EFFECT OF DIETARY TYPE AND LEVEL OF FIBRE ON CARCASS YIELD AND ITS MICROBIOLOGICAL CHARACTERISTICS

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ABSTRACT

The aim of this trial was to study the effect of level and type of fibre during the last week of the fattening period on carcass characteristics. A total of 6602 New Zealand × Californian rabbits, weaned at 35 days of age, were fed with a commercial diet (C0: 35% of NDF, 13.4% of starch and soluble fibre, beet pulp as fibre source) from weaning to 56 days. The last week of fattening period (56-63d) animals were fed with three different diets (C0, C1 and C2). Diet C1, was formulated to have a similar NDF content as diet C0, but the fibre source was replaced by a more insoluble fibre (straw) and diet C2 was formulated to reduce the NDF to 32.4%, but keeping the same fibre sources as diet C1, and increasing the starch content (17.3%). Seven multi-floor cage rolling stand (MFRS) with 290 and 280 animals, were assigned to C0 and C1 diets, respectively, and other six MFRS (288 animals) to diet C2. In four animals per MFRS were determined the carcass yield. In two of them (14 animals/treatment) a sample of caecal content was taken to determine the same day the *C. perfringens*, *Enterobacteriaceae*, *E. coli* and *Coliform* counts. Temperature and pH in *Biceps femoris* were measured after the cold time (2 hours after slaughter at -1ºC) and 24 h *post mortem* and samples from the *Longissimus dorsi* and *Biceps femoris* were also taken to study the carcass bacteriological quality at days 1, 7 and 11 after slaughter (*Total Aerobic*, *Enterobacteriae*, *Coliform* and *Coagulase-positive Staphylococcus)*. Animals fed with the lower dietary fibre content (C2) increased (P=0.05) its carcass yield. Carcass temperature was higher in the muscle of the animals fed diet C1 (P=0.001). The log cfu/g of *Enterobacteriae*, *Coliform* and *Coagulase-positive Staphylococcus* analysed in caecum content were higher for the animals fed treatment C1. The highest values of microorganisms content of the carcass were reached 11 days after slaughter (P<0.001). From these results, it might be concluded that a decrease of dietary fibre (from 35 to 32% NDF) when insoluble fibrous sources are included enhances the carcass yield and the carcass microbiological quality. For the same level of fibre, the inclusion of moderate amount of beet pulp (10%) improved the microbiological characteristics without impairing the carcass yield.

Key words: Rabbit, Microbial carcass quality, Carcass yield, Type and level of fibre.

INTRODUCTION

The elimination of risk materials implies an extra cost for the slaughterhouses after European Commission legislation of Transmissible Spongiform Encephalopathies (TSE). The digestive tract accounts for around 60% of the total wastes and its transport and elimination are especially difficult because of its high volume and humidity content. Furthermore, the manipulation of these residues may lead to a higher contamination of the final product increasing the sanitary risk by zoonoses transmission. The main responsible of the weight of digestive tract is the presence of the feed in the lumen that maintains a balance between the intake and the excretion. The level and type of dietary fibre are the most important factors to control the digestive content. Fibre regulates the retention time in the caecum and the dry matter intake, as it is usually negatively correlated with the dietary energy content (de Blas *et al.*, 1999). So, levels of fibre from 33-36% NDF and the use of insoluble fibre minimised the weight of the digestive tract (de Blas *et al.*, 1986, Fraga *et al.*, 1991) This effect has been widely observed in experiments where a long period (usually the whole fattening period) has been controlled; however, when a short period is considered there is an interaction with the previously diet fed by the animals (Villena *et al.*, 2008). The use of a high fibrous diet, based on indigestible fibre, led to an increment of the weight of digestive tract when the previous diet is lower in fibre. Furthermore, the use of different sources of fibre can modulate the caecal microbiota (García *et al.*, 1999; Gómez Conde *et al.*, 2007) and affect to the presence of microbiota in the carcass. The aim of this trial was to study the effect of type and level of dietary fibre in the finishing diet (supplied the last week of the fattening period) on carcass characteristics.

MATERIALS AND METHODS

A total of 6602 mixed-sex rabbits New Zealand x Californian from a commercial farm of the group HERMI S.L were used. Rabbits, weaned at 35 days of age, were caged collectively in groups of eight animals and offered *ad libitum* access to the feed. A commercial diet (C0) containing high level of NDF (35.1%) and low level of starch (13.4) was used as a control diet. Another diet (C1) was formulated maintaining a similar content of NDF and starch of the control diet, but substituting beet pulp by treated wheat straw, with a higher content of insoluble fibre. The third diet (C2) was formulated reducing NDF and increasing starch content (32.4% and 17.3%, respectively) with respect the C1 diet, but maintaining the same source of fibre. All the essential nutrients content (amino acids, minerals and vitamins) were formulated according to the nutrient recommendations of De Blas and Mateos (1998). The ingredients and calculated chemical composition of the diets are shown in Table 1. During the first 21 days of the fattening period the rabbits were fed with the control diet (C0), but in the finishing period (from 56 to 63 days of age) they were assigned at random to the three treatments.

Table 1: Ingredients and calculated chemical composition of diets (%)

	C0	C1	C2
Ingredients			
Barley	12.8	14.8	21.8
Alfalfa hay	33.0	33.0	30.0
Treated wheat straw	-	8.0	4.0
Sunflower meal 28%	12.0	9.0	9.0
Beet pulp	10.0	-	-
Soybean meal 44%	3.7	6.7	6.7
Calculated chemical composition			
Crude Protein	15.9	15.8	16.0
NDF	35.1	35.3	32.4
ADF	19.1	21.5	19.2
ADL	5.09	5.43	4.93
Starch	13.4	13.8	17.3
Digestible Energy[1] (MJ/kg)	9.48	9.16	9.76

All diets contained (%): Wheat Bran: 23; Palm oil: 0.5; Molasses: 2.0; Sodium chloride: 0.425; Calcium carbonate: 0.8; Sepiolite: 1; Mineral and vitamin premix: 0.5. Mineral and vitamin composition (mg/kg diet): Mg, 290; Na, 329; S, 275; Co, 0.7; Cu, 10; Fe, 76; Mn, 20; Zn, 59.2; I, 1.25; Choline, 250; Riboflavin, 2; Niacin, 20; Vitamin B_6, 1; Vitamin K, 1; Vitamin E, 20 IU/kg; Thiamine, 1; Vitamin A, 8375 IU/kg,, Vitamin D_3, 750 IU/kg, Robenidine, 60. [1]Value estimated according to FEDNA (2003)

The temperature in the farm was partially controlled and maintained in the range 18 to 24°C. A cycle of 12 h of light and 12 h of dark was used throughout the growth trial. Rabbit weight in the farm and slaughterhouse, feed intake and conversion rate were measured using the multi-floor cage rolling stand (MFRS), which carried the animals to the slaughterhouse, as experimental unit. There were seven MFRS with 290 and 280 animals, assigned to the C0 and C1 diets, respectively, and other six MFRS contained 288 animals that were fed with the diet C2. The mortality on the total number of the rabbits was controlled in the whole fattening period. Four animals per MFRS were selected at random to determine the carcass yield (28 animals per treatment, except for diet C2 (24 animals) that was calculated by the rate between the live and hot carcass weight. Anatomical parts of the digestive tract were weighted separately with their contents. A sample of caecal content was taken in two of these animals (14 animals/treatment) to determine the same day the *C. perfringens*, *Enterobacteriaceae*, *E. coli* and *Coliform* counts. Samples were stored into sterile polystyrene tubes and were inserted into anaerobiosys bags GENbag (bioMérieux S.A., Marcy létoile, France) to keep the microbial flora viability. *C. perfringens* enumeration was determined according to the standard ISO 7937 (1997). The cultural medium used was agar tryptose sulphite added with antibiotic D-cycloserine. Later on, the plates were incubated during 18 hours at 37ºC. E. coli and Coliforms counts were determined according to the standard ISO 9001 (2000) by 3MTM PetrifilmTM E. coli/Coliform count (EC) Plate. The culture medium system contained Violet Red Bile (VRB) nutrients, an indicator or glucuronidase activity and 5-bromo-4-chloro-3-indolyl-b-D-glucoronide (BCIG). The 3M Petrifilm Enterobacteriaceae Count (EB) Plate was used to Enterobacetriaceae enumeration according to the standard ISO 9002 (1994). The culture medium system contained modified Violet Red Bile Glucose (VRBG) nutrients. The Petrifilm EC and EB Plates also contained a cold-water-soluble gelling agent and a tetrazolium indicator that facilitated colony enumeration; both were incubated during 24 hours at 37°C.

The measurements used to evaluate meat quality were pH and temperature in *Biceps femoris* of the same two animals. Both traits were measured after the cold time (2 hours after slaughter at -1ºC) and 24 h post-mortem. The pH was recorded with a Crison MicropH 2001 (Crison instruments, Barcelona, Spain) using a combined electrode penetrating 3 mm. Samples from the *Longissimus dorsi* and *Biceps femoris* were also taken from the same animals to study the carcass bacteriological quality. The carcass were stored at 4ºC and the microorganisms analyzed at days 1, 7 and 11 after slaughter, were *Total Aerobic, Enterobacteriae, Coliform* and *Coagulase-positive Staphylococcus* according to the standard ISO 4833 (2003), 7402 (1993), 4832 (1991) and 6888 (1999), respectively. All the plates were incubated at 37ºC during 24 hours, except for *Total Aerobic* (72 hours at 30ºC).

Data were analysed with the General Lineal Model Procedure program of SAS statistical package (SAS, 2000) with the diet as main effect. In the microbiological analysis a Levene´s test showed lack of homogeneity of variance; accordingly, values were transformed to a logarithmic scale. The mortality was analysed with the χ^2 test.

Carcasses temperature, pH and its microbiological quality, were analysed with the MIXED procedure program of SAS statistical package using the diet, time and its interaction as main effects.

RESULTS AND DISCUSSION

Treatments had no effect either on ingestion during the last week of the fattening period or on final live weight of animals at farm and slaughterhouse (Table 2). However, weight losses from the farm to the slaughterhouse were lower for the rabbits of the diet C1 (P<0.001), probably because these animals were the first slaughtered. Mortality in the whole fattening period was higher (by 1.24%) in animals fed the last week before slaughter with the diet containing high level of indigestible fibre (C1), relative to the other two diets, although this result is not relevant in connection with the treatment.

Table 2: Productive traits in the finishing period (56-63 days)

	Treatments				
	C0	C1	C2	SEM	P
MFRS (no) (rabbits/MFRS)	7 (290)	7 (285)	6 (288)		
Live weight at farm (kg)	2.13	2.10	2.11	0.012	0.14
Live weight at slaughterhouse (kg)	2.08	2.06	2.06	0.011	0.32
Weight losses farm-slaughterhouse (%)	2.52^a	1.77^b	2.41^a	0.098	<0.001
Feed intake (56-63 days) (g/rabbit)	1460	1440	1430	0.024	0.77
Mortality on the whole fattening period (%)	3.86^b	5.08^a	3.82^b	-	<0.050

Animals fed with the lower dietary fibre content (C2) tended to decrease the stomach weight related to live weight (P=0.085), and this effect could explain the increase (P=0.05) in the carcass yield observed with respect to the animals that fed treatments C0 and C1 (Table 3). Several authors (de Blas *et al.*,

1986) has also shown that inclusion of high levels of fibre in fattening diets led to an increase of the stomach content weight. Previous studies have indicated that an increase on the proportion of the digestive tract with the increase of the level of fibre also leads to a lower carcass yield (Ouhayoun, 1998; Margüenda *et al.*, 2006). Carcass temperature measured after the cold time and 24 hours after the slaughtering were higher in the muscle of the animals of the treatment C1 (P=0.001; Table 4). Meat pH also tended (P=0.16) to be higher in animals fed C1 diet. Time also affected pH and temperature. Both traits were lower 24 h post-mortem respect to the cold time. The rabbit meat pH data reported in the literature are very variable, because it depends on many factors, as stunning methods, bleeding, stress and management of the animal before the slaughter. The average pH values of our study were higher than those obtained by others authors in the same muscle, which ranged from 5.80 to 6.03 (Hulot and Ouhayoung, 1999). However, our results were according with the pH values of *Biceps femoris* measured 24 hours post-mortem by María *et al.* (2001), which varied from 6.01 to 6.18 using different stunning methods, and by López-Calleja *et al.* (2005), who found a mean pH values of 6.26. No significant differences among diets were found for the *Total Aerobic* enumeration of the carcass. However, the log cfu/g of *Enterobacteriae, Coliform* and *Coagulase-positive Staphylococcus* were higher (19.2, 21.6 and 5.6%, respectively) for the animals fed treatment C1 with respect the other two diets (Table 5). The higher pH and temperature found in the animals of this treatment might be related with the impairment of its carcass microbiology quality, because it was not found any effect of the treatments on caecal content microorganisms, being on average 5.73, 0.86, 0.63 and 4.42 log cfu/g for *C. Perfringens, Enterobacteriae, E. Coli* and *Coliform*, respectively.

Table 3: Effects of level and type of fibre on live weight and slaughtering data in rabbits

	Treatments			SEM	P
	C0	C1	C2		
Rabbits (no)	28	28	24		
Live body weight (BW) (g)	2.22	2.17	2.20	0.033	0.47
Hot carcass weight (g)	1.32	1.29	1.34	0.024	0.41
Carcass yield (%)	59.3^{b}	59.6^{b}	60.7^{a}	0.40	0.05
Digestive weight (% BW)	19.2	19.5	18.9	0.42	0.69
Stomach weight (% BW)	5.06	5.26	4.69	0.17	0.085
Caecum weight (% BW)	7.36	7.65	7.33	0.22	0.56

Table 4: Effect of level and type of fibre on physical meat quality characteristics

	Treatments			Time		RSD	$P_{treatment}$	P_{time}	P_{trexti}
	C0	C1	C2	After cold	24 h				
Rabbits (no)	14	14	12	40	40	-	-	-	-
Temperature (ºC)	2.54^{b}	2.91^{a}	2.16^{c}	2.76	2.31	0.66	0.001	0.005	0.29
pH	6.48	6.54	6.43	6.81	6.15	0.21	0.16	< 0.001	0.87

A gradual increase with the time was observed in the microorganisms content of the carcass (Table 5). The highest values were reached the 11 days after slaughter (P<0.001). These results seem to indicate that mean shelf live for rabbit meat is around 7 days and are in agreement with Rodríguez-Calleja *et al.* (2005) who reported that the average shelf life of carcass of rabbits was 6.8 days. An interaction was found (P=0.005) between type of diet and time post slaughter on *Coagulase-positive Staphylococcus* content in carcass, showing that animals fed with C1 diet at 11 d post slaughter a higher value than at 1 and 7 d, and also than animals fed C0 and C2 diets, independently of the day post slaughter (2.02 vs. 1.70 on average).

Table 5: Effect of level and type of fibre on carcass microbiological characteristics (log cfu/g)

	Treatments			Time post laughter			RSD	$P_{treatment}$	P_{day}	$P_{treatxday}$
	C0	C1	C2	1	7	11				
Rabbits (no)	14	14	12	40	40	40	-	-	-	-
Total Aerobic	3.60	3.75	3.50	2.01^{c}	3.19^{b}	5.65^{a}	0.51	0.17	< 0.001	0.57
Enterobacteriaceae	2.18^{b}	2.51^{a}	2.03^{b}	1.02^{c}	2.10^{b}	3.59^{a}	0.64	0.027	< 0.001	0.48
Coliform	1.71^{ab}	1.94^{a}	1.48^{b}	1.01^{c}	1.60^{b}	2.52^{a}	0.56	0.029	< 0.001	0.51
Coagulase-positive Staphylococcus	1.72^{b}	1.80^{a}	1.69^{b}	1.69^{b}	1.70^{b}	1.82^{a}	0.19	0.058	0.003	0.005

CONCLUSIONS

The results of this work indicate that a decrease of dietary fibre (from 35 to 32% NDF) when insoluble fibrous sources are included enhances the carcass yield and the carcass microbiological quality. For the same level of fibre, the inclusion of moderate amount of beet pulp (10%) improved the microbiological characteristics without impairment of carcass yield.

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