Animal Feed Science and Technology 239 (2018) 44–54

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

# Effect of dietary soluble fibre and n-6/n-3 fatty acid ratio on growth performance and nitrogen and energy retention efficiency in growing rabbits

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ARTICLE INFO

*Keywords:*
Digestible energy and nitrogen retention efficiency
n-6/n-3 fatty acid ratio
Rabbits
Soluble fibre

ABSTRACT

The aim of this work was to study whether the dietary supplementation with soluble fibre (SF) and the reduction of the n-6/n-3 fatty acid ratio or the combination of both influence the growth performance and digestible nitrogen and energy (DN and DE) retention efficiency in rabbits from 27 to 62 d of age. Four diets in a 2 × 2 factorial arrangement were used with two levels of SF (7.8 vs. 13.0%, on DM basis, LSF vs. HSF) and two different n-6/n-3 ratio (13.4/1 vs. 3.5/1, Hn-6/n-3 vs. Ln-6/n-3). Nitrogen and energy retention in the body and in the carcass were determined by bioelectrical impedance. The increase of SF reduced the mortality (38.3 vs. 24.1%; P = 0.018), with no effect of the n-6/n-3 ratio. The feed efficiency in the whole experimental period (27–62 d of age) improved with the increase of the level of SF (+3.5%; P = 0.003) and the reduction of the n-6/n-3 (+2%; P ≤ 0.048). The increase of SF decreased the ratio DN/DE (-2%; P = 0.035). The increase of SF and the reduction of the n-6/n-3 ratio reduced the DN intake (-4%. P ≤ 0.030). However, the amount of nitrogen retained in the body or in the carcass was not affected by treatments (P ≥ 0.26). Consequently, the increase of dietary SF and the reduction of the n-6/n-3 ratio improved the retention of DN in the body and in the carcass (between 3.4 and 5.4%. P ≤ 0.017). It was associated with a reduction of the urinary nitrogen excretion in HSF respect to LSF groups (−13%; P = 0.004) and in Ln-6/n-3 respect to Hn-6/n-3 groups (-12%; P = 0.006). In contrast, the increase of SF increased the faecal nitrogen excretion (+5%; P = 0.004). Treatments had no effect on DE intake and on body and carcass energy retention (P ≥ 0.13). The increase of SF improved the body and carcass DE retention efficiency (+3%. P ≤ 0.042). It was mainly due to the impairment observed in rabbis fed LSF_Hn-6/n-3 respect to those fed LSF_Ln-6/n-3 diet (P = 0.071). In conclusion, the increase of SF improved the survival of fattening rabbits, with no influence of the n-6/n-3 ratio, and both factors especially improved the efficiency of DN but also the DE retained in the body and in the carcass.

*Abbreviations:* aNDFom-cp, α-amylase neutral detergent fibre corrected for ash and protein; CP, crude protein; DE, digestible energy; DEi, DE intake; DN, digestible nitrogen; DNi, digestible nitrogen intake; ER *in vivo*, GE retained *in vivo*; ER carcass, GE retained in carcass; ER *in vivo*/GEi, *in vivo* energy retention efficiency; ER carcass/DEi, carcass energy retention efficiency; GEi, gross energy intake; LSF and HSF, low and high soluble fibre; Hn-6/n-3 and Ln-6/n-3, high and low n-6/n-3 ratio; Ni, nitrogen intake. NR *in vivo,* nitrogen retained *in vivo*. NR carcass, nitrogen retained in carcass; NR *in vivo*/Ni, *In vivo* nitrogen retention efficiency; NR carcass/DNi, Carcass nitrogen retention efficiency; SBP, sugar beet pulp; SF, soluble dietary fibre; TDF, total dietary fibre

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https://doi.org/10.1016/j.anifeedsci.2018.03.006
Received 19 January 2018; Received in revised form 19 February 2018; Accepted 12 March 2018
0377-8401/ 

## 1. Introduction

The inclusion of 12% of soluble fibre (SF) in diets for growing rabbits affected by epizootic rabbit enteropathy reduced the mortality, although it did not disappear (Trocino et al., 2013), with different results in growth performance depending on the ingredients substituted (Gómez-Conde et al., 2009; Martínez-Vallespín et al., 2011). The recommended level of dietary SF is usually attained by including 15–25% sugar beet pulp (SBP). However, its inclusion might impair the nutrient retention efficiency. Thus, the substitution of barley by SBP limited the digestible energy intake and decreased the nitrogen and energy retention efficiencies when SBP inclusion exceeded a 15% (García et al., 1993; De Blas and Carabaño, 1996). In contrast, the substitution of alfalfa hay by SBP did not affect these traits (Carabaño et al., 1997). It would be interesting to combine SF with other nutrients that could have a synergic effect on rabbit health and that might improve nutrient efficiency. In this way, the dietary enrichment with n-3 fatty acids using linseed oil, that decreased the n-6/n-3 fatty acid ratio, also reduced the mortality in growing rabbits compared with a control diet (Maertens et al., 2005; Casado et al., 2013). The reduction of the n-6/n-3 ratio did not modify the fat content of different tissues in rabbits but their fatty acid profile (Bernardini et al., 1999). It is not known whether these changes in the fatty acid profile might improve the efficiency of retention of digestible energy and nitrogen.

The aim of this work was to study the effect of the combination of two dietary levels of SF and two ratios of n-6/n-3 fatty acids on growth performance, and nitrogen and energy body and carcass retention in growing rabbits using a technique based on the bioelectrical impedance recording.

## 2. Materials and methods

### 2.1. Animals and housing

A total of 300 weaned rabbits were used. They came from a farm affected by epizootic rabbit enteropathy, and from rabbit does fed with the same diets described below. After weaning rabbits received the same diets offered to their mother. Rabbits were individually caged, kept between 18 and 23 °C, had ad libitum access to feed and no antibiotic was supplemented by the feed or drinking water. All the experimental procedures used were approved by the Animal Ethics Committee of the Universidad Politécnica de Madrid, in compliance with the Spanish guidelines for care and use of animals in research (BOE, 2013).

### 2.2. Diets

Four diets in a 2 × 2 factorial arrangement were used with two levels of SF (7.8 vs. 13.0, on DM basis; LSF and HSF diets) and two different n-6/n-3 fatty acids ratio (13.4/1 vs. 3.5/1; Hn-6/n-3 and Ln-6/n-3 diets) (Table 1). A control diet was formulated to meet nutrient requirements for growing rabbits (Carabaño et al., 2009; De Blas and Mateos, 2010), and to have a low SF level and a high n-6/n-3 fatty acid ratio by including standard and high oleic sunflower oil (LSF_Hn-6/n-3). The increase of SF was obtained by replacing wheat straw and bran from control diet by SBP (HSF_Hn-6/n-3). In these two diets the n-6/n-3 fatty acids ratio was lowered by replacing high oleic sunflower oil and part of the standard sunflower oil by linseed oil (LSF_Ln-6/n-3 and HSF_Ln-6/n-3).

### 2.3. Growth performance and body chemical composition trial

At 27 d of age, 240 rabbits (60/diet) weighing 458 ± 89 (s. d.) g were weaned and growth traits were recorded until 62 d of age. *In vivo* body and carcass chemical composition and energy content was estimated using the bioelectrical impedance analysis technique in 40 rabbits/diet from this group, weighing 460 ± 80 g at weaning (Saiz et al., 2013a, 2013b, 2017). Resistance and reactance were measured in rabbits with a body composition analyzer (Model Quantum II, RJL Systems, Detroit, MI, USA) at 27, 39 and 62 d of age. Multiple regression equations according to Saiz et al. (2013a, 2013b, 2017) were used to estimate water, protein, ash, fat and energy concentrations both in the body and in the carcass.

### 2.4. Faecal digestibility trial

At 27 d of age, another group 60 rabbits (15/diet) weighing 449 ± 54 g were weaned, and feed intake and faeces recorded from 39 to 42 d of age to determine the apparent faecal digestibility of gross energy and nitrogen (Gómez-Conde et al., 2011).

### 2.5. Calculations of energy and nitrogen efficiency

Estimated values for the total body nitrogen and energy content were used to obtain the nitrogen and energy retention *in vivo* (NR *in vivo* and ER *in vivo*, respectively) at 27, 39 and 62 d of age. Values were expressed per kg $BW^{0.75}$ and day (BW was calculated as the average of the final and the initial BW in each period). Estimated values for the carcass nitrogen and energy content were used to calculate the nitrogen and energy retention in the carcass (NR carcass and ER carcass, respectively) between 27 and 62 d of age. Moreover, nitrogen and GE intake (Ni and GEi, respectively) and digestible nitrogen and energy intake (DNi and DEi, respectively) were recorded to calculate the overall N and GE *in vivo* body retention efficiency as: NR *in vivo*/Ni, NR *in vivo*/DNi, ER *in vivo*/GEi and ER *in vivo*/DEi, expressed as%. The overall N and GE carcass retention efficiency were estimated as: NR carcass/DNi and ER carcass/DEi, both expressed as%.