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Organic poultry production system and meat characteristics

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Abstract

The effect of the organic poultry production system on some qualitative characteristics of the meat is reported. The effect is mainly due to the greater age and physical activity of animals but it is largely modulated by the farming protocols used e.i., genetic strain (fast and slow-growing strains) and pasture availability. Due to economic reasons and chicks availability, generally fast or intermediate-growing chicks are used. Such animals are not adapted to the organic system and health and welfare problems caused by leg disorders and lameness are recurrent. Nevertheless, compared to conventional chickens, the carcasses have higher breast and drumstick percentages and a lower level of abdominal fat. Even the physical-chemical characteristics of the meat are affected: muscles have lower final pH and water holding capacity. Instead cooking loss, lightness, shear values, Fe, and polyunsaturated fatty acids increase. Unfortunately, the greater physical activity increases the oxidative metabolism of the body and determines a higher level of TBA-RS. Slow-growing strains, probably due to their particular behaviour (more kinetic activity, foraging) and metabolism, show larger differences in qualitative traits, compared to both conventional and organic fast-growing strains. In particular, with respect to fast-growing strains, they have a higher antioxidant level (715 vs 522 nmol HClO mL^{-1}), serum α-tocopherol (19.0 vs 17.2 mg L^{-1}) and grass ingestion. As a result, the oxidative stability of fresh and stored meat is much higher than fast-growing strains (2.0 vs 3.05 mg MDA kg^{-1}). In conclusion, the organic poultry production system seems to be an interesting alternative method especially if suitable farming protocols will be developed and used.

According to the National Organic Standards Board (1995) the primary aim of organic agriculture is the optimizing of an ecological production management that promotes and enhances biodiversity, environmental sustainability and food safety.

However, for animal production recommendations and compulsory rules provided by the REG 1809/99 outline the productive methods with effects on animal welfare and on the characteristics of the products are expected.

In organic poultry production the most important factors affecting meat characteristics are the slaughter age (minimum 81 d) and the physical activity of birds. Clearly, other factors as the genetic strain, the pasture availability and the farming protocols modulate the extent of such effects and many experimental efforts need to fully optimize this system.

The availability of pasture increases the motor activity of chickens but many behavioural differences arise from the comparison of slow-growing strains (S) with fast-growing strains (F) (Castellini *et al.,* 2003; Lewis *et al.*, 1997). Fast-growing animals are not adapted to the organic system and health and welfare problems are recurrent, but economic reasons and limited chicks availability render these animals widely used in organic poultry production (Network for Animal Health and Welfare in Organic Agriculture, 2002).

Although F birds have a faster growing rate, the organic rearing system greatly reduces their growth potential decreasing of about 25% their performance obtained under conventional system. Evidently, F birds do not perform well under poor environmental conditions, whereas intensive rearing provides them with what is needed to cover all of their physiological needs (Reiter and Bessei, 1996). On the contrary, S genotype show almost the same performance in organic farming (-8% data not shown) indicating a superior degree of adaptation.

Selection for high production rates modifies animal behaviour (Schütz and Jensen, 2001) reducing all the activities involving high energetic costs and allowing birds to reallocated the saved energy to production traits. These birds, reared in free-range or kept inside, make little use of pasture and tend to stay indoors or near the house, rather than forage in the pasture (Weeks *et al.*, 1994) probably due to the excessive weight and to leg weakness. This account agrees with welfare problems, high culling and mortality rates of F birds organically reared (Jones and Hocking, 1999).

In contrast, S strains show a more active behaviour (Bokkers and Koene, 2003; Lewis *et al.*, 1997), with more walking activity, less lying and more interest in the observer; even more they spend more time outdoor than indoor and have a shorter time of tonic immobility (Table 1).

The differences in behaviour are confirmed by the comparative analysis of crop content (Table 2). The crop of S chickens has less protein and energy and higher amounts of α–tocopherol and carotenoids, indicating higher grass ingestion (Castellini *et al.*, 2003). Consequently, these genotypes show a better *in vivo* antioxidant capacity (715 *vs* 522 nmol HClO mL^{-1}) ascribable to a greater intake of antioxidants and to higher motor activity. In fact, higher oxidative metabolism increases free-radical production (Alessio *et al.,* 2000) and consequently the body enhances his antioxidant capacity (Powers and Leeuwenburgh, 1999). In such contest the intake of grass by organic chicks should be considered crucial to increase antioxidant defence for the high amount of carotenoids (102.10 mg kg d.m.$^{-1}$) α-tocopherol (175.25 mg kg d.m.$^{-1}$) and polyphenols assumed with pasture (Lopez-Bote *et al.,* 1998).

The organically reared birds have carcasses (Table 3) which, compared to conventional ones, have higher breast and drumstick percentages and a lower level of abdominal fat (mainly S types). Further, the final pH (pH_u) of breast and drumstick is lower probably for the higher amount of glycogen stored in muscle by more mobile animals (Dal Bosco *et al.*, 2001).

At the age of slaughtering, the low rate of maturity of S birds, determines high moisture content, less protein and Water Holding Capacity. S strains reach commercial maturity later and need a longer rearing period, they need more than 75 d to achieve 50% of the adult body weight, whereas F ones need only 50 d (Castellini *et al.*, 2003).

The comparison of S *vs* F shows that pH_u is superior in S chicks probably for the highest oxidative metabolism and the number of mitochondria in α-white fibres and hence turns them in α-red (Dransfield and Sosnicki, 1999) with an effect even in the muscle iron.

The fatty acid composition of breast and drumstick is not affected by strains (Table 4), whereas differences respect to conventional chicken meat are important. The data are in agreement with those reported by O'Keefe *et al.* (1995) and confirm the poor deposition of EPA compared with DHA in chicken (Richardson and Mead, 1999).

Several hypotheses could be done to explain the better oxidative status of the fresh and stored meat obtained in S genotypes respecting to F ones (Figure 1): the lower lipid level; the different reaction of muscular fibres to physical activity and the higher antioxidant intake.

Unfortunately, compared to the commercial broiler, the organic poultry meat show higher TBA-RS values that decrease the shelf-life of products. The lower lipid stability of organic poultry meat could be ascribed to the higher content of metallic ions (Fe) that catalyse peroxidation, and to the greater degree of unsaturation of intramuscular lipids (Castellini *et al.,* 2002ab).

A possible strategy to improve the meat oxidative status could be that of reducing the motor activity of animals few days before slaughtering. Slow-growing birds organically reared and submitted to a restriction of movement strongly reduce TBARS (-26%), by lowering ROMS level (-33%) without essential reduction in the antioxidant capacity (-11%; Castellini *et al.,* 2004). Further, this reduction of movement improved muscle acidification (< pH_u in breast muscle) probably due to the higher amount of glycogen at slaughter in turn caused by the lower consumption of glycogen.

In our trials the sensorial analysis of meat of S and F strains showed an overall preference for S birds in comparison to F one (Figure 2) which is not discriminated from conventional broiler (Castellini *et al.,* 2003). The capacity of a panel to discriminate meat from different genotypes is largely debated (Richardson and Mead, 1999) and many authors have reported interactions and not univocal results (Farmer *et al.,* 1997).

In conclusion, even if the qualitative characteristics of products are not the main goal of organic farming, the applications of suitable protocols (grass availability, slow-growing strains) have important repercussions on poultry meat. Unfortunately, these aspects are not obligatory for the organic farmers, and a change of Regulation 1804/99 should be appropriate permitting to attain further improvements in the qualitative aspects and welfare.

As for other productive sector, organic farming has special research and service needs and it is not advisable to import productive protocols tailored for intensive systems (diets, environments and genetic strains).

In particular, the role of slow-growing breeds as an organic product could be strengthened if future research would confirm their ability to perform with lower quality feed, and to produce meat with well-differentiated qualitative characteristics (low lipid, high PUFA, and Fe, good shelf-life). It is clear that such strains, requiring a very long fattening period (until 120 d) result in high production costs, and would require a special market niche even with an organic label. It would be advisable to studies crosses between S animals and heavier genotype, in order to improve the growth rate trying to maintain the specific behaviour and qualitative characteristics.

Further, many S strains are in danger of extinction and organic farming should be considered an important chance to assure their preservation.

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Table 1 Behaviour pattern of different poultry strains (from Castellini *et al.*, 2003 modified).

behaviour		Slow-growing	Fast-growing	Significance
Initial interest	%	60	31	*
Time spent outdoors	% total time	65	35	*
Lying	"	54.0	62.5	*
Walking	"	12.0	8.0	*
Standing	"	18.5	16.0	n.s.
Eating	"	7.5	8.5	n.s.
Others	"	8.0	5.0	n.s.
Tonic immobility	sec	41	110	*

*: $P \leq 0.05$; n.s. not significant

Table 2 Chemical composition of the crop content in slow- and fast-growing strains organically reared and in vivo antioxidant capacity (from Castellini *et al.*, 2003, modified).

Strain		Slow-growing	Fast-growing	Significance
Crude protein	%	10.0	12.4	*
Ether extract	"	2.9	3.5	n.s.
NDF	"	10.2	9.8	n.s.
ADF	"	6.3	5.7	n.s.
Carotenoids	mg kg^{-1}	21.2	19.1	*
α-tocopherol	mg kg^{-1}	38.5	36.2	*
Antioxidant capacity	μmol HClO mL^{-1}	715	*522*	*
serum α-tocopherol	mg L^{-1}	19.0	*17.2*	*

*: $P \leq 0.05$; n.s. not significant

Table 3 Main characteristics of carcass, breast and drumstick in conventional or organic reared chicken strains (from Castellini *et al.*, 2002a b modified).

Strain		Conventional	Slow-growing	Fast-growing	Significance (organic *vs* conventional)
Carcass					
Abdominal fat	% carcass weight	1.9	0.3	1.0	*
Breast	"	22.0	12.0	25.2	*
Drumstick	"	14.8	16.7	15.5	*
Breast					
Moisture	%	75.54	76.01	75.73	n.s.
Protein	"	22.39	22.71	22.76	n.s.
Fat	"	1.46	0.49	0.81	*
Ash	"	0.61	0.79	0.70	n.s.
pH_u		5.96	5.82	5.75	*
Shear force	kg/cm^2	1.98	2.66	2.69	*
Water holding capacity	%	52.02	53.65	53.49	*
Fe total	$mg\ kg^{-1}$	3.40	6.45	4.15	*
Drumstick					
Moisture	%	76.02	77.19	76.89	n.s.
Protein	"	19.01	19.32	19.28	n.s.
Fat	"	4.46	2.49	2.99	*
Ash	"	0.51	1.00	0.84	*
pH_u		6.18	6.14	6.03	*
Shear force	kg/cm^2	2.39	3.07	3.12	*
Water holding capacity	%	59.69	57.08	57.45	*
Fe total	$mg\ kg^{-1}$	6.22	9.48	6.93	*
*: $P \leq 0.05$; n.s. not significant					

Table 4 Major fatty acids (% total fatty acids) in breast and drumstick muscles of in conventional or organic reared chicken strains (from Castellini *et al.*, 2002ab modified).

Strain	Conventional	Slow-growing	Fast-growing	Significance (organic *vs* conventional)
Breast				
Σ SFA	34.68	38.77	38.05	*
Σ MUFA	33.89	29.22	29.41	*
Σ PUFA	31.43	32.01	32.54	*
C20:5(n-3) EPA	0.45	0.54	0.57	n.s.
C22:6(n-3) DHA	0.96	1.89	1.92	*
Σ (n-3)	4.52	5.08	5.16	*
Drumstick				
Σ SFA	33.90	36.54	36.43	*
Σ MUFA	38.07	31.79	31.73	*
Σ PUFA	28.03	31.67	31.84	*
C20:5(n-3) EPA	0.21	0.35	0.36	n.s.
C22:6(n3) DHA	0.38	1.23	1.26	*
Σ (n-3)	3.34	4.78	4.81	*
*: $P \leq 0.05$; n.s. not significant				

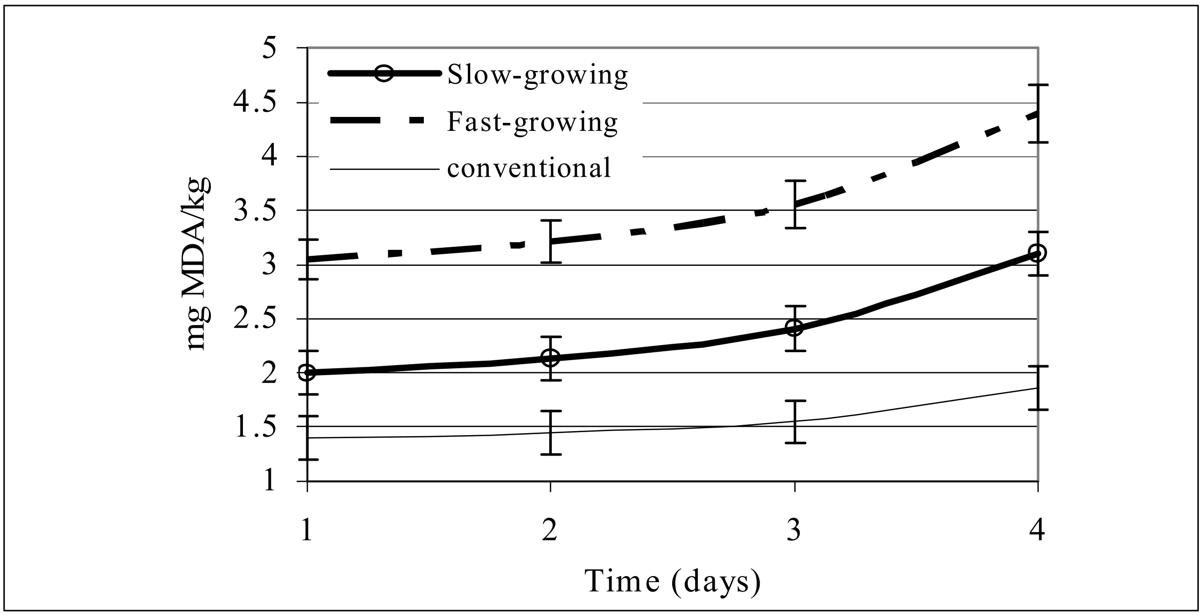

Figure 1 TBA-RS in *pectoralis major* during display (95% upper and lower limits, from Castellini *et al.,* 2002b modified).

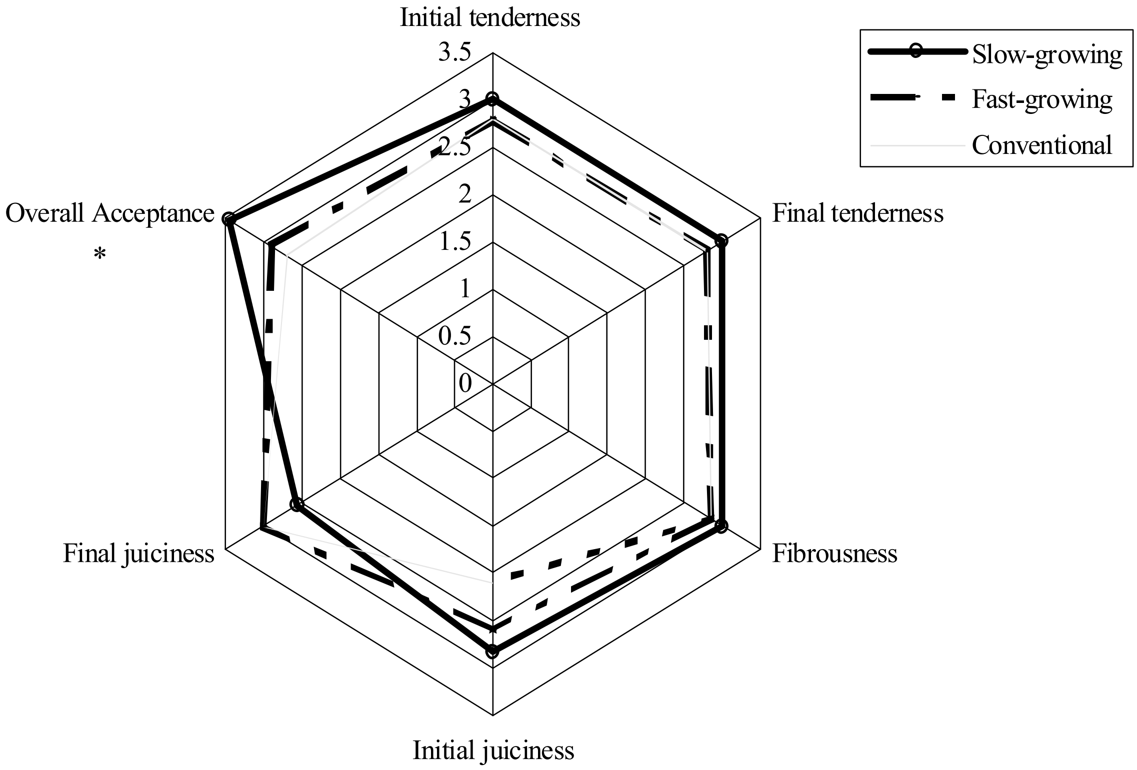

Figure 2 Sensory analysis of breast muscle in conventional or organic reared chicken strains (from Castellini *et al.,* 2002b modified).