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Rabbit meat production as affected by a delayed-weaning technique

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SUMMARY – Nowadays there is an increasing interest towards breeding systems, also for rabbit meat production, more mindful of animal welfare through an attenuation of the productive cycle intensity. These particular rearing techniques provide a delaying of the weaning age to reduce stress in young rabbits. The present research investigated the influence of weaning age on 192 crossbred rabbits (New Zealand White x Californian) divided in two experimental groups weaned at 28 (W28) and 63d (W63) respectively. From the statistical analysis significant differences emerged by comparing resulting data from W28 *vs* W63 rabbits, concerning productive parameters, commercial traits and composition of carcasses, meat chemical-nutritional characteristics.

Keywords: Weaning age, productive performance, meat, rabbit.

***RESUME* – *"Production de viande de lapin selon une technique se sevrage retardé". L'intérêt pour des systèmes d'élevage de lapin à viande respectueux du bien-être des animaux est grandissant. La conduite plus souple des cycles de production et un sevrage tardif des lapereaux font partie des techniques testées. Le présent travail concerne l'influence de l'âge du sevrage sur les performances zootechniques (croissance, composition des carcasses) et technologiques de la viande. En situation d'élevage contrôlé, 192 lapins croisés (Néo-Zélandais Blanc x Californien), sont considérés et divisés en deux groupes sevrés respectivement à 28 (W28) et 63 (W63) jours. Les résultats montrent des différences significatives entre les deux lots sur les paramètres de production, la composition et la qualité commerciale des carcasses, les caractéristiques chimiques-nutritionnelles de la viande.*

Mots-clés : *Age au sevrage, performances productives, viande, lapin.*

Introduction

The weaning age has been significantly anticipated in virtue of the deep variations occurred within the rabbit rearing during the last two decades. In particular, its transformation from rural to exquisitely industrial has implied the intensification of the rearing techniques with a productive answer typically quantitative. The weaning age has been anticipated also to improve the corporal condition of reproductive rabbit does by shortening the lactation period. But inevitably, the excessive exploitation of the rabbit species has seen as a consequence the spreading of several conditioned pathologies (Marongiu *et al.,* 2004).

The increased interest in "ethical quality" of meat (Dal Bosco *et al.,* 2002) has led to the implementation, also for rabbit production, of less intensive breeding systems, that are more mindful of animal welfare. These particular rearing techniques provide a delaying of the weaning age to reduce young rabbits stress. The present research aimed to investigate the rabbit meat production as affected by a delayed-weaning technique by comparing two experimental groups of rabbits weaned at 28 and at 63 days of age respectively. The survey was carried out in a Sardinian farm where rabbits are usually weaned at about 60 days of age. Surely this managerial choice could be considered rather questionable but from a scientific point of view could also represent a unique opportunity to examine *in vivo* productive performance, carcasses commercial traits and composition, meat chemical-nutritional characteristics of rabbits submitted to such a late weaning.

Materials and methods

Animals

The trial was carried out on a total of 192 crossbred rabbits (New Zealand White x Californian) belonging to 24 litters. At birth litters were equalized at eight kits all individually weighted. Rabbit does were given *ad libitum* a commercial pelleted feed and suckled by their kits once daily in the morning. Individually conducted live weights of litters were weekly recorded. At 28 days of age half the litters were weaned, that is to say 96 subjects (W28) were separated from their mothers successively to the weekly live weight recording. After weaning, rabbits were fed *ad libitum* a commercial pelleted feed (16.5% protein, 2520 kcal/kg ME) and given free access to water. They were housed two to a cage kept in a room with artificial ventilation and a 16h light-8h dark schedule. The following parameters were weekly and individually recorded: live weight; daily solid feed intake; daily weight gain. A late weaning was performed at 63 days of age on the remaining 96 experimental rabbits (W63). After weaning they were reared with the same modalities and submitted to the same weekly controls with regard to the rabbits previously weaned at 28 days. Rabbits were all slaughtered at 83 days of age. Care and use of animals were performed in accordance with the guidelines established by the European Community (no. 86/609/CEE) and approved by the Italian Ministry of Health (L. n. 116/92) regarding animal treatment and commercial slaughtering.

Carcass measurements

Immediately prior slaughter all experimental rabbits live weights (LW) were recorded. The rabbits were rendered unconscious by electric stunning and killed by exsanguinations. Blood was removed and the net live weight (NLW) was individually calculated subtracting the blood weight from the LW values. The carcasses were prepared by removing skin, distal legs, genital organs, urinary bladder and gastrointestinal tract (Blasco *et al.,* 1993). Hot carcasses were weighted (HCW), dressing out percentage (DP) was calculated and pH was measured 30 minutes after slaughter (pH_{30min}). After refrigeration at 2°C for 24 h cold carcasses weights (CCW) were recorded and ultimate pH (pH_u) measured. Head, lungs, thymus gland, trachea, heart, liver and kidneys were removed and carcasses were classified, by visual examination, using a scale of 5 ± scores for the conformation, fatness and colour of carcasses (ASPA, 1991 with our adaptation). The main linear measurements were also effectuated on cold carcasses hanging from a 18 cm wide hook peculiar to maintain carcass hind legs 18 cm wide: body length, loin width, chest width, carcass length, chest depth and leg length. Carcasses were then dissected to measure fat content and muscle to bone ratio (M/B) (Parigi Bini *et al.,*1992a).

Meat analyses

From 18 carcasses of W28 and 18 of W63 group the left hind legs were isolated and the meat was milled for moisture and ash analysis (AOAC, 2000). Fat was analysed according to Folch *et al.* (1957) and the protein content was calculated by difference. Hydroxyproline (ASPA, 1996) allowed to determine the collagen content (Sorensen, 1981). Meat samples were frozen at -18°C prior mineral analysis. The mineralization in Microware ETON D (Millistone) was performed using an Atomic Absorbance Spectrometer (SpectrAA220, Varian). Fatty acid composition was determined after extraction (Folch *et al.,* 1957) and metilation (Christies, 1989), by using a GC ThermoQuest series 8000Top (column Omega-Wax 320cm X 0.25*µ*m Supelco). The n6/n3 ratio as well as the atherogenic (IA) and thrombogenic (IT) indexes were calculated from the fatty acid composition, as suggested by Ulbricht and Southgate (1991).

Statistical analyses

Comparison between means was effectuated by the Student-Newman-Keuls *t*-test. Meat data were analysed by ANOVA (SAS, 2000) using the model: $Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$, where Y is the single observation, μ the general mean, α the age at weaning effect (i = 28 or 63d), ε the error.

Results and discussion

The productive performance from birth to slaughter of experimental rabbits are reported in Table 1. Mean values of live weight at 83 days and daily weight gain from 64 to 83 days of the two experimental groups W28 *vs* W63 (2167 *vs* 1837 g; 28.4 *vs* 18.0 g) showed highly significant differences (P<0.01). W28 rabbits also performed a greater daily feed intake (113.0 *vs* 88.9; P<0.05) and a better feed conversion index (3.979 *vs* 4.439; P<0.05).

Table 1. Main productive traits of rabbits. Means ± s.d. and statistical significance

	W28	W63	Significance
Live weight (g)			
0 d	58±11	57±9	ns
28 d	493±25	521±42	ns
63 d	1600±28	1477±125	ns
83 d	2167±21	1837±121	**
Daily weight gain (g/d)			
0-28 d	15.6±0.6	16.6±0.9	ns
29-63 d	31.6±0.	27.3±2.5	ns
64-83 d	28.4±1.3	18.0±6.4	**
Daily feed intake (g/d)			
29-63 d	78.1±13.5	--	
64-83 d	113.0±36.5	88.9±42.8	*
Feed conversion index			
29-63 d	2.472±0.057	--	
64-83 d	3.979±0.044	4.439±0.149	*

ns = not significant; * = P<0.05; ** = P<0.01.

Main commercial characteristics of carcasses at slaughter are shown in Table 2. Data about W28 carcasses appear to be in agreement with other researches carried out on rabbits slaughtered at the same age (Parigi Bini *et al.,* 1992a; Bernardini *et al.,* 1994). The dressing out percentage of carcasses, which is considered a very important economic variable in the rabbit market, was significantly higher in W28 compared to W63 group (59.71 *vs* 51.71 %; P<0.05). Moreover, except for pH_{30min}, all the considered traits showed statistically significant differences between the two experimental groups.

Data concerning the carcass conformation, using a 5 ± scores evaluation scale, put in evidence a better result of W28 in comparison to W63 carcasses. W28 group was evaluated quite good also from a commercial point of view, considering that 82.3 % of the carcasses were scored 2±.

In Table 3 are presented the linear measurements of rabbit carcasses. It can be noticed that loin width, chest width and chest depth measurements of W28 carcasses were significantly higher compared to W63 experimental group (12.4 *vs* 11.3 cm, P<0.01; 9.0 *vs* 8.2 cm, P<0.01; 6.5 *vs* 6.1 cm, P<0.05). The linear measurements values obtained in the present survey appear in disagreement with previous researches (Battaglini *et al.*, 1993; Lukefahr and Ozimba, 1991). Nevertheless the mentioned studies report some linear measurement effectuated *in vivo* and at different ages. Therefore the main linear measurements of carcasses could represent an additional tool for supporting the evaluation of rabbit meat production.

Table 4 shows the average coefficients of correlation between the linear measurements and the dressing out percentage of carcasses. These correlations, expect for the loin width and the chest width, resulted closer between the linear measurements and dressing out percentage of W28 carcasses if compared to the correlations of W63 group. In particular, the closest coefficient of correlation (r=0.844) resulted between the chest depth and the dressing out percentage of W28 carcasses.

Table 2. Commercial traits of carcasses. Means ± s.d. and statistical significance

	W28	W63	Significance
Live weight (LW) (g)	2167±157	1837±100	**
Net live weight (NLW) (g)	2102±110	1787±91	*
Hot carcass weight (HCW) (g)	1294±98	950±82	**
Cold carcass weight (CCW) (g)	1179±96	829±73	*
pH_{30min}	6.45±0.22	6.50±0.24	ns
pH_u	6.08±0.16	6.24±0.17	**
Dressing out percentage (DP) (%)	59.71±8.05	51.71±6.12	*
Incidence (%) on NLW:			
Carcass	61.56±8.08	53.16±6.44	*
Head	5.19±0.14	6.94±0.18	**
Skin	13.13±2.01	14.87±2.08	**
Distal legs with skin	6.85±0.32	7.93±0.52	**
Lungs, thymus and trachea + heart	2.95±0.02	3.96±0.03	*
Empty gastrointestinal tract	5.42±0.15	6.88±0.17	**
Gastrointestinal fat	0.90±0.01	0.75±0.01	**
Blood	2.90±0.02	3.31±0.03	*
Genitals + losses	1.10±0.01	2.20±0.02	**

ns = not significant; * = P<0.05; ** = P<0.01

Table 3. Linear measurements of carcasses (cm). Means ± s.d. and statistical significance

	W28	W 63	Significance
Body length	32.8±1.0	32.3±1.0	ns
Loin width	12.4±0.7	11.3±0.8	**
Chest width	9.0±0.4	8.2±0.	**
Carcass length	26.9±1.0	26.8±1.0	ns
Chest depth	6.5±0.6	6.1±0.	*
Leg length	16.5±0.8	16.2±0.7	ns

ns = not significant; * = P<0.05; ** = P<0.01

Table 4. Mean coefficients of correlation (r) between the linear measurements and the dressing out percentage of carcasses

Linear measurements	Dressing out percentage		Significance
	W28	W63	
Body length	0.659	0.070	**
Loin width	-0.063	0.242	*
Chest width	0.347	0.512	*
Carcass length	0.633	0.224	*
Chest depth	0.844	0.176	**
Leg length	0.392	0.316	ns

ns = not significant; * = P<0.05; ** = P<0.01

Table 5 synthesizes the average composition and the meat to bone ratio of carcasses. Resulting data about W28 group appear in agreement with other studies considering similar carcass traits (Pla *et al.,* 1998; Parigi-Bini *et al.,* 1992a). In W28 carcasses the fat percentage was significantly higher while the bone percentage significantly lower when compared to W63 carcasses (4.3 *vs* 2.4 %, P<0.01; 11.3 *vs* 13.4, P<0.01). Consequently, also the meat to bone ratio was significantly higher in W28 group (7.54 *vs* 6.28, P<0.01).

Table 5. Average composition and meat to bone ratio (M/B) of carcasses

	n	Fat %	Muscle %	Bone %	M/B
W63	96	2.4^{B}	84.2	13.4^{A}	6.28^{B}
W28	96	4.3^{A}	84.4	11.3^{B}	7.54^{A}

A, B: P<0.01

According to that, the meat chemical composition (Table 6) showed significant differences for fat, higher in W28 rabbits. At this regard, it seems appropriate specify that it was not possible to measure the solid feed intake of suckling rabbits (allowed to consume the same diets of the mothers). On the other hand, the feed intake of W28 group was significantly higher in the period 64 - 83d (113 *vs* 89 g/d; P<0.05). Our data are anyhow in agreement with those reported by other authors (Parigi-Bini *et al.,* 1992b; Nizza and Moniello, 2000). Although collagen content was higher in W28 rabbits, there were not significant differences between groups.

Table 6. Chemical composition of meat

	n	Moisture %	Ash %	Protein %	Total Fat %	Collagen mg/100g
W63	18	71.79±1.65	1.47±0.11	24.11±2.91	2.63^{b}±0.69	47.66±5.06
W28	18	72.32±2.15	1.44±0.18	23.22±3.42	3.02^{a}±0.73	49.10±6.52

a, b: P<0.05

With regard to the macro and micro mineral meat composition (Table 7), in agreement with the values reported by Parigi-Bini *et al*. (1992b), the most important differences consisted in iron (1.25 *vs* 0.93 mg/100g, P<0.01), copper (0.17 *vs* 0.14 mg/100g, P<0.05) and manganese (0.03 *vs* 0.02 mg/100g, P<0.05) contents, significantly higher in W28 rabbits.

Table 7. Mineral composition (mg/100g) of meat

	Ca	P	Na	Mg	Fe	K	Se	Cu	Mn	Zn
W63	10.91	212.78	60.22	31.35	0.93^{B}	440.81	24.54	0.14^{b}	0.02^{b}	1.58
n=18	(1.90)	(25.28)	(5.86)	(2.73)	(0.07)	(29.03)	(3.74)	(0.04)	(0.004)	(0.23)
W28	10.33	210.42	62.42	30.78	1.25^{A}	432.90	24.27	0.17^{a}	0.03^{a}	1.59
n=18	(1.38)	(30.87)	(6.24)	(2.91)	(0.10)	(27.02)	(3.12)	(0.03)	(0.006)	(0.25)

(…) standard deviation; A, B: P<0.01; a, b: P<0.05

Table 8 shows the meat fatty acid (FA) composition as well as the atherogenic and thrombogenic indexes by weaning age. The W63 rabbits meat, looking at FA expressed as percentage of total determined FA, showed significantly higher saturated FA (SFA, 43.0 *vs* 40.3%, P<0.05) and lower monounsaturated FA contents (20.3 *vs* 23.7%, P<0.01). This could be presumably due to the longer lasting milk intake in W63 rabbits. As a matter of fact does milk, in terms of FA composition, consists for about 80% in SFA (Castellini *et al.,* 2004). There were not differences in total polyunsaturated FA content while higher C18:2 and C18:3 (P<0.05) levels were found in W28 group. This could be explained by the earlier and more conspicuous vegetable feed intake performed by the W28 rabbits, considering that the origin of these fatty acids are not endogenous but it is the result of diet: cereals particularly provides linoleic acid and lucerne linolenic acid. Our fatty acid profile data appear in accordance with those recently reported by Ramírez *et al.* (2005).

Table 8. Fatty acid composition (means ± s.d.) of meat

	W63 (n=18)	W28 (n=18)	W63 (n=18)	W28 (n=18)
	mg/100g of meat		% of total FA	
C14:0	47.01^{B}±4.44	54.72^{A}±4.03	2.58±0.29	2.77±0.32
C16:0	584.9^{B}±40.2	658.6^{A}±59.44	32.15±4.81	33.34±4.17
C18:0	137.9^{b}±11.33	151.6^{a}±17.37	7.57±2.55	7.68±1.58
C20:0	7.14^{a}±1.63	6.43^{b}±1.52	0.39±0.09	0.33±0.08
C22:0	5.78±0.94	5.15±1.34	0.32±0.12	0.26±0.10
SFA†	782.8^{B}±71.33	876.6^{A}±70.14	43.01^{a}±3.06	40.30^{b}±2.51
C18:1	359.7^{B}±32.55	502.8^{A}±41.70	19.74^{B}±1.36	25.44^{A}±2.91
C20:1	7.87±0.89	7.99±0.78	0.43±0.02	0.40±0.05
C22:1	3.08^{B}±0.65	4.37^{A}±0.63	0.17^{B}±0.02	0.22^{A}±0.03
MUFA†	370.6^{B}±32.59	515.1^{A}±42.45	20.34^{B}±1.36	23.69^{A}±1.11
C18:2	603.7^{B}±47.46	708.9^{A}±48.93	33.17±4.95	35.91±4.09
C18:3	63.16^{B}±5.24	73.36^{A}±3.57	3.47^{b}±0.21	3.72^{a}±0.40
PUFA†	666.8^{B}±58.2	782.3^{A}±52.38	36.64±2.03	36.01±3.24
n6/n3	9.56±1.22	9.66±1.93	-	-
IA	0.75^{A}±0.03	0.68^{B}±0.02	-	-
IT	1.14^{A}±0.04	1.04^{B}±0.06	-	-
Total FA, g/100g	1.82^{B}±0.15	2.17^{A}±0.14		

Between columns: A, B: P<0.01; a, b: P<0.05.
† SFA: Saturated fatty acids; MUFA: Mono-unsaturated fatty acids; PUFA: Poly-unsaturated fatty acids.

Finally, W63 group also displayed less favourable atherogenic and thrombogenic indexes. Thus, W63 meat seems also related to dietary-nutritional characteristics less corresponding to the modern requirements of consumers, mainly focused on the well known relationship of meat fat composition with human cardiovascular diseases.

However, it has to be considered that consumers' definition of meat quality in developed countries not only includes nutritional properties such as appropriate proportions of bioactive compounds, proteins, lipids and their essential sub-constituents, healthiness such as fat and saturated fatty acids, but also views or perception about the conditions of animal production in relation to animal welfare (Dalle Zotte *et al.,* 2002). Moreover, meat sensory characteristics are crucial for the "traditional" consumer's choice: the appearance (colour and consistency of the raw meat), texture (tenderness and juiciness) and flavour (taste, smell and aroma). For this reason, it is our intention to get this investigation completed by performing a tasting test with regard to W28 and W63 meat products.

Conclusions

An extremely delayed weaning, beside being not convenient in terms of farm economy, affects the rabbit meat production by getting *in vivo* productive performance and carcass commercial traits worse. It seems also related to a meat product with dietary-nutritional characteristics less corresponding to the modern link meat quality-human health (fatty acid profile, atherogenic and thrombogenic indexes), if compared to the 28 days-weaning technique. On the other hand, a less intensive rearing system is surely more mindful of animal welfare, which is a concept nowadays of increased interest for several consumers.

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