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Organic egg production. I: Effects of different dietary protein contents and forage material on organic egg production, nitrogen and mineral retention and total tract digestibility of nutrients of two hen genotypes

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ABSTRACT

The purpose of the study was to determine the effect of organic layer diets differing in protein and amino acid content on egg production and feed intake with two hen genotypes. Three experimental layer diets A, B and C were formulated to contain decreasing content of protein (A: 193 g/kg, B: 187 g/kg, C: 170 g/kg) but with similar energy content (average: 11.3 MJ ME/kg). No synthetic amino acids were added to the diets in line with the organic legislation, so the content of amino acids changed with the different protein content (e.g. methionine, A: 3.6 g/kg, B: 2.8 g/kg, C: 2.6 g/kg). Diets A, B and C were fed to both genotypes (Lohmann Silver (LS); New Hampshire (NH)), together with maize silage and carrots or alfalfa silage in a complete randomised design with 4 replicate pens each of 25 hens (total 1200 hens). Each pen had a separate house and outdoor hen yard of 4 m^2/hen. The experiment was carried out from 18 to 41 weeks of age, and layer diets and foraging material were fed ad libitum. A balance and digestibility experiment was performed at the end of the production study. The production parameters were significantly affected by genotype, diet and foraging material. The NH genotype had an average laying rate of 70%, compared to 85% for LS, ($P < 0.001$). The FCR was also most efficient with LS hens fed diet A, and there was a significant effect of genotype ($P = 0.001$; LS < NH) and diet ($P = 0.008$; A < B = C) on FCR. Both genotypes showed preference for maize silage and carrots (104 g/hen/d) compared to alfalfa silage (57 g/hen/d), which reduced diet intake for both NH and LS given maize silage and carrots ($P = 0.002$). This decreased laying rate with diet B and C, which could indicate insufficient supply of essential amino acids. The retentions of N and P were low, however, the N content in excreta was significantly influenced by both genotype ($P = 0.002$; NH > LS), diet ($P = 0.004$; A > B = C) and forage material ($P < 0.001$; Alfalfa silage > maize silage plus carrots). Ca retention was significantly higher with LS hens ($P < 0.001$), and with diet A compared to diet B and C ($P = 0.015$). The coefficient of total tract digestibility (CTTAD) of the different nutrients was affected differently, having only minor effect on CTTAD of starch, being high in all groups. The CTTAD of methionine and cysteine was higher with

Abbreviations: LS, Lohman Silver; NH, New Hampshire; L, layer diets; L-P1, layer diets phase 1; MS, maize silage; AS, alfalfa silage; FM, forage material; D, diet; G, genotype; FCR, feed conversion ratio; DM, dry matter; NSP, non-starch polysaccharides; NCP, non-cellulosic polysaccharides; DF, dietary fibres; t, trace; SEM, standard error of mean; N, nitrogen; P, phosphorus; Ca, calcium; CCTAD, coefficients of total tract apparent digestibility; ME, metabolisable energy; AME_n, apparent metabolisable energy nitrogen corrected; NRC, National Research Council.

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diet A, compared with B and C ($P < 0.001$). It is concluded that protein and amino acid content and high intake of foraging material influence production parameters in both genotypes, where LS performed more efficiently than NH. The hens obtain most likely some nutrients from the high intake of maize silage plus carrots and alfalfa silage, however, the foraging material have diluted the total intake of nutrients to some extent, which possibly influenced the results obtained on the overall production parameters.

1. Introduction

Organic egg production is increasing in Europe, where France and Germany are the largest producers, with approximately 5–6% of the total egg production (Magdelaine et al., 2010). However, the highest market share of organic eggs has been reached in Denmark being 20.4% in 2013 (The Danish Poultry Council, 2013). An important topic in organic farming is the use of 100% organic feed, however, the time for introduction of 100% organic feeding in EU has been postponed until January 1, 2018, allowing 5% non-organic ingredients for another three years (EU, 2014). This decision is caused by the challenge and concerns that a change into a 100% organic diet may not supply sufficient levels of certain essential amino acids, and any dietary imbalances may influence the egg production and stress laying hens initiating unwanted behaviour such as feather pecking in laying hens (Ambrosen and Petersen, 1997; Van Krimpen et al., 2005). The supply of sufficient levels of amino acids in organic egg production is often achieved by feeding diets with higher protein content than required by the birds. This approach increases nitrogen output in excreta and the risk of wet litter and higher ammonia concentration in the hen house as well as higher concentration of nitrogen on the outdoor area with negative effect on the environment due to leaching (Dekker et al., 2012, 2013).

In Northern Europe it is possible to grow cereals, rape seed and different legumes such as lupin, peas and faba beans. For a sustainable organic production, ideally, a high proportion of the feedstuffs should be produced locally, and the interest in growing a larger part of protein sources locally has increased by organic poultry producers. Especially, certain species of lupin (*Lupinus* spp.) are important for enhanced availability of organic grown protein, however, like most legume proteins, the content of the sulphur containing amino acids is low (Petterson, 2000). A higher local production of more climate-robust soya beans cultivars, would be an important supplement to home-grown protein. Alternative crops as quinoa (*Chenopodium quinoa*) are of interest in organic farming and have potential as poultry feed due to a fine balanced amino acid composition, especially regarding content of methionine, which however may vary for different cultivars (Ruales and Nair, 1992; Gonzalez et al., 2012).

Present genotypes used in organic egg production are mainly bred through many generations to fit the conventional systems, and have high nutrient requirements in order to maintain a high production, so genotypes with lower protein-requirements may have some interesting perspectives. Genotypes exist that differ in behaviour and nutrient requirement compared to more high-yielding types, and which are more suited to free-range organic systems, e.g. the Hellevad and the New Hamshire genotypes, with more innate foraging behaviour (Blair, 2008). Both genotypes are heavy type birds and can be considered as "dual-purpose", where male chickens can be used in organic meat production, compiling well with the organic principles.

Organic egg production requires access to outdoor pasture with either good quality grass/herbs or alternatively supplement forage material such as fresh hay, silages or vegetables can be fed to the hens. The consumption of foraging material can be considerable and reach a daily intake of around from 60 to 120 g/hen/day (Hammershøj and Steenfeldt, 2005; Horsted et al., 2006; Steenfeldt et al., 2007), and it is expected that good quality foraging material can contribute to the nutrient intake of organic layers to some extent. It is reported that the consumption of foraging material can reduce the feed intake by up to 20% (Blair, 2008), indicating that digestion and absorption of the foraging material take place. Further, access to foraging material seems to have a positive effect on behaviour as it motivates the hens to spend more time foraging and less on feather pecking (Aerni et al., 2000; Steenfeldt et al., 2007; Kalmendahl and Wall, 2012).

The overall objective of the study was to examine different strategies for a more sustainable production of organic eggs, which supports the overall welfare of the hens. Specific objectives were to include two hen genotypes with different nutrient requirements given experimental diets with decreasing levels of protein and amino acids and with access to different kinds of foraging material. The intake of the experimental diets and forage material, egg production, egg quality, use of outdoor area, plumage condition and mortality were the response parameters considered. Further, a balance and digestibility experiment was conducted at the end of the experiment. The results obtained on egg quality parameters are presented separately in the paper by Hammershøj and Steenfeldt (2015).

2. Materials and methods

2.1. Hen genotype and rearing period

The hens used in the experiment were reared from day-old in one stable unit in the poultry facility at Aarhus University (AU), Foulum. A total of 675 Lohmann Silver chickens were obtained from a commercial hatchery (Triova) and 675 New