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Effects of dietary substitution of maize silage by amaranth silage on feed intake, digestibility, microbial nitrogen, blood parameters, milk production and nitrogen retention in lactating Holstein cows

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ABSTRACT

The effect of dietary feeding amaranth (*Amaranthus hypochondriacus*) silage (AS) instead of maize silage (MS) on the feed intake, digestibility, microbial nitrogen (N), blood parameters, milk production and N retention of the lactating Holstein cows, in third lactation (140 ± 13 days in milk) with 38.9 ± 4.7 kg milk/day, was assessed in a completely randomized design. Three iso-energetic (NE_L = 6.37 MJ/kg dry matter [DM]) and iso-nitrogenous (crude protein [CP] = 164 g/kg DM) diets were formulated in which MS was replaced by different rates (0, 105 or 210 g/kg diet DM) of AS. The diets were assigned randomly to one of three groups of eight cows each in a completely randomized design for 63 days. Diets were provided as total mixed rations at 07:00 and 19:00 h. All the animals had free access to feed ensuring 100 g orts/kg of the amount fed daily. The DM intake (DMI), diet digestibility, N retention, microbial N supply (MNS), blood parameters and milk yield and composition were determined using standard procedures. Data were analysed as a mixed model using the PROC MIXED of SAS. The values for DMI, DM digestibility, retained N, MNS, blood concentrations of glucose, urea-N, non-esterified fatty acids, nitrate, nitrite, milk yield and milk fat in the cows fed with the diet without AS were 24.3 kg/d, 633 g/kg, 47.0 g/d, 306 g/d, 64.8 mg/dL, 14.9 mg/dL, 0.303 mmol/L, 8.53 μg/mL, 0.167 μg/mL, 36.9 kg/d and 33.8 g/kg, respectively. The DMI, diet digestibility, MNS and milk yield were greatest (P<0.05) for the cows fed with the diet containing 105 g of AS/kg DM as compared to the others. Increasing the rates of AS in the diet had no effect on milk fat, protein and lactose. The concentration of blood urea-N increased linearly (P=0.03) when the cows were offered diets with the increasing levels of AS. The serum concentrations of calcium, phosphorous, magnesium, nitrate and nitrite were not affected by the dietary treatment. Based on the obtained results, although partial replacement of MS by AS up to 210 g/kg DM was possible in the diet of lactating Holstein cows, the maximum values for DMI and milk yield were observed in the cows that were fed with the diet containing 105 g of AS/kg DM.

Abbreviations: ADFom, ash-free acid detergent fibre; AS, amaranth silage; BUN, blood urea nitrogen; BW, body weight; CP, crude protein; DM, dry matter; DMI, dry matter intake; DOMI, digestible organic matter intake; DOMR, digestible OM intake truly fermented in the rumen; ECM, energy-corrected milk; EE, ether extract; FCM, fat-corrected milk; FE, feed efficiency; Lignin(sa), lignin measured by solubilisation of cellulose with sulphuric acid; MNS, microbial nitrogen supply; MS, maize silage; N, nitrogen; NEB, net energy balance; NEFA, non-esterified fatty acids; NFC, non-fibre carbohydrates; NDFom, ash-free neutral detergent fibre; OM, organic matter; OMI, organic matter intake; PD, purine derivatives; RDP, rumen degradable protein; RUP, rumen un-degradable protein; TPD, total purine derivatives.

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1. Introduction

Forages are usually the least expensive sources of nutrients for ruminant animals. Cultivation and utilization of particular forages to support livestock production should be based on some factors, such as available land, soil type, climatic condition and economic factors (Sotomayor-Ríos and Pitman, 2001). Maize is one of the main ensiled crops in both developed and developing countries, however maize silage (MS) contains less crude protein (CP) (<100 g/kg dry matter [DM]) and rumen degradable protein (RDP) as compared to the other high quality forages such as alfalfa and clover (NRC, 2001).

Amaranth is a low cost unconventional plant adapted to poor soils and a shortage of water, and when harvested at a favourable stage of growth can be a useful feedstuff for ruminants in semi-arid and arid regions (Sleugh et al., 2001; Abbasi et al., 2012). This plant is resistant to water deficit (Barba de la Rosa et al., 2009), and needs less water than maize (Rezaei et al., 2014). Amaranth is characterized by its high yield performance (up to 85 t fresh matter/ha) and high nutritional value, which may vary depending on the species and crop management (Abbasi et al., 2012). The concentrations of CP, neutral detergent fibre (NDF) and ash were respectively 92.5, 477 and 195 g/kg DM for *Amaranthus cruentus* (Olorunnisomo, 2010), and 134, 449 and 92 g/kg DM for *Amaranthus hypochondriacus* (Rezaei et al., 2014). In the study conducted by Sleugh et al. (2001), the contents of CP, NDF, lignin, and DM digestibility for *A. cruentus*, *A. hypochondriacus* and *Amaranthus hybridus* were 80–285, 260–470, 17–73 and 590–790 g/kg DM between 42 and 112 days after planting, respectively. Olorunnisomo (2010) reported that feed intake and growth rate were less in sheep fed with amaranth (*A. cruentus*) silage (AS), as the sole feed, than those fed with MS. Ensiling has been used successfully to preserve fresh amaranth (*A. hypochondriacus*) for a long time (Rezaei et al., 2014). Dietary inclusion of AS (*A. hypochondriacus*) instead of MS, up to 300 g/kg DM, improved performance of fattening lambs without adverse effects on animal health (Rezaei et al., 2013). Variable contents of nitrate and oxalate (Sleugh et al., 2001; Abbasi et al., 2012) were found in amaranth, but the influences of these anti-nutrients on the blood parameters of dairy cow have not been assessed. Moreover, to our knowledge, there is scarce information on the effect of feeding diets containing AS on the performance of dairy cows. Hence, this study was conducted to assess the effect of feeding diets containing different levels of AS instead of MS on the feed intake, diet digestibility, microbial nitrogen (N) supply (MNS), blood parameters, milk production and N retention in lactating Holstein cows.

2. Materials and methods

2.1. Forage and silage preparation

The seeds of amaranth (*A. hypochondriacus*) and maize were sowed in the experimental field (5 ha) located in Shahriar county (Tehran Province, Iran) on the 1st of August. The area is at an altitude of 1160 m above sea level, with the latitude and longitude of 35°47'N and 51°08'E, respectively. The mean temperature and annual rainfall are 16.3 °C and 240 mm, respectively. The amaranth field was fertilised with 150 kg of N (as urea)/ha. Phosphorus and potassium fertilisers were not applied on the basis of soil test results. The maize field was fertilised with 180 kg of N (as urea) and 60 kg of phosphorous (as triple super phosphate)/ha. Weeds were controlled through row cultivation during the first weeks after plant sowing. Both forages were harvested at the mid-milk stage of seeds in early autumn. Harvesting was done by a maize harvester set at 10 cm above ground level. The particle lengths of chopped amaranth and maize were approximately 15–30 mm and 20–40 mm, respectively. The chopped plants were ensiled into permanent horizontal silos (one 60 t silo per amaranth and one 130 t silo per maize), with airtight lids to ensure good fermentation, for 6.5 months. The materials were compacted by driving over them with a compaction machine (a tractor). The compaction density of the AS was about 970 kg of wet matter/m^3. Representative samples were taken from the fresh silages, and frozen (−20 °C) for later chemical analysis. The chemical compositions of fresh and ensiled forages are shown in Table 1.

2.2. Animals and treatments

Twenty-four lactating Holstein cows averaging 140 ± 13 days in milk (in third lactation), 630 ± 36 kg of body weight (BW) and 38.9 ± 4.7 kg milk/day, at the beginning of the study, were selected for this experiment. Three iso-energetic and iso-nitrogenous diets were formulated according to Nutrient Requirements of Dairy Cattle (NRC, 2001), in which the MS was replaced by different rates (0, 105 or 210 g/kg diet DM) of AS. Experimental diets (Table 2) contained (per kg DM) 210 g of MS (Diet 1), 105 g of MS + 105 g of AS (Diet 2), or 210 g of AS (Diet 3). The diets were assigned randomly to one of three groups of eight cows each in a completely randomised design. The diets were offered as total mixed rations with a concentrate to forage ratio of 56:44 (DM basis). Diets were provided at 07:00 and 19:00 h. All the animals had free access to feed ensuring 100 g orts/kg of the amount fed daily and had free access to fresh water at all times. Three diets were given to the cows, which housed in individual stalls, for period of 63 days. Measurements were made during the final 42 days of the study.

2.3. Feed intake and chemical analysis

During the period of data collection, feed distributed to each animal and corresponding ort were recorded daily to estimate voluntary feed intake, and the representative samples were taken for subsequent analyses. The samples of silages, feeds offered, orts and faeces were oven-dried at 60 °C to a constant weight to determine DM content, then ground to