would be very useful in improving the accuracy of formulation of animal diet (Kamalak et al., 2005; González-Rodríguez et al., 2014).

It is well known that the disappearance of feed protein in the rumen is an important aspect in ruminant nutrition in different ruminant feed evaluation systems (AFRC, 1993; NRC, 2001). Although some feeding trials have been conducted with inclusion of PSW in animal diets as previously reviewed by Jayathilakan et al. (2012), there is still insufficient information on the chemical composition, nitrogen solubility, protein fractions, and amino acid profile of this by-product. Furthermore, the comparison of PSW degradation in the rumen with common protein sources in animal nutrition is not well documented. Consequently, evaluation the chemical composition of these waste materials as well as their nutritional value would increase their use in the animal nutrition industry and reduce their negative effects on environment. In the present study, the chemical composition, protein fractionation based on Cornell Net Carbohydrate and Protein System (CNCPS), and amino acid contents of different sources of PSW were evaluated. Additionally, rumen degradation rate of PSW was compared with that of fish meal and roasted soybean to evaluate the potential of substituting common feedstuffs with this by-product in ruminant nutrition.

2. Materials and methods

2.1. Samples preparation

The PSW samples were obtained from three slaughter-houses from Tehran province, Tehran, Iran (Teyhoo; S1, Kooshan; S2 and Makian; S3) (35°41′ N 51°20′ E). Nine sub-samples were collected from each slaughter-house. The samples contained all waste materials such as blood, necks, feathers, skin and bones. However, the gastrointestinal organs were not included in the samples to avoid contamination and because of disease infection concerns. The above mentioned parts were cooked to produce PSW at a relatively high boiling temperature of 90 C°.

The samples were then evaluated for total volatile nitrogen (TVN) and total bacterial count (TBC). For the determination of TVN, 10 g of each sample was obtained and placed in the Kjeldahl distillation system and volatile nitrogen collected in a glass balloon containing boric acid 2%, methyl red and bromocresol green and consequently titrated with sulfuric acid (0.1 N) for the measurement of TVN (mg 100 g^{-1} of sample) (AOAC, 1992). The TBC was determined as described by Karaboz and Dincer (2006). The dry matter (DM) of the samples was determined by oven drying at 50–55 °C for 48 h (AOAC, 1990) and the dry samples stored for further chemical analysis.

2.2. Chemical analysis

The nine samples from each slaughterhouse were pooled and sub-sampled to make three samples per slaughterhouse. Dried PSW samples were ground through a 1 mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA), and samples analyzed for amino acids, total nitrogen, fat, ash and organic matter (AOAC, 1990). The CNCPS protein fractions of the PSW was determined according to standardized procedure of Licitra et al. (1996) at the University of Bahonar, Kerman. The B_2 fraction was calculated by difference and results are reported as CP percentage. Phosphate buffer soluble nitrogen (PBSN) was determined using the phosphate buffer. Neutral detergent insoluble nitrogen (NDIN) and acid detergent insoluble nitrogen (ADIN) were determined as the nitrogen content of the residual after neutral and acid detergent procedures. The analysis of 11 amino acids i.e. arginine, cysteine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine in three different PSW samples was performed using NIRS, FOSS 5000 Denmark at the Paya Amin Mehr Company (Tehran, Iran).

2.3. In situ experiment

Samples of PSW from three slaughterhouses was used in the *in situ* experiment. The ruminal degradation of nutrients in PSW was compared with fish meal (FM) and roasted soybean (RSB). The *in situ* experiment was conducted at Azad University (Tabriz branch), animal station center, Iran. Three rumen-cannulated male Ghezel sheep averaging BW 35 ± 2.5 kg were used in a 3 × 3 Latin square design experiment. The basal diet consisted of 50% alfalfa hay and the rest was concentrate which consisted of 35% barley plus 15% of equal mixture of three experimental treatments (i.e., FM, RSB and PSW). The animals were kept in individual cages and had free access to water. The animals were fed twice daily at 08:00 and 14:00 h. The samples were ground to pass through a 2 mm screen size (Wiley mill, Arthur H. Thomas, Philadelphia, PA). 3.5 g of samples was weighed into nylon bags with 45 μm pore size and the bags labeled with a waterproof permanent marker. Triplicate samples were incubating for 0, 4, 8, 16, 24, 36 and 48 h, before morning feeding. After incubation, bags were removed from the rumen and rinsed with cold tap water, until the rinse water remained clear. The bags were then dried at 55 °C for 48 h in a forced air oven and then weighed. Aliquots of the residuals in the bags were used for DM, OM and CP determination. The degradation profiles were calculated by the nonlinear model described by Ørskov and McDonald (1979). The effective degradability (ED) in the rumen was calculated as, $ED = a + [(b \times c)/(c + k)]$, using the NEWAY software, where "a" is the water-soluble fraction, "b" the potentially degradable fraction, "c" the rate of degradation of "b", and "k" the passage rate of the digesta out of the rumen. Different ED values were measured at different passage rates of k = 0.02, 0.05 and 0.08. The chemical analysis (%) of the PSW sample used in the *in situ* experiment was as follow; OM = 88.5, CP = 56.2, EE = 20.5 and ash = 10.8. The OM contents (%) of FM and RSB were 91.3 and 94.5, CP contents of FM and RSB were 68.9 and 38.1, and EE contents