MEAT QUALITY OF RABBITS OF DIFFERENT GENOTYPES REARED IN DIFFERENT ENVIRONMENTAL CONDITIONS

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Abstract - The trial was carried out in order to study the rabbit meat quality of 85 day-old subjects in relation to genotype and temperature. New Zealand White (NZW), Grimaud (G) and Provisal (P) rabbits and rearing temperatures of 20 (Thermoneutrality=TN) and 28°C (Heat stress=HS) were compared. The pH of muscles of the intermediate and hind parts of the carcass did not changed either in relation to genotype or temperature, but the colour was affected (P<0.01) both by breed and environment. Genotype and experimental temperatures did not influenced the meat's water, protein and lipid content and cholesterol, sodium and potassium levels. P lipids presented higher (P<0.01) monounsaturated fatty acids (36.88 vs 35.02%) than NZW and G ones. The rearing at 28°C increased (P<0.01) C 14:0 (3.99 vs 3.59%), C 16:0 (33.38 vs 31.43%) and decreased (P<0.01) C 18:2 (16.99 vs 18.82%). The stressed rabbits presented intramuscular lipids with a higher (P<0.01) content of saturated fatty acids (47.11 vs 44.37%) and a lower (P<0.01) polyunsaturated fatty acid content (18.05 vs 20.22%) and Iodine value (63.41 vs 69.33); the PCL/PCE ratio was higher (P<0.01) in TN rabbit meat (1.07 vs 0.95).

INTRODUCTION

The positive qualitative and organoleptic requisites of rabbit meat in comparison to other meat are well-known (OUHAYOUN and LEBAS, 1987; OUHAYOUN, 1992). The quality of rabbit meat has been studied in relation to many factors such as feeding (CAMBERO *et al.*, 1991a, b; COBOS et al., 1995), sex (PARIGI-BINI et al., 1992) and age (CAMBERO et al., 1991a, b; PARIGI-BINI et al., 1992). The indications available on the effect of genotype and environmental conditions of rabbit meat quality refer only to some purebreds and hybrids (DELTORO and LOPEZ, 1987; CAMBERO *et al.*, 1991a, b; RISTIC and ZIMMERMANN, 1992; BERNARDINI BATTAGILINI *et al.*, 1995) and consider the comparison between seasonal conditions (LEBAS and OUHAYOUN, 1987; DELTORO *et al.*, 1988).
The aim of the present work is the study of the effect of three different genotypes and two rearing temperatures on the meat quality of growing rabbits.

MATERIALS AND METHODS

The trial was carried out on 57 weaned male rabbits (35 day-old) belonging to New Zealand White (NZW-21 animals), Grimaud (G-18 animals) and Provisal (P-18 animals) genotypes. The latter two groups were four-way crossbred commercial type rabbits. The animals were housed into two rooms at average temperatures of 20°C (Thermal neutrality condition=TN-28 animals) and 28 °C (Heat stress condition=HS-29 animals); the relative humidity averaged 83% and 70%, respectively. The photoperiod was 8D:16L (40 lux). The rabbits were fed "ad libitum" a commercial pellet (dry matter=89.33%; crude protein=17.18% d. m.; crude fiber=15.48% d. m.; digestible energy=10.57 MJ/kg as feed basis). The rabbits were reared up to 85 days of age and then slaughtered at a body weight of about 2.8 kg. At 3 and 24 h after slaughtering, pH measurements on muscles of the intermediate and hind parts of the carcass were recorded using a Hanna Instruments pH-meter with Ingold electrodes (Refill 9811). On some commercial carcass muscles, colour data (CIE La*b* system) were recorded using a Minolta colorimeter (Chroma Meter-CR 100). On the left hindleg the muscles were separated from the bone without heating, the obtained meat was then freeze-dried and analyzed for water, protein, lipid and ash contents using official methods (A.O.A.C., 1984). Cholesterol content was measured using the enzyme-colorimetric method with the Boehringer Biochemia kit n. 139050 (LUKEFAHR et al., 1989). Sodium and potassium concentrations were determined by atomic absorption (A.O.A.C., 1984). The fatty acid composition of intramuscular hindleg lipids was analyzed by gas-chromatography (N.G.D., 1976). The PCL/PCE was calculated as the ratio between the hypocholesterolemic (PCL=Plasma Cholesterol Lowering) and hypercholesterolemic fatty acids (PCE=Plasma Cholesterol Elevating) (REISER and SHORLAND, 1991) where: PCL/PCE= (Polyunsaturated FA + 1/2 monounsaturated FA) / (lauric acid + myristic acid + palmitic acid). The fat's Iodine value was calculated as the sum of the iodine numbers of each unsaturated fatty acid (CAMBERO et al., 1991a).

All the data were submitted to variance analysis using the following model (HARVEY, 1991):

$Y_{ijk} = \mu + G_i + T_j + (GT)_{ij} + e_{ijk}$

where:

Y_{ijk}**Erreur! Signet non défini.** = experimental data; μ=overall mean; G_i=fixed effect of -ith genotype (i=1, 2, 3); T_j=fixed effect of -jth thermal levels (j=1, 2); $(GT)_{ij}$=effect of interaction; e_{ijk} = residual random error.

RESULTS AND DISCUSSION

The Tables provide only the main effects because no significant interaction between breed and temperature was found.

Table 1: pH, colorimetric data measured on some muscles of the carcass

		Genotype			Temperature		
		NZW	G	P	HS	TN	s.e.*
pH							
Psoas major		5.97	6.06	6.07	6.04	6.02	0.24
Long. dorsi		6.33	6.33	6.34	6.34	6.33	0.18
Biceps femoris		6.14	6.18	6.18	6.19	6.14	0.22
Colour							
Psoas major	L	52.32	51.87	52.22	52.76^{a}	51.51^{b}	2.39
	a*	5.80	5.75	5.97	5.37^{b}	6.31^{a}	0.83
	b*	3.39	3.55	3.89	3.33	3.86	1.07
Longissimus. dorsi	L	56.27	56.44	56.30	57.77^{A}	55.60^{B}	3.02
	a*	2.42^{A}	2.02^{B}	1.68^{B}	1.83	2.25	1.03
	b*	0.40	0.62	0.62	0.99^{A}	0.15^{B}	1.73
Biceps femoris	L	52.17^{A}	52.52^{A}	51.04^{B}	53.05^{A}	51.47^{B}	1.83
	a*	3.11	3.57	3.44	2.87^{b}	3.57^{a}	0.77
	b*	3.90^{ab}	3.53^{b}	4.21^{a}	3.20^{B}	4.20^{A}	1.16

$^{a, b}$: Values with different superscript differ by P<0.05; $^{A, B}$: Values with different superscript differ by P<0.01; *: 51 degrees of freedom

Meat pH and colour data

The pH and colour data are shown in Table 1. The pH data (the average of the values collected at 3 and 24 h after slaughter) of some carcass muscles did not differ among the genotypes considered. pH values can change in relation to breed (RISTIC and ZIMMERMANN, 1992), but the differences observed are generally slight (OUHAYOUN and DALLE ZOTTE, 1993). The colour data are similar among the breeds in terms of psoas major, while the *longissimus dorsi* and biceps femoris muscles presented different values. The *longissimus dorsi* presented a higher (P<0.01) redness (a*) value in NZW than in hybrid rabbits, while the biceps femoris showed a higher (P<0.01) lightness (L) value in NZW and G rabbits. The yellowness (b*) value was higher (P<0.05) in P biceps femoris and lower in NZW and G ones. Other researches observed a significant effect of genotype on muscle colour (RISTIC and ZIMMERMANN, 1992).

The rearing temperature did not influence muscle pH values, but altered the colour: the lightness (L) values of psoas major (P<0.05), *longissimus dorsi* (P<0.01) and biceps femoris (P<0.01) muscles were higher in the HS group, while redness values were lower (P<0.05). A contrasting trend was observed for yellowness values of *longissimus dorsi* and biceps femoris.

Meat chemical composition

Table 2 presents the chemical composition of the hindleg meat. The chemical analysis of the meat provided similar water, protein, lipid and ash values for all the three genotypes. Other findings obtained from other genotypes show either the presence (RISTIC and ZIMMERMANN, 1992) or the absence (PERRIER and OUHAYOUN, 1990) of differences in meat chemical composition and attribute such differences primarily to the different degree of somatic maturity achieved and the speed with which such maturity has been reached

(OUHAYOUN, 1980). The meats of purebred and hybrid subjects reveal similar cholesterol, sodium and potassium contents.
As concerns the chemical composition of the meat in relation to environmental temperature, HS hindleg meat presents similar water, protein and lipid content percentages when compared with those of TN animals. The rearing environmental conditions did not affect also the cholesterol, sodium and potassium contents, either. The existing literature does not provide indications on the effect of genotype or temperature on chemical composition of rabbit meat.

Table 2. Meat chemical composition

		Genotype			Temperature		
		NZW	G	P	HS	TN	s.e.*
Reference carcass	g	1413	1415	1440	1345^{B}	1500^{A}	76
Water	%	72.26	72.47	72.60	72.62	72.27	0.93
Proteins	%	22.48	22.47	22.34	22.40	22.45	0.36
Lipids	%	3.46	3.41	3.18	3.25	3.45	0.61
Ash	%	1.27	1.25	1.24	1.25	1.24	0.05
Cholesterol	mg/100 g	62.5	64.7	63.7	64.4	62.9	4.8
Sodium	mg/kg	522	554	561	547	544	73
Potassium	mg/kg	3799	3768	3746	3748	3793	232

$^{A, B}$: Values with different superscript differ by P<0.01; *: 51 degrees of freedom

Meat fatty acid composition

The fatty acid composition of the hindleg meat lipids is summarized in Table 3. There are no significant differences among the three genotypes. The literature available provides little information on the effect of breed on the fatty acid composition of rabbit meat. CAMBERO *et al.* (1991a, b) found a significant effect of breed (Hyla and New Zealand White), and in particular on the fatty acids C 16:0, C 18:0 and C 18:2. BERNARDINI BATTAGILINI *et al.* (1995) observed a fatty acid compositions substantially similar among different crossbred rabbits.
The acidic composition of lipids was affected by thermal conditions. The HS rabbit meat lipids presented significantly higher (P<0.01) percentages of some saturated fatty acids in particular myristic (C 14:0) and palmitic (C 16:0) acids, when compared to the TN subjects. Regarding the monounsaturated fatty acids, the miristoleic (C 14:1) (P<0.01) and palmitoleic (C 16:1) (P<0.05) acid percentage values are higher in HS than TN subjects, but the opposite was true for C15:1 (P<0.01). On the contrary, polyunsaturated fatty acids such as linoleic (C 18:2) and linolenic (C 18:3) acids decreased (P<0.01) at higher environmental temperature. LEBAS and OUHAYOUN (1987) obtained different results, under experimental conditions that differed from ours..
Table 3 shows also the proportion of each fatty acid group, the PCL/PCE ratio and the Iodine value. There is a similarity of values among the three breeds for saturated fatty acids, but significant (P<0.01) differences in unsaturated, in particular in monounsaturated fatty acids, that resulted higher (P<0.01) in P lipids than NZW and G ones. The PCL/PCE ratio was similar in the three genotypes. The rabbit meat presented similar Iodine value for the NZW, G and P groups.
As regards temperature, HS treatment increased (P<0.01) the saturated fatty acid proportion and lowered (P<0.05) the unsaturated fatty acid fraction, and in particular, the polyunsaturated acids (P<0.01). Consequently, the PCL/PCE ratio changed significantly (P<0.01): the meat of the rabbits reared under conditions of thermal neutrality presented a more favourable ratio than the meat of the heat-stressed animals because of the marked effect on the fatty acid composition cited above. The Iodine value of the meat also was influenced by environmental conditions, resulting higher (P<0.01) in TN meat with respect to the HS one.
In conclusion, the results demonstrate that at a body weight of 2.8 kg the three genotypes studied presented some similar meat characteristics, such as the pH and chemical composition of muscles. NZW and G rabbit meat lipids presented a lower content of monounsaturated fatty acids than P rabbits. In 85 day-old rabbits, heat stress conditions did not affect the pH and chemical composition of the meat, whereas intramuscular lipids presented higher saturated fatty acid contents, in particular C 14:0, C 16:0 and C 17:0 and lower percentages of polyunsaturated fatty acids, such as C 15:1, C 18:2 and C 18:3 than TN rabbit meat. As a result the PCL/PCE ratio and the Iodine value were higher for TN meat than HS meat.

Table 3: Fatty acid composition, PCL/PCE ratio and Iodine value of inframuscolar lipids

		Genotype			Temperature		
		NZW	G	P	HS	TN	s.e.*
- C12:0	%	0.53	0.50	0.51	0.58^{A}	0.45^{B}	0.08
- C14:0	%	3.86	3.63	3.89	3.99^{A}	3.59^{B}	0.35
- C14:1	%	0.40	0.37	0.40	0.41^{A}	0.37^{B}	0.05
- C15:0	%	0.76	0.79	0.78	0.76	0.79	0.09
- C15:1	%	0.47	0.47	0.47	0.41^{B}	0.53^{A}	0.09
- C16:0	%	32.85	32.23	32.13	33.38^{A}	31.43^{B}	1.94
- C16:1	%	5.23	5.45	5.93	5.90^{a}	5.17^{b}	1.12
- C17:0	%	0.83	0.81	0.84	0.86^{A}	0.79^{B}	0.08
- C17:1	%	0.38	0.43	0.43	0.45^{A}	0.38^{B}	0.24
- C18:0	%	7.02	7.14	7.17	7.22	7.00	0.91
- C18:1	%	28.06	28.05	29.29	28.38	28.55	1.70
- C18:2	%	17.66	18.03	18.01	16.99^{B}	18.82^{A}	1.24
- C18:3	%	0.90	1.05	0.94	0.86^{B}	1.06^{A}	0.70
- C20:0	%	0.16	0.15	0.18	0.17	0.16	0.03
- C20:1	%	0.37	0.37	0.36	0.38^{a}	0.35^{b}	0.05
Saturated	%	46.16	45.42	45.64	47.11^{A}	44.37^{B}	2.53
Unsaturated	%	53.27^{B}	54.23^{B}	56.83^{A}	53.99^{b}	55.56^{a}	2.27
Monounsaturated	%	34.89^{B}	35.15^{B}	36.88^{A}	35.93	35.34	2.03
Polyunsaturated	%	18.56	19.08	18.95	18.05^{B}	20.22^{A}	1.46
PCL/PCE		0.97	1.01	1.06	0.95^{B}	1.07^{A}	0.04
Iodine value		66.72	67.22	65.17	63.41^{B}	69.33^{A}	5.15

$^{a, b}$: Values with different superscript differ by P<0.05; $^{A, B}$: Values with different superscript differ by P<0.01; *: 51 degrees of freedom

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Caratteristiche qualitative della carne cunicola in funzione del tipo genetico e della temperatura di allevamento. E' stata realizzata una prova al fine di studiare l'effetto del genotipo e della temperatura ambientale sulle caratteristiche qualitative della carne cunicola in soggetti di 85 giorni di età. Allo scopo sono stati posti a confronto conigli Nuova Zelanda Bianchi (NZW), Grimaud (G) and Provisal (P) e livelli termici di 20 (termoneutralità=TN) and 28°C (stress da caldo=HS). Il pH dei muscoli della parte mediana e posteriore della carcassa non è variato in funzione nè del genotipo nè delle condizioni termiche di allevamento, mentre il colore degli stessi si è modificato in maniera significativa ($P<0.01$) in funzione sia dell'assetto genetico che della temperatura. Il contenuto in acqua, proteine e lipidi delle carni ed il tasso di colesterolo, sodio e potassio non ha subito variazioni in funzione del genotipo e della temperatura. I conigli P hanno fornito carni con un più elevato ($P<0.01$) contenuto di acidi grassi monoinsaturi (36.88 vs 35.02%) rispetto ai soggetti NZW e G. Nei conigli allevati a 28°C si è osservato un aumento ($P<0.01$) di C14:0 (3.99 vs 3.59%), C 16:0 (33.38 vs 31.43%) ed una diminuzione di C 18:2 (16.99 vs 18.82%). I soggetti HS hanno presentato un grasso inframuscolare più ricco ($P<0.01$) di acidi grassi saturi (47.11 vs 44.37%), più povero ($P<0.01$) di acidi grassi poliinsaturi (18.05 vs 20.22%) e con un corrispondente numero di iodio più basso (63.41 vs 69.33). Il rapporto PCL/PCE è risultato più elevato ($P<0.01$) nella carne fornita dai soggetti allevati in condizioni di termoneutralità (1.07 vs 0.95).