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Effects of Golden Flaxseed Supplementation on the Performance and Feed Digestibility of Rabbits

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Abstract: The objective of this study was to determine the effects of different levels of golden flax (*Linus usitatissimum* L.) seeds (GFS) on rabbit performance and nutrient utilisation. The trial was carried out on 30 crossbred rabbits that were randomly allocated to 3 groups each with 10 animals (5 male and 5 female rabbits each), kept separate in individual cages. Three diets were formulated with increasing levels (0, 8, or 16%) of GFS. The experimental period lasted 5 weeks and the faeces were collected during the last week. No obvious health problems were encountered during the experiment. The measured parameters were growth performances and digestibility of Dry Matter (DM), Organic Matter (OM), Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE), Nitrogen Free Extract (NFE), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF) and Gross Energy (GE). The weight gain and food intake did not differ significantly ($p>0.05$) among the dietary treatments. The digestibility coefficients were calculated according to standard procedures following the indirect digestibility method, using acid insoluble ash as an inert marker. The apparent digestibility of the mixed feed with a GFS inclusion level of 16% was higher than those of the other 2 diets. It can be concluded that golden flaxseed can be given to rabbits at levels of up to 16% in the diet without any adverse effects on growth performance and with a better digestibility than the control diet.

Key words: Rabbit, apparent digestibility, acid insoluble ash, *Linus usitatissimum*

INTRODUCTION

The revival of interest in flaxseed is due to the oil content, which is about 37-41 % on a dry matter basis (Canadian Grain Commission, 2001; Bhatty, 1997) and to its richness in essential fatty acids mainly alpha-linolenic acid (C18:3 n-3) (Daun and Przybylski, 2000). There is an ever-growing interest in the use of seeds, oil and cakes in animal nutrition with the aim of improving food safety to defend and promote the health of consumers (Cavani *et al*., 2003). The dietary use of flaxseed in rabbit feeding has been proposed by many authors to improve the performance (Johnston and Berrio, 1985) or to obtain meat with increased PUFA (Bernardini *et al*., 1999; Cavani *et al*., 2003; Bianchi *et al*., 2003, 2006). However, to the authors' knowledge, there are no published reports on the feeding value of flaxseed for rabbits. The present work was designed to study the effects of different levels of Golden Flax (*Linus usitatissimum* L.) Seeds (GFS) on the growth performance and nutrient utilisation of rabbits.

MATERIALS AND METHODS

Animals and diets: The study was carried out at the CISRA (Centro Interdipartimentale Servizio Ricovero Animali) experimental rabbitry of the University of Turin. Thirty weaned crossbred rabbits aged 9 weeks and weighing on average 2093±149 g were randomly assigned to 3 groups of 10 (5 male and 5 female rabbits each) with equal initial weight variability. The animals were housed individually under standard conditions at a temperature of 22±2°C in wire cages at a height of 90 cm from the concrete floor. The animals were assigned three dietary treatments containing 0, 8 or 16% GFS (GFS0, GFS8 and GFS16, respectively). All the diets were pelleted and formulated to contain the same crude protein and crude fibre content. The ingredients of the diets are presented in Table 1. After 1 week for adaptation to the diets and cages, the animals were fed *ad libitum* for 5 weeks. The unconsumed fed was weighed and discarded before offering feed to determine the intake of the previous day. The rabbits had free access to clean drinking water.

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Table 1: Ingredients of the diets (g kg $^{-1}$ DM diet)

	GFS0	GFS8	GFS16
Dehydrated alfalfa meal	460	440	420
Corn	150	170	170
Barley	190	150	145
Soybean seed meal	120	100	65
Palm oil	40	20	0
Golden flax seed	0	80	160
Lignosulphite	20	20	20
Vitamin-mineral premix [1]	20	20	20

[1]per kg diet: Vit. A 200 UI; α-tocopheryl acetate 16 mg; Niacine 72 mg; Vit. B_6 16 mg; Choline 0.48 mg; DL-methionine 600 mg; Ca 500 mg; P 920 mg; K 500 mg; Na 1 g; Mg 60 mg; Mn 1.7 mg; Cu 0.6 mg

The rabbits were weighed individually at weekly intervals to determine the weight gain and growth curves.

Analytical determinations: All the analysis were carried out on duplicate samples. The proximate composition of the diets and faeces were determined according to the AOAC method (1990). The diet and faeces samples were analysed to determine: Dry Matter (DM), total N content, ash by ignition to 550°C and Ether Extract (EE) using the Soxlet method, crude fibre according to the Weende method, Neutral Detergent Fibre (NDF) without sodium sulfite and á-amylase and Acid Detergent Fibre (ADF), as described by Van Soest *et al.* (1991) expressed exclusive of residual ash. ADL was determined by solubilization of cellulose with sulphuric acid, as described by Robertson and Van Soest (1981) and Gross Energy (GE) by means of an adiabatic calorimeter bomb (IKA C7000, Staufen, Germany). The acid insoluble ash content of the diets and faeces was determined according to Van Keulen and Young (1977).

Digestibility studies: The apparent digestibilities of the 0, 8 or 16% GFS diets were determined in the 5th week. The faeces were collected over a period of 5 days and the collection was performed at approximately 09:00 h each morning before the next daily ration was provided. The faeces were collected using a nylon net placed under the cages of each trial, to avoid urine contamination. Each pooled fecal sample was taken and placed in a two-layer plastic bag to prevent the loss of moisture. The frozen samples were individually mixed thoroughly and pooled, ground in a homogenizer (Tecator, Herndon, VA, USA) and, thereafter, the representative samples were weighed on an aluminium foil pan and dried in a draft oven at 80°C to constant weight and stored for chemical analysis.

Calculation and statistical analysis: The digestibility coefficients were calculated through standard procedures following the indirect digestibility method (Crampton and Harris, 1969) using the Acid Insoluble Ash (AIA) as an inert marker. The calculation of the DM digestibility was as follows:

$$\text{DM digestibility (\%)} = (1\text{-}A/B) \times 100$$

Where, A and B are the AIA concentrations in the feed and faeces, respectively.

The digestibility of the other nutriets (X) was calculated as follows:

$$\text{Digestibility (X in \%)} = (1\text{-}A/B \times XB/XA) \times 100$$

where, XA and XB are the concentrations of X in the feed and faeces, respectively.

The Gross Energy digestibility (dGE) coefficients of each trial were also calculated on the basis of previous studies (De Blas *et al.*, 1992; Ortíz and De Blas, 1989; Fernandez-Carmona *et al.*, 1996) and compared with *in vivo* digestibility data.

Statistical analyses were performed using the SPSS software package (version 11.5.1 for Windows, SPSS Inc., USA). The analysis of variance was used to evaluate the effects of different concentrations of GFS on the growth performances and the digestibility of rabbits. The means were compared with a Duncan test and the significance level was set to a level of 5% ($p<0.05$).

RESULTS AND DISCUSSION

Chemical composition: The chemical composition of the GFS and three diets are reported in Table 2. The oil content of the GFS raw material is similar to that of the brown flaxseed varieties (Canadian Grain Commission, 2001) and higher than other oilseeds used in digestibility trials, i.e. Chia (*Salvia hispanica* L.) seed (Meineri and Peiretti, 2007) and false flax (*Camelina sativa* L.) seed (Peiretti *et al.*, 2007) while the GFS fiber content was lower than those of the other 2 oilseeds. The inclusion of GFS in the diets increased the ether extract and decreased the crude fibre and fibrous fractions.

Growth performance: No rabbit died during the trial. The diets did not significantly modify the productive performances (Table 3) and the growth curves were similar for all the experimental groups (Fig. 1). The performance results of the present study are generally in agreement with Dal Bosco *et al.* (2004) who found that the inclusion of 8% of flax in rabbit diets had no significant effect on the weight gain or feed conversion rate. The negative effect of high raw ground flaxseed inclusion (>10%) in diets on broiler performances has been reported extensively (Ajuyah *et al.*, 1993; Bond *et al.*, 1997) while pigs have been fed 10% whole flaxseed with no detrimental effects on the daily weight gain or feed

Table 2: Chemical composition (g kg $^{-1}$ on DM basis) of the golden flax seed (GFS) and the diets

	GFS	GFS0	GFS8	GFS16
Dry matter (g kg^{-1} as fed)	933.0	904.0	911.0	917.0
Organic matter	966.0	922.0	918.0	922.0
Crude protein	235.0	189.0	191.0	184.0
Crude fibre	171.0	155.0	156.0	156.0
Ether extract	369.0	53.0	73.0	97.0
Ash	34.0	78.0	82.0	78.0
Neutral detergent fibre	261.0	285.0	296.0	284.0
Acid detergent fibre	188.0	172.0	168.0	170.0
Acid detergent lignin	84.0	31.0	30.0	44.0
Acid insoluble ash	0.0	12.0	12.0	10.0
Gross energy (MJ kg^{-1} DM)	27.0	18.6	19.0	19.7

Table 3: Productive performance

	GFS0	GFS8	GFS16
Number of rabbits	10	10	10
Mortality (%)	0	0	0
Weight gain (g day^{-1})	35.3±3.1	35.5±3.3	35.7±2.0
Food intake (g day^{-1})	181.7±8.0	177.7±9.1	166.6±5.0

The values are mean±standard error of mean

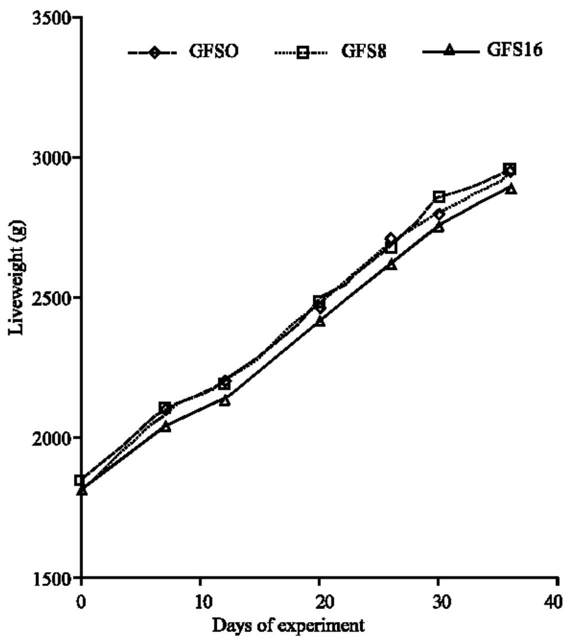

Fig. 1: Growth curves of the rabbits fed increasing dietary levels of Golden Flax Seed (GFS)

conversion ratio (Matthews *et al*., 2000). A correct pelletting procedure may have a good effect on reducing the content of anti-nutritional factors, as reported by Shen *et al*. (2005) who found a satisfactory growth performance in broilers when fed diets containing 12% of pellet-processed flaxseed.

Digestibility coefficients: The apparent digestibility coefficients are reported in Table 4. The digestibilities of DM, OM, CP, CF, EE, NDF and ADF of the mixed feed with a GFS inclusion level of 16% were higher than those

Table 4: Percent of the apparent digestibility coefficients (mean±SE) obtained using AIA (acid insoluble ash) as the internal marker

	GFS0	GFS8	GFS16
Dy matter	65.4±0.07^{b}	63.2±0.75^{a}	67.7±0.33^{c}
Organic matter	66.2±0.08^{b}	63.9±0.77	68.5±0.34^{c}
Crude protein	65.0±0.40^{a}	65.7±0.93^{a}	68.4±0.54^{b}
Crude fibre	24.9±0.65^{b}	20.8±1.09^{a}	30.6±0.40^{c}
Ether extract	83.5±0.19^{a}	87.3±1.09^{b}	90.6±0.48^{c}
Neutral detergent fibre	27.0±0.34^{a}	26.9±1.06^{a}	32.5±0.72^{b}
Acid detergent fibre	25.3±0.95^{b}	20.08±2.08^{a}	31.9±0.98^{c}
Gross energy	65.2±0.19^{a}	64.5±0.71^{a}	69.2±0.40^{b}

The values are mean±standard error of mean. Differences among groups within the same row; $p>0.05$

Table 5: Percent apparent digestibility coefficients of gross energy (dGE) calculated using linear regression equations based on the chemical composition of the rabbit diets

	GFS0	GFS8	GFS16
dGE = 83.2-1.07 ADF[1]	64.8	65.2	65.0
dGE = 86.3-1.23 ADF[2]	65.1	65.6	65.4
dGE = 84.9-1.13 ADF[3]	65.5	65.9	65.7

[1]Fernandez-Carmona *et al.* (1996), [2]De Blas *et al.* (1992) and [3]Ortíz and De Blas (1989)

of the other 2 diets. The diets with 8% of GFS presented similar CP and NDF digestibilities as the control diet, while the DM, OM, CF and ADF digestibilities were lower than those of the other 2 diets. The EE digestibility increased as the proportion of the GFS increased; a similar trend was observed in a digestibility trial with rabbits fed increasing levels of false flax seeds (Peiretti *et al*., 2007).

The GE digestibility (dGE) was higher for the GFS16 diet (69.2%) than for the other 2 diets (65.2 and 64.5% on average, for the GFS0 and GFS8 diets, respectively). The dGE calculated using some linear regression equations based on the chemical composition of rabbit diets are reported in Table 5. The dGE values determined *in vivo* using the AIA method for the GFS0 and GFS8 diets were quite similar to those calculated with the equations proposed by Fernandez-Carmona *et al.* (1996), Ortíz and De Blas (1989) and De Blas *et al*. (1992). The *in vivo* dGE of the GFS16 diet was higher than those calculated with the same equations; this is probably due to its high EE content in this diet. The dGE calculated with the equation proposed by De Blas *et al.* (1992): dGE = 84.4-1.24 ADF+ 0.77 EE was in fact close to that determined *in vivo*. The range of the *in vivo* dGE of the GFS diets was the same as that found by Meineri and Peiretti (2007) in diets formulated for rabbit with increasing levels of chia and by Peiretti *et al.* (2007) in rabbit diets with 10 and 15% of added false flax. The good value of digestibility energy of these mixed feeds is probably due to the pelletting process that optimizes the nutrient utilisation and reduces the antinutritional factors frequently present in the seeds. Feeding flaxseed in pellet form has been shown to increase its metabolisable energy value in adult roosters

(Conzalez-Esquerra and Leeson, 2000). Under the increased temperature and high pressure during pelletting, the hull structure of flaxseed may undergo changes that permit nutrients to be exposed to extensive intestinal digestion (Shen and Chavez, 2003).

CONCLUSION

Golden flaxseed may be used satisfactorily as a nutrient supplement for rabbit at levels of up to 16% in the diet without any adverse effects on growth performance and with a better digestibility of DM, OM, EE, NFE and GE than in the control diet.

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