Proceedings 5th World Rabbit Congress, 25-30 July 1992, Corvallis – USA, 819-826.

EFFECT OF SLAUGHTER AGE AND WEIGHT ON CARCASS AND MEAT QUALITY OF THE COMMERCIAL RABBIT

R. Parigi-Bini, G. Xiccato, M. Cinetto, A. Dalle Zotte

Dipartimento di Scienze Zootecniche, Via Gradenigo 6 - 35131 Padova - Italy

Abstract

Sixty growing "hybrid" rabbits (30 males and 30 females) were individually allocated in metabolism cages. Twelve (6 males and 6 females) were slaughtered weekly, at 9, 10, 11, 12 and finally 13 weeks of age.

The sex had no effect on carcass traits or meat quality, while the slaughter age significantly influenced both carcass traits and meat quality.

As slaughter age increased, dressing percentage also increased (from 58.8% of l.w. at 9 weeks to 61.4% at 13 weeks, $P<0.01$) and chilling losses decreased (from 3.4% of l.w. to 2.5%, respectively).

The muscle to bone ratio (m/b), a "meatiness" index, also increased ($P<0.01$) with age, both in hindleg (from 7.69 at 9 weeks to 9.64 at 13 weeks) and in carcass (from 6.38 to 7.95, respectively).

The same trend was shown by perirenal and scapular fat ("adiposity" index) (from 1.9% and 0.6% of the "reference" carcass at 9 weeks to 3.3% and 0.9% at 13 weeks, respectively).

The chemical composition of *l. dorsi* muscle differed from that of hindleg muscles and was influenced by age. At all ages, *l. dorsi* m. contained more water and protein and less fat than hindleg muscles. The latter contained more Na and cholesterol than *l. dorsi* m. (46.6 mg/100 g *vs* 37.1 mg/100 g and 59.6 mg/100 g *vs* 47.8 mg/100 g, respectively) ($P<0.01$). The minimum level of Na and cholesterol was found in *l. dorsi* m. of rabbits slaughtered at 13 weeks of age (33.4 mg/100 g and 44.8 mg/100 g, respectively).

The fatty acids (FA) composition of perirenal and scapular fat also changed with age, showing an increased unsaturated FA to saturated FA ratio (1.32 to 1.45; $P<0.01$). The increased proportion of unsaturated FA was mostly due to higher levels of monounsaturated FA (mainly palmitoleic and oleic acids) which increased with age.

The Iodine value and PCL-FA to PCE-FA ratio did not significantly change with age.

Introduction

In the last few years there has been a renewed interest in the carcass and meat quality of the commercial rabbit. The reasons for this are based on the growing concerns expressed in the market and by consumers regarding the safety and quality of animal foods. Therefore, a more exact definition of "carcass and meat quality" must be established, together with the characteristics to measure and the experimental procedures to use for purposes of data comparison with other laboratories.

The aim of the present research was to study the effect of age and weight at slaughter on some traits defining carcass and meat quality of the commercial rabbit.

Materials and methods

Sixty young rabbits (30 males and 30 females) of a commonly raised commercial "hybrid" (Provisal S.p.A., Molinella, Bologna, Italy) were allocated in individual metabolism cages,

about two weeks after weaning (when 48 days old). After 7 days of dietary transition, all animals were fed *ad libitum* with a commercial fattening diet. The pelleted diet was based on dehydrated lucerne meal, wheat bran, barley and wheat meal, soybean and sunflower extracted meal, minerals and vitamins (DM: 905 g/kg; CP: 170 g/kg; CF: 132 g/kg; DE: 10.14 MJ/kg; DP: 125 g/kg).

The apparent digestibility of nutrients and energy was measured by "ingesta-excreta" balance carried out on 20 rabbits between 70 and 76 days of age.

From 9 to 13 weeks of age, 12 rabbits (6 males and 6 females) were slaughtered each week. After slaughter, the pelt, distal portion of legs, blood, urinary bladder and digestive tract were removed to obtain the "commercial" carcass, which was refrigerated for 24 h at 4 °C. Then, the head, lungs, thymus gland, trachea, heart, liver and kidneys were removed to obtain the "reference" carcass. This latter was dissected to separate the perirenal and scapular fat. The *l. dorsi* m. and both hindlegs (excluding the sacral bone) were also separated. The muscles of the left hindleg and those of the rest of the "reference" carcass were separated from bones by heating them in water in sealed bags under vacuum (2 h 30 min at 80 °C) in order to calculate the muscle to bone ratio (m/b). The right hindleg was also dissected without heating. The muscles of this leg and the *l. dorsi* m. were freeze-dried and analyzed for chemical and mineral composition and energy value (A.O.A.C., 1984). Cholesterol was also measured in both muscles using an enzyme-colorimetric method (Boehringer Biochemia no. 139050; Lukefahr *et al.*, 1989). Perirenal and scapular fat were analyzed by gas-chromatography (N.G.D., 1976). Experimental data were statistically analyzed by the least square method (Harvey, 1987) according to a factorial design (sex x muscle or fat site x slaughter age). The covariate "slaughter weight at the same age" was also considered.

Results and discussion

In this paper, only the main effect of slaughter age (and muscle or fat site) will be considered. In fact, the effect of sex was not significant for most of the data collected.

Carcass traits

The data in table 1 show that slaughter age had an obvious effect on slaughter weight. Both hot and cold dressing percentages increased as slaughter age increased ($P<0.01$). This linear trend is explained by the reduction of slaughter losses and particularly by the reduced percentage of digestive tract weight as age at slaughter increased. Moreover, the difference between hot and cold dressing percentages (*i.e.*, chilling losses) was smaller when slaughter age increased (3.4% at 9 weeks to 2.5% at 13 weeks). These results confirm experimental observations by others (Ouhayoun, 1986 and 1990).

The dissection of the "reference" carcass (table 2) shows that perirenal and scapular fat increase with age at slaughter. However, the body muscle mass simultaneously increased as well, while bone weight percentage decreased (linear component, $P<0.01$).

Consequently, the muscle to bone ratio (both of the "reference" carcass and of the hindleg) also increased linearly. The hindleg m/b ratio and that of the carcass were highly correlated ($r=0.83$; $P<0.01$) and the former can be assumed as a good index of the "meatiness" of the rabbit carcass. This correlation has been found by others (Varewyck and Bouquet, 1982; Lambertini *et al.*, 1991). The new finding from the present research is that the m/b ratio increase linearly until the 13th week of age, after the average slaughter weight had exceeded 3 kg. On the contrary, Ouhayoun (1986 and 1990) observed the maximum m/b ratio in rabbits slaughtered at 11 weeks of age, when the slaughter weight was about 2.4 kg. Thereafter, the m/b ratio remained constant or showed a declining trend. These contrasting results can be related to genetic differences of the rabbits in trial. The "hybrid" rabbit used in the present work is particularly suitable for a "heavy" rabbit production (2.8 to 3.0 kg market weight), while in the experiments of Ouhayoun the rabbits were more-suited for a "medium" weight production.

In any case, it is evident that more research work is required in the field of the meat rabbit breeds or "hybrids" used today.

As regards as the effect of weight "per se" (*i.e.*, weight at the same age), only a few va-

riables were concerned: among them, the proportion of perirenal fat (which increases 0.2% per each 100 g of extra live weight at the same age, P<0.05); the proportion of the head (plus 0.2%, P<0.01) and that of the liver (plus 0.3%, P<0.01), respectively. The scarce effect of weight "per se" can be explained in terms of growth allometry. As shown by Ouhayoun (1983), the development of muscles and bones is much more dependent on somatic maturity (namely, on the percentage of the adult weight reached at a certain age) than on the weight at the same age.

Meat composition and quality

The chemical analysis of hindleg and *l. dorsi* muscles confirmed the good dietetic quality of rabbit meat, which is low in fat and high in protein (table 3). The chemical composition of *l. dorsi* m. was significantly different from that of hindleg muscles. The latter were higher in fat (45 *vs* 21 g/kg, P<0.01), in minerals and in energy (6.77 *vs* 6.03 MJ/kg, P<0.01) and lower in protein and water than *l. dorsi* m. The very high Ca content of hindleg muscles in comparison with *l. dorsi* m. (9.3 *vs* 2.7 mg/100 g) may be due to contamination with bone consequent to dissection. As reported by others (Janieri, 1987; Lawrie, 1966; Ouhayoun, 1984), rabbit meat appears to be higher in P, K and Mg and lower in Ca, Fe and especially in Na than other meats. The concentration of Na appears to be higher in hindleg than in *l. dorsi* muscles (46.6 *vs* 37.1 mg/100 g, P<0.01) (figure 1). The explanation is that Na is an extra-cellular element and consequently is more concentrated in muscular portions containing several muscles (as in the hindleg) than in single hypertrophic muscle such as *l. dorsi* m.

The effect of age at slaughter on meat composition and quality was also highly significant. In fact, when slaughter age increased from 9 to 13 weeks, the fat content of meat also increased (from 28 to 35 g/kg, linear component: P<0.01), while water and minerals decreased. The Na concentration decreased with age (figure 1) and the minimum Na level (33.4 mg/100 g) was detected in *l. dorsi* m. of rabbits slaughtered when 13 weeks old.

The cholesterol level of rabbit meat is on average lower than that of other meats (Janieri, 1987; Lukefahr *et al.*, 1989). As shown in figure 2, the cholesterol concentration was higher in hindleg than in *l. dorsi* muscles and it decreased with age in both muscles. This trend can be explained by the fact that 60-80% of the cholesterol contained in muscles is linked to cell membrane, the proportion of which decreases as muscle mass increases (Hoelscher *et al.*, 1988). As for Na, the minimum cholesterol level (44.8 mg/100 g) was observed in the *l. dorsi* m. of rabbits slaughtered at 13 weeks of age.

Fat composition and quality

Perirenal and scapular fat differed significantly in the proportion of saturated and unsaturated FA (table 4 and, for more details, table 5). In particular, perirenal fat was lower in saturated FA and higher in monounsaturated and polyunsaturated FA than scapular fat. Moreover, perirenal fat was higher in linoleic and linolenic acids than scapular fat (19.05% *vs* 18.24% of total FA, P<0.01 and 6.42% *vs* 6.20% of total FA, P<0.05, respectively). Myristic and stearic acids were lower in perirenal fat (P<0.01), while both fats had the same level of palmitic acid (about 30% of the total FA, on average). Consequently, the calculated PCL-FA to PCE-FA ratio was higher in perirenal than in scapular fat (1.26 *vs* 1.20, P<0.01). The composition of depot fat can be assumed as representative of that of intramuscular fat (Raimondi *et al.*, 1975a and 1975b), even if there is some difference between the two. Intramuscular fat is normally higher in arachidonic acid than depot fat (3-4% of total FA *vs* 0.2-0.5%) and lower in linolenic acid (1-3% *vs* 5-7%, respectively). The other FA are contained in similar proportion both in intramuscular and in depot fat (Ouhayoun and Lebas, 1987). From the dietetic point of view, the rabbit fat approaches the "ideal fat" recommended for human nutrition by the National Cholesterol Education Program (1988), namely 1/3 of saturated FA, 1/3 of monounsaturated FA and 1/3 of polyunsaturated FA.

Slaughter age significantly modified the composition of rabbit fat (tables 4 and 5). The proportion of saturated FA linearly decreased with age (from 43.2% of total FA at 9 weeks to 40.9% at 13 weeks) and that of unsaturated FA increased. However, the increased proportion of unsaturated FA was due to a higher level of monounsaturated FA (from 29.7% of the total FA at 9 weeks to 34.6% at 13 weeks), while the proportion of polyunsaturated FA decreased with age. In particular, the above age-dependent variations were mostly due to the increased proportions of palmitoleic (from 4.88% of total FA at 9 weeks to 6.77% at 13

weeks, P<0.01) and of oleic acids (from 24.06% to 26.93%, P<0.01, respectively), while linoleic and linolenic acids decreased linearly with age. The short-chain saturated FA (capric and lauric acids) were strongly reduced as age increased (P<0.01).

Conclusions

In addition to confirming previous knowledge, the results of the present research have provided new elements for the evaluation of rabbit carcass and meat quality, as influenced by slaughter age and weight.

The age at slaughter seems to be the most important factor of variability of carcass "meatiness" and "adiposity", as measured by muscle to bone ratio and by perirenal fat proportion, respectively. The weight "per se", measured at the same age, was much less important.

Moreover, the age at slaughter significantly influenced the quality of meat and fat. The meat of the more mature rabbit (*i.e.*, about 12 weeks of age and about 2.8 to 3.0 kg market weight) contained less water, the same protein and a little more fat and energy than that of the younger and lighter rabbit. The dietetic value of this more mature meat is high, containing a low level of fat, Na and cholesterol. Moreover, the fat of this meat contains more monounsaturated than polyunsaturated FA. This is favourable for human nutrition and meat conservation.

All these aspects justify the current trend of a part of the Italian market which shows a preference for a more mature and relatively heavier meat rabbit.

References

A.O.A.C. - Association of Analytical Chemists. 1984. *Official Methods of Analysis of the Association of Official Analytical Chemists*. 14th Edition. Association of Official Analytical Chemists, Washington, DC.

Harvey, W.R. 1987. *LSMLMW-PC1 Version. Mixed model. Least-squares and maximum likelihood computer program*. Department of Dairy Science. Ohio State University. Columbus, Ohio 43210.

Hoelscher L.M., Savell J.W., Smith S.B. and Cross H.R. 1988. Subcellular distribution of cholesterol within muscle and adipose tissue of beef loin steaks. *J. Food Sci.*, 53, 718, 722.

Janieri A. 1987. Qualità nutritive delle carni di coniglio. *Coniglicoltura*, 24 (1), 27-29.

Lambertini L., Benassi M.C. and Zaghini G. 1991. Ricerche sugli elementi di previsione delle componenti tessutali della carcassa di coniglio. *Coniglicoltura*, 28 (8), 35-39.

Lawrie R.A. 1966. *Meat science*. Pergamon Press, Oxford.

Lukefahr S.D., Nwosu C.V. and Rao D.R. 1989. Cholesterol level of rabbit meat and trait relationships among growth, carcass and lean yield performances. *J. Anim. Sci.*, 67, 2009-2017.

National Cholesterol Education Program - NCEP 1988. Rapport of the National Cholesterol Education Program expert panel on detection, evaluation and treatment of high blood cholesterol in adult. Cited by Reiser e Shorland (1990).

N.G.D. (Norme Grassi e Derivati). 1976. Determinazione della composizione degli acidi grassi mediante analisi gas-cromatografica. Metodo NGD C42. In *Norme italiane per il controllo dei grassi e derivati*. Stazione Sperimentale per le industrie degli oli e dei grassi, Milano.

Ouhayoun J. 1983. La croissance et le developpement du lapin de chair. *Cuni-Sciences*, 1 (1), 1-15.

Ouhayoun J. 1984. Croissance et qualités bouchères du lapin. *Cuniculture*, n. 58, 11 (4), 181-188.

Ouhayoun J. 1986. La qualité de la viande de lapin; valorisation des carcasses par leur alourdissement. *Cuniculture*, n. 69, 13 (3),143-150.

Ouhayoun J. 1990. La carne di coniglio di allevamento intensivo. *Atti del Convegno: Allevamento intensivo e produzione della carne di coniglio*, American Soybean Association, Bologna, 53-87.

Ouhayoun J. and Lebas F. 1987. Composition chimique de la viande de lapin. *Cuniculture*, n.73, 14 (1), 33-35.

Raimondi R., Auxilia M.T., Masoero G. and De Maria C. 1975a. Effetto della grassatura dei

mangimi sulla produzione della carne di coniglio. II - Risultati delle prove di cottura e di assaggio delle carni. *Ann. Ist. Sper. Zootec.*, 8, 89-99.

Raimondi R., De Maria C., Auxilia M.T. and Masoero G. 1975b. Effetto della grassatura dei mangimi sulla produzione della carne di coniglio. III - Contenuto in acidi grassi delle carni e del grasso perirenale. *Ann. Ist. Sper. Zootec.*, 8, 167-181.

Reiser R. and Shorland F.B. 1990. Meat fats and fatty acids. In Pearson A.M., Dutson T.R. (Eds.) *Meat and health. Advances in meat research*. Volume 6, 21-62. Elsevier Science Publishers Ltd., London.

Varewick H. and Bouquet Y. 1982. Relations entre la composition tissulaire de la carcasse de lapins de boucherie et celle des principaux morceaux. *Ann. Zootech.*, 31 (3), 257-268.

This research was carried out with a grant from the Ente di Sviluppo Agricolo del Veneto, Italy (Del. n. 1/C/89).

Table 1: Slaughter data and dressing percentage

		Slaughter Age (weeks)					Statistical significance(1)
		9	10	11	12	13	
Animals(2)	no.	12	12	12	12	12	
Slaughter live weight	kg	2.07	2.34	2.60	2.83	3.07	P<0.01
Feed conversion (55 days to slaughter weight)		4.48	4.59	4.87	5.06	5.18	P<0.01
Dressing percentage (hot)(3)		58.8	60.0	60.2	61.0	61.4	P<0.01
Dressing percentage (cold)(3)		55.4	56.8	57.3	58.3	58.9	P<0.01
Slaughter losses:							
Blood	% l.w.	2.3	2.5	2.3	2.5	2.7	n.s.
Digestive tract	"	20.4	18.4	17.3	16.3	15.7	P<0.01
Pelt + distal legs	"	17.7	18.1	19.0	19.4	19.0	P<0.01
Other losses(4)	"	0.8	1.0	1.2	0.8	1.2	n.s.

1) Linear component

2) 6 males and 6 females per age

3) ("Commercial" carcass weight/Slaughter l.w.) x 100
"Commercial" carcass = Slaughter l.w. - (pelt + distal legs + blood + digestive tract + urinary bladder)

4) Urine, bladder and other losses

Table 2: "Reference" carcass and hindleg composition and muscle to bone ratio

		Slaughter Age (weeks)					Statistical significance(1)
		9	10	11	12	13	
Animals	no.	12	12	12	12	12	
"Reference" carcass(2)	kg	0.91	1.07	1.23	1.36	1.50	P<0.01
Perirenal fat	% of "refer." carc.	1.9	2.4	2.6	3.2	3.3	P<0.01
Scapular fat	"	0.6	0.5	0.8	1.0	0.9	P<0.01
Muscle	"	84.2	83.7	84.0	84.5	85.1	P<0.01
Bone	"	13.3	13.4	12.6	11.3	10.7	P<0.01
Muscle to bone ratio(3)		6.38	6.27	6.75	7.54	7.95	P<0.01
Left hindleg							
Muscle	g	125.1	146.3	166.0	184.5	204.2	P<0.01
Bone	"	16.4	18.8	19.7	19.9	21.2	P<0.01
Muscle to bone ratio(3)		7.69	7.82	8.52	9.27	9.64	P<0.01

1) *Linear component*

2) Refrigerated "commercial" carcass - (head + lungs + thymus gland + trachea + heart + liver + kidneys)

3) The left hindleg and the remaining portions of the "reference" carcass were dissected after heating in sealed bags under vacuum (2 h 30 min at 80 ° C)

Table 3: Chemical composition and mineral content of rabbit meat (hindleg and *l. dorsi* muscles)

		Muscles		Slaughter Age (weeks)					Statistical significance(1)
		Hindleg	L. dorsi	9	10	11	12	13	
Analyses	no.	60	60	24	24	24	24	24	
Water	g/kg	726^{B}	746^{A}	739	738	735	734	734	P<0.01
Crude protein(2)	"	216^{B}	221^{A}	220	218	217	218	219	n.s.
Fat	"	45^{A}	21^{B}	28	32	36	36	35	P<0.01
Ash	"	12.6^{A}	12.0^{B}	12.7	12.3	12.3	12.3	11.8	P<0.01
Energy	MJ/kg	6.77^{A}	6.03^{B}	6.26	6.27	6.46	6.52	6.49	P<0.01
Ca	mg/100 g	9.3^{A}	2.7^{B}	6.3	7.0	5.0	5.9	5.7	n.s.
P	"	230.0^{A}	222.3^{B}	232.6	228.7	224.7	220.2	224.5	P<0.01
Mg	"	29.3	28.3	28.9	29.0	28.1	28.2	29.7	n.s.
K	"	427.7	430.9	437.2	421.1	424.6	440.7	422.5	n.s.
Na	"	46.6^{A}	37.1^{B}	45.5	43.5	41.8	39.9	38.6	P<0.01
Fe	"	1.34^{A}	1.13^{B}	1.34	1.22	1.14	1.27	1.19	n.s.

A,B: P<0.01; a,b: P<0.05

1) *Linear component*

2) The protein content was obtained by difference and includes glycogen

Table 4: Quality of perirenal and scapular fat

		Fat		Slaughter Age (weeks)					Statistical
		Perirenal	Scapular	9	10	11	12	13	significance(1)
Analyses	no.	60	53	22	21	22	24	24	
Saturated FA	%	40.9^{B}	42.5^{A}	43.2	41.8	41.4	41.2	40.9	P<0.01
Unsaturated FA	"	59.1^{A}	57.5^{B}	56.8	58.2	58.6	58.8	59.1	P<0.01
Monounsaturated FA	"	33.1^{A}	32.5^{B}	29.7	32.7	33.1	34.0	34.6	P<0.01
Polyunsaturated FA	"	26.0^{B}	25.0^{A}	27.1	25.5	25.5	24.8	24.5	P<0.01
Iodine value(2)		82.5^{A}	79.9^{B}	81.9	81.2	81.6	80.8	80.7	n.s.
PCL-FA to PCE-FA ratio(3)		1.26^{A}	1.20^{B}	1.21	1.22	1.24	1.23	1.24	n.s.

A,B: P<0.01; a,b: P<0.05

1) Linear component

2) Calculated on the basis of each FA percentage

3) PCL-FA = Plasma Cholesterol Lowering FA (polyunsaturated FA + ½ monounsaturated FA)
PCE-FA = Plasma Cholesterol Elevating FA (lauric ac. + myristic ac. + palmitic ac.)

Table 5: Fatty acid composition of perirenal and scapular fat

		Fat		Slaughter Age (weeks)					Statistical
		Perirenal	Scapular	9	10	11	12	13	significance(1)
Analyses	no.	60	53	22	21	22	24	24	
Fatty acids:									
Capric (C10:0)	% Total FA	0.49	0.56	0.96	0.45	0.53	0.48	0.20	P<0.01
Lauric (C12:0)	"	0.55	0.49	0.83	0.49	0.51	0.44	0.31	P<0.01
Myristic (C14:0)	"	3.27^{B}	3.68^{A}	3.47	3.43	3.50	3.52	3.46	n.s.
Myristoleic (C14:1)	"	0.51	0.47	0.34	0.46	0.56	0.57	0.54	P<0.01
Pentadecanoic (C15:0)	"	0.67^{A}	0.63^{B}	0.72	0.63	0.64	0.67	0.58	P<0.01
Palmitic (C16:0)	"	29.72	30.05	30.12	30.26	29.54	29.69	29.77	n.s.
Palmitoleic (C16:1)	"	6.37^{a}	5.92^{b}	4.88	6.07	6.53	6.49	6.76	P<0.01
Heptadecanoic (C17:0)	"	0.73	0.70	0.80	0.70	0.68	0.73	0.65	P<0.01
Heptadecenoic (C17:1)	"	0.45	0.41	0.42	0.42	0.42	0.47	0.42	n.s.
Stearic (C18:0)	"	5.50^{B}	6.41^{A}	6.30	5.86	5.96	5.72	5.92	P<0.05
Oleic (C18:1)	"	25.76	25.72	24.06	25.73	25.54	26.46	26.93	P<0.01
Linoleic (C18:2)	"	19.05^{A}	18.24^{B}	19.72	18.54	18.67	18.17	18.14	P<0.01
Linolenic (C18:3)	"	6.42^{a}	6.20^{b}	6.91	6.43	6.34	6.06	5.81	P<0.01
Higher than C18	"	0.51	0.51	0.47	0.52	0.52	0.54	0.50	n.s.

A,B: P<0.01; a,b: P<0.05

1) Linear component

Figure 1: Sodium level in rabbit meat as influenced by slaughter age

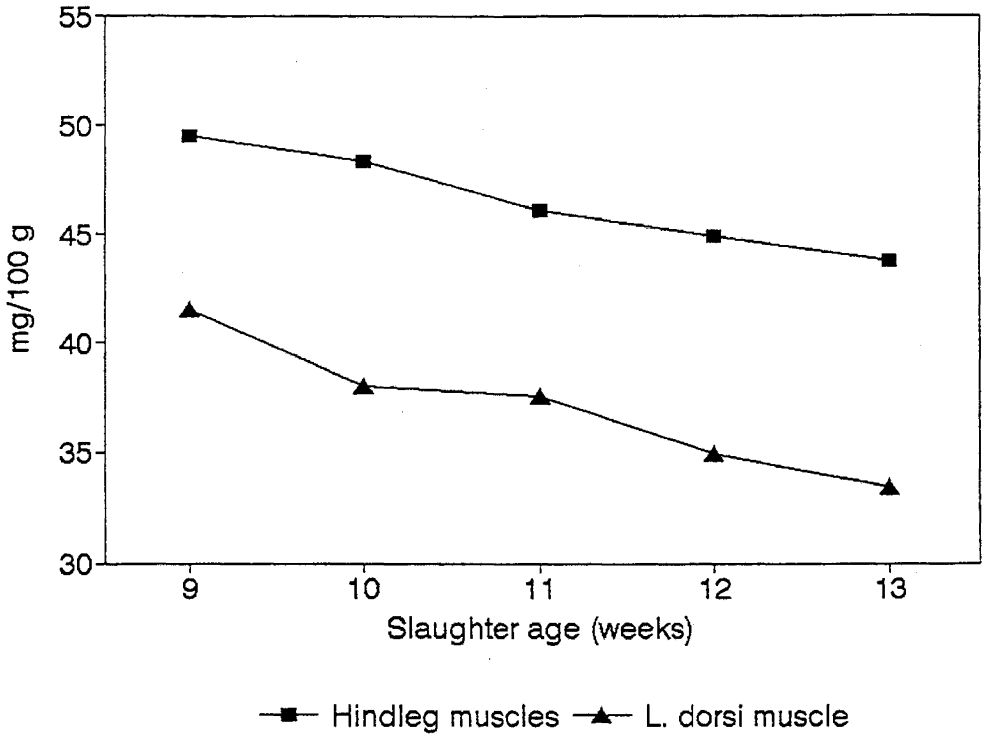

Figure 2: Cholesterol level in rabbit meat as influenced by slaughter age