EFFECT OF THE DIETARY N-3 AND N-6 FATTY ACIDS ON TEXTURE PROPERTIES AND SENSORY CHARACTERISTICS OF RABBIT MEAT

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ABSTRACT

The effect of enriching rabbit meat with long-chain n-3 and n-6 PUFA through dietary fat on texture properties and sensory characteristics was studied. Rabbits from the same genetic type were fed *ad libitum* with three different diets. The experimental diets included a 3% of added fat: animal fat (A), sunflower oil (SF) or linseed oil (L). The three diets were supplemented with 100 ppm of α-tocopherol. 144 rabbits were used in this experiment, 48 rabbits of each group from both sexes. Animals were slaughtered at 63 days of age. *Longissimus* muscles from the right and left side of the carcasses were used for sensory and texture analysis, respectively. Textural properties were measured by Warner-Bratzler (WB) shear device and by the texture profile analyses (TPA) test. A sensory analysis was performed by six trained tasters of rabbit meat. The parameters evaluated were: juiciness (J), hardness (H), intensity of rabbit odor (IRO), aniseed flavor (AF), liver flavor (LF) and metallic/acid flavor. Changes in instrumental texture and sensory characteristics during 3 and 7 days of aging have been evaluated. A Bayesian analysis was performed.

There was a storage time effect for shear force and area, having the meat after 7 days of aging lower values than after 3 days of aging. In the texture profile analysis, rabbit muscle after 3 days of aging had 2% higher values for cohesiveness, 4% higher values for springiness and 8% higher values for chewiness than muscle after 7 days of aging. In the sensory analysis, rabbit loins after 3 days of aging were 12% harder than after 7 days. Nevertheless, there was a decrease in the intensity of rabbit odor with aging time. No storage time effect was found in juiciness and aniseed, liver and metallic flavor. Regarding the diet effect, the largest differences appeared between diet A and the others. Diet SF and diet L showed a 9% and 7% higher shear force than diet A. The total work performed to cut the sample (area) was an 11% higher in SF group than in A group. L group showed an 8% higher area than A group. No diet effect was found between SF and L diets. The results from the TPA showed no diet effect for most of the traits. Some of the texture variables measured indicates that the meat from group A could be more tender; however, no diet effect was found in hardness evaluated by sensory analysis. No evidence of diet effect was found for all the sensory characteristics measured.

Our results show that enriching rabbit meat with long-chain n-3 and n-6 PUFA through dietary fat has a small effect on instrumental texture properties but seems to have no effect on sensory characteristics. Moreover, instrumental texture and sensory analysis confirms that ageing improved the tenderness of rabbit meat.

Key words: Dietary fat, Texture, Sensory characteristics, Rabbit.

INTRODUCTION

The nutritive value of meat has an increasing importance among the factors determining meat quality and consumer acceptability. There is an increasing interest in the lipid composition of edible meat and fat because of its relationship with human health, particularly with cardiovascular illness. The recommendations from a nutritional point of view are to reduce saturated fatty acid moieties consumed and to increase ingestion of n-3 and n-6 polyunsaturated fatty acids (PUFA).

In monogastric animals including the rabbit, the quantity and composition of fatty acids in the fat and meat can be manipulated by diet (Oliver *et al*., 1997; Hernández *et al*., 2007). However, increasing unsaturated fatty acid dosage could lead to soft and oily carcasses and the development of rancidity problems as a consequence of lipid oxidation. Therefore, adverse effects could appear in meat quality and sensory traits.

The aim of this study is to examine the effect of enriching rabbit meat with long-chain n-3 and n-6 PUFA through dietary fat, on meat texture properties and sensory characteristics.

MATERIALS AND METHODS

Animal material

Rabbits from the same genetic type (a three-way commercial cross) were divided into three groups at weaning (4 wk old) and fed *ad libitum* with three different diets. The experimental diets included a 3% of added fat: animal fat (A), sunflower oil (SF) or linseed oil (L). The three diets were supplemented with 100 ppm of α-tocopherol. A total of 144 rabbits were used in this experiment, 48 rabbits of each group from both sexes. Animals were slaughtered at 63±2 days of age. Animals were electrically stunned and bled without fasting. After slaughter and bleeding, the carcasses were cooled in a refrigerated chamber at 3ºC until 24 h *post-mortem*.

Carcasses were prepared according to the standard procedures of the World Rabbit Science Association (Blasco and Ouhayoun, 1996). *Longissimus* muscles were dissected between the 8th thoracic vertebra and 7th lumbar vertebra. *Longissimus* muscles from the right and left side of the carcasses were used for sensory and texture analysis, respectively. Muscles were vacuum-packed in bags and kept at 4ºC during 3 and 7 days. After each time of aging, samples were stored at -20ºC for later analysis.

Texture analysis

Muscle samples were thawed at 4ºC/24 h in their vacuum-packed plastic bag, cooked at 80ºC for 1 h by immersion in a water bath with automatic temperature control and then cooled at room temperature (20±2ºC) before the analysis. The samples for Warner-Bratzler shear test (WB) were obtained by cutting at least two rectangles of 2 x 1 cm of cross section, parallel to the muscle fiber direction. They were completely cut using a WB shear blade with a triangular slot cutting edge and three parameters were measured: the maximum shear force, the shear firmness and the total work performed to cut the sample or the area under the curve obtained. Samples for Texture Profile Analysis (TPA) were obtained by cutting cubes of 1 cm each side parallel to the muscle fiber direction and then compressing to 75%. In this test the following variables were obtained: hardness, cohesiveness, springiness and chewiness. The Texture Analyser Mod. TA-XT2 (Stable Micro Systems, UK) was used for both tests and all the samples were cut or compressed perpendicular to the muscle fiber direction at a crosshead speed of 5 mm/s. The average value for each *Longissimus* sample was recorded (mean of two to four replicates).

Sensory analyses

A quantitative descriptive analysis was performed by six trained tasters of rabbit meat in 20 sessions. The parameters evaluated were: juiciness (J), hardness (H), intensity of rabbit odor (IRO), aniseed flavor (AF), liver flavor (LF) and metallic/acid flavor. Samples were thawed at 4ºC/24 h in their vacuum-packed plastic bag, and cooked in a water bath at 80ºC for 1 hour. Samples were cut into four pieces and distributed in such a way to the tasters as to eliminate any location effect within the loin.

Statistical analysis

The statistical model for sensory data included, diet (A, SF, L), storage time (3 and 7 *post-mortem* days), taster (with six levels), sex, order of muscle presentation (with four levels), muscle location (with four levels) and session (with 20 levels) effects. For texture analysis, the statistical model included, diet, storage time and sex effects.

A Bayesian analysis was performed. All inferences were made from estimated marginal posterior distributions of the ratios of the different levels of each effect. Bounded flat priors were used for all unknowns. Data were assumed to be normally distributed. Marginal posterior distributions of all unknowns were estimated by using Gibbs Sampling (Blasco, 2005). After some exploratory analyses we used one chain of 10,000 samples, with a burning period of 2,000, thus marginal posterior distributions were estimated with 8,000 samples in each one. Convergence was tested for each chain using the Z criterion of Geweke.

RESULTS AND DISCUSSION

Mean values and coefficient of variation of the instrumental texture variables measured by the WB and TPA methods are shown in Table 1. The textural analysis of the rabbit muscle at 3 and 7 days of ageing by WB showed an effect for shear force and area, having the meat after 3 days of aging a 5% and a 8% higher values for shear force and area, respectively, than meat after 7 days of aging. No days of aging effect was found for shear firmness. In the texture profile analysis, several meat texture properties differ between 3 and 7 days of aging. Rabbit muscle after 3 days of aging had 2% higher values for cohesiveness, 4% higher values for springiness and 8% higher values for chewiness than muscle after 7 days of aging. No effect was found for hardness. Gil *et al*. (2006) also found and improvement of meat tenderness measured by WB and TPA after 7 days of aging in rabbit loins. These authors pointed out that the improvement in meat tenderness could be related with the myofibrillar protein degradation pattern, which showed in samples aged 7 days an extra 30 kDa band respect to samples aged 1 day. This band could be attributed to the degradation of troponin T. No differences sex effect was found for instrumental texture characteristics measured by the WB and TPA methods.

Table 2 shows the features of the marginal posterior distributions of the ratios between aging time effects for sensory characteristics of rabbit meat. In agreement with instrumental texture, some evidence of diet effect can be found for meat tenderness. Rabbit loins after 3 days of aging were 12% harder than after 7 days of aging with a P>1 of 1. Nevertheless, there was a decrease in the intensity of rabbit odor with aging time, having a 6% more odor the meat after 3 days of aging than the meat after 7 days of aging, with a P>1 of 0.99. No storage time effect was found in juiciness and aniseed, liver and metallic flavor.

Table 3 shows the features of the marginal posterior distributions of the ratios between the different diets for instrumental texture variables measured by the WB and TPA methods. The largest differences appeared between A diet and the others. The results from the WB test showed a diet effect for shear force and area. Diet SF and diet L showed a 9% and 7% higher shear force than diet A with a P>1 of 98% and 95%, respectively. The total work performed to cut the sample or the area under the curve obtained, was an 11% higher in SF group than in A group (P>1 = 0.99). L group showed an 8% higher area than A group (P>1 = 0.94). No evidence of a diet effect was found between SF and L diets. The results from the TPA (Table 3) showed no diet effect for most of the traits. Only small differences appear for springiness. Loins from diet SF had higher values of springiness than diet L, and diet L showed lower values of springiness than diet A. Some of the texture variables measured indicates that the meat from group A could be more tender; however, no diet effect was found in hardness evaluated by sensory analysis. Table 4 shows the features of the marginal posterior distributions of the ratios among the diet effects for sensory characteristics of rabbit meat. No evidence of diet effect was found for all the characteristics measured.

Different studies confirm the possibility of increasing PUFA content in rabbit meat without a relevant alteration of sensory quality of the meat (Dal Bosco *et al*., 2004; Oliver *et al.*, 1994). Hernández *et al*. (2007) in a previous study in leg meat from rabbits fed with the same diets used in the present study found that the meat of the group A had higher saturated fatty acids than the meat from groups SF and L. Linoleic acid was greater in SF than in L group, and linolenic acid was superior in L group. These authors also studied the lipid oxidation. No differences between diets were found for TBARS values after 2 days of aging. However, after 5 aging days, meat from L group had higher TBARS value than meat from SF and A groups. Nevertheless, the values were well below the threshold level in which rancidity of warmed-over flavor could be detected. Thus, the different fatty acid composition seems to have no effect on sensory characteristic of rabbit meat.

Table 1: Features of the marginal posterior distributions of the ratios between refrigerated storage time effects for textural variables of *Longissimus* muscle of rabbits

			3 pm days/7 pm days		
	Mean	CVx100	Median	P>1	HPD
W-B					
Shear Force	3.19	20.5	1.05	0.95	0.991; 1.12
Shear firmness	1.58	21.6	1.00	0.53	0.936; 1.07
Area	4.75	21.4	1.08	0.98	1.01; 1.15
TPA Test					
Hardness	12	12.6	1.02	0.79	0.974; 1.06
Cohesiveness	0.486	5.83	1.02	0.96	0.998; 1.04
Springiness	0.480	7.30	1.04	1.00	1.01; 1.06
Chewiness	2.82	21.1	1.08	0.98	1.00; 1.16

pm: *post-mortem.* Units: Shear Force (kg), Shear firmness (kg/s), Area (kg s), Hardness (kg), Chewiness (kg). CV: coefficient of variation. P>1: probability of the ratio (3 pm days/7 pm days) being higher than 1. HPD: high posterior density interval at 95% of probability

Table 2: Features of the marginal posterior distributions of the ratios between refrigerated storage time effects for sensory characteristics of *Longissimus* muscle of rabbits

			3 pm days/7 pm days		
	Mean	CVx100	Median	P>1	HPD
J	1.00	49.3	0.979	0.25	0.916; 1.04
H	1.98	41.7	1.12	1	1.05; 1.18
IRO	2.31	33.6	1.06	0.99	1.00; 1.11
AF	0.443	85.3	1.00	0.49	0.890; 1.12
LF	1.59	39.8	1.01	0.71	0.963; 1.07
MF	0.835	66.9	0.924	0.07	0.833; 1.02

Juiciness (J), hardness (H), intensity of rabbit odor (IRO), aniseed flavor (AF), liver flavor (LF) and metallic/acid flavor (MF). pm: *post-mortem*. CV: coefficient of variation. P>1: probability of the ratio (3 pm days / 7 pm days) being higher than 1. HPD: high posterior density interval at 95% of probability

Table 3: Features of the marginal posterior distributions of the ratios among the diet effects for textural variables of *Longissimus* muscle of rabbits

	SF/L			SF/A			L/A		
	Median	P>1	HPD	Median	P>1	HPD	Median	P>1	HPD
W-B									
Shear Force	1.02	0.69	0.947; 1.10	1.09	0.98	1.01; 1.19	1.07	0.95	0.982; 1.16
Shear firmness	1.01	0.64	0.937; 1.11	1.07	0.92	0.978; 1.17	1.05	0.86	0.956; 1.14
Area	1.03	0.76	0.955; 1.12	1.11	0.99	1.02; 1.21	1.08	0.94	0.981; 1.16
TPA Test									
Hardness	0.992	0.39	0.939; 1.05	1.00	0.52	0.948; 1.06	1.01	0.63	0.955; 1.06
Cohesiveness	0.998	0.45	0.975; 1.03	1.01	0.70	0.982; 1.03	1.01	0.75	0.984; 1.04
Springiness	1.03	0.96	1.00; 1.06	0.990	0.25	0.962; 1.02	0.963	0.01	0.936; 0.995
Chewiness	1.01	0.60	0.926; 1.11	0.992	0.43	0.902; 1.08	0.982	0.35	0.882; 1.07

Animal fat (A), sunflower oil (SF), linseed oil (L) diets. Units: Shear Force (kg), Shear firmness (kg/s), Area (kg s), Hardness (kg), Chewiness (kg). P>1: probability of the ratio (SF/L, SF/A, L/A) being higher than 1. HPD: high posterior density interval at 95% of probability

Table 4: Features of the marginal posterior distributions of the ratios among the diet effects for sensory characteristics of *Longissimus* muscle of rabbits

	SF/L			SF/A			L/A		
	Median	P>1	HPD	Median	P>1	HPD	Median	P>1	HPD
J	0.946	0.08	0.870; 1.02	1.01	0.56	0.925; 1.09	1.06	0.94	0.980; 1.15
H	1.03	0.83	0.963; 1.11	1.01	0.58	0.938; 1.08	0.974	0.23	0.902; 1.04
IRO	0.995	0.42	0.936; 1.05	1.00	0.56	0.945; 1.06	1.01	0.62	0.95; 1.07
AF	0.927	0.13	0.807; 1.06	1.02	0.58	0.880; 1.17	1.10	0.91	0.951; 1.25
LF	0.977	0.23	0.916; 1.04	0.984	0.30	0.924; 1.05	1.01	0.60	0.946; 1.07
MF	0.952	0.22	0.840; 1.07	0.966	0.28	0.854; 1.09	1.01	0.59	0.900; 1.14

Animal fat (A), sunflower oil (SF) and linseed oil (L) diets. Juiciness (J), hardness (H), intensity of rabbit odor (IRO), aniseed flavor (AF), liver flavor (LF) and metallic/acid flavor (MF). P>1: probability of the ratio (SF/L, SF/A, L/A) being higher than 1. HPD: high posterior density interval at 95% of probability

CONCLUSIONS

The effect of enriching rabbit meat with long-chain n-3 and n-6 PUFA through dietary fat has a small effect on instrumental texture properties but seems to have no effect on sensory characteristics. Moreover, instrumental texture and sensory analysis confirms that ageing improved the tenderness of rabbit meat.

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