QUALITY OF EGGS OF HYBRID AND ITALIAN HENS REARED UNDER AN ORGANIC PRODUCTION SYSTEM

Chiara Rizzi* and Martino Cassandro

Department of Animal Science, University of Padova, Viale dell'Università, 16 – 35020 Legnaro (Padova) - Italy

Corresponding Author: chiara.rizzi@unipd.it

Abbreviated title: Sensory properties of broiler meat

Summary

A trial was carried out to compare the quality of eggs from two hybrid strains (Hy-Line Brown, HLB and Hy-Line White, HLW) and two Italian breeds (Ermellinata di Rovigo, ER and Robusta maculata, RM) of hens reared under an organic production system, from July to December in Northern Italy. Hen-day egg production was higher (P<0.01) in hybrid strains when compared to ER and RM. Aging (from 30 to 42 weeks of age) of animals significantly affected the egg weight, the eggshell thickness and the eggshell weight according to genotype and variations in environmental conditions. The HLB hens did not show any variation in eggshell thickness, but a constant decrease in eggshell percentage from 34 weeks of age. From 34 to 42 weeks of age significant (P<0.01) variations affected the ash content of hybrid yolks according to genotype, and the n-6/n-3 ratio of yolk lipids in all groups. At 44 weeks of age the HLW femurs and tibiae showed stress and modulus of elasticity higher (P<0.01) than the other genotypes.

Keywords: hen, organic, egg quality, bone quality

Introduction

In poultry meat and egg production under non-conventional rearing conditions such as free-range and organic system the use of local breeds instead of hybrid genotypes is encouraged (European Union, 1999). Meat and egg genotypes have different hen-day egg productions since a negative genetic correlation exists between these two parameters (Bell, 2002a). During the productive cycle changes in egg yield and quality occur as well as bone conditions (Whitehead and Fleming, 2000). These changes are known for hybrid hens under conventional rearing conditions (Bell, 2002b), whereas data on organic hybrids and local breeds are still limited (Rizzi et al., 2002). From a wellness point of view, decreases in bone strength and in structural bone leads to increased fragility and susceptibility to fracture causing pain to the hens (Whitehead and Fleming, 2000). Factors affecting these conditions are battery cage use and increased genetic selection for earlier sexual maturity, and a high rate of laying (Schreiweis et al., 2003; Fleming et al., 2006).

The objective of this trial is to study the laying rate and the egg quality, and the physiological response according to the aging of laying hens belonging to two hybrid genotypes and two Italian dual-purpose genotypes reared under organic conditions during the first phase of the production cycle.

Materials and methods

Laying hens belonging to two hybrid strains, Hy-Line Brown (brown eggshell - HLB) and Hy-Line White-36 (white eggshell - HLW) and to two Italian dual-purpose breeds, Ermellinata di Rovigo (brown eggshell - ER) and Robusta maculata (brown eggshell - RM) were reared under organic farming production system (European Union, 1999). The local genotypes were created in Veneto (Italy) during the 1950s from Sussex and Rhode Island (ER breed) and Brown Orpington and White America (RM breed) purebreds. The hens were reared from 24 weeks until 44 weeks of age, from July to December. The birds were kept under the same prophylaxis procedures, rearing and feeding conditions from time of hatching until the end of the experimental period. Throughout the trial the environmental temperature and the relative humidity levels ranged widely from summer (30°C - 68%) to autumn (5°C - 82%). The photoperiod was

16L:8D. The birds of each genotype were allowed access to outdoor (4 m^2/bird) and indoor space (0.20 m^2/bird), and to nests (8 birds/nest) and perches (22 cm/bird) (European Union, 1999). The birds were fed *ad libitum* an organic crumbled feed (CP=17%; Ca=3.30%; ME=11.8 MJ/kg). Every four weeks egg quality was checked on a sample of 30 eggs per genotype, within 24h of being layed. At 44 weeks of age, 12 birds per genotype were slaughtered and the legs were frozen at -20°C. After thawing, tibiae and femurs were used in all tests, being dissected from the fresh meat; the bones were prepared for an analysis of length, breaking force, stress and modulus of elasticity. Physical bone characteristics were determined by the three-point bending test (Crenshaw et al., 1981) using an Instron Universal Testing Machine (Stable Micro System TA-HD). At the diaphyseal level, wall thickness was measured using a digital micrometer (Mitutoyo), again perpendicular and parallel to the applied force. Stress and the modulus of elasticity were calculated (Crenshaw et al., 1981). The crumbled feed and the yolk were analysed for dry matter, protein and ash content (AOAC, 1995). Yolk fatty acid profile was also analyzed.

Data on egg quality parameters were submitted to ANOVA using the general linear model (GLM) procedure of SAS (SAS Institute, 2001) with age as main effect. On data concerning hen-day egg production and bone physical properties an ANOVA analysis was performed with genotype as main effect. Differences between means were tested using Duncan's multiple range test (SAS, 2001).

Results and Discussion

The hen-day egg production (Figure 1) showed a progressive increase from 25 to 44 weeks of age; hybrid hens (Table 1) showed higher ($P<0.01$) values than the local breeds which showed higher body gain according to their dual-purpose productivity (Rizzi et al., 2002).

Figure 1. Hen-day egg production from 25 to 44 weeks of age

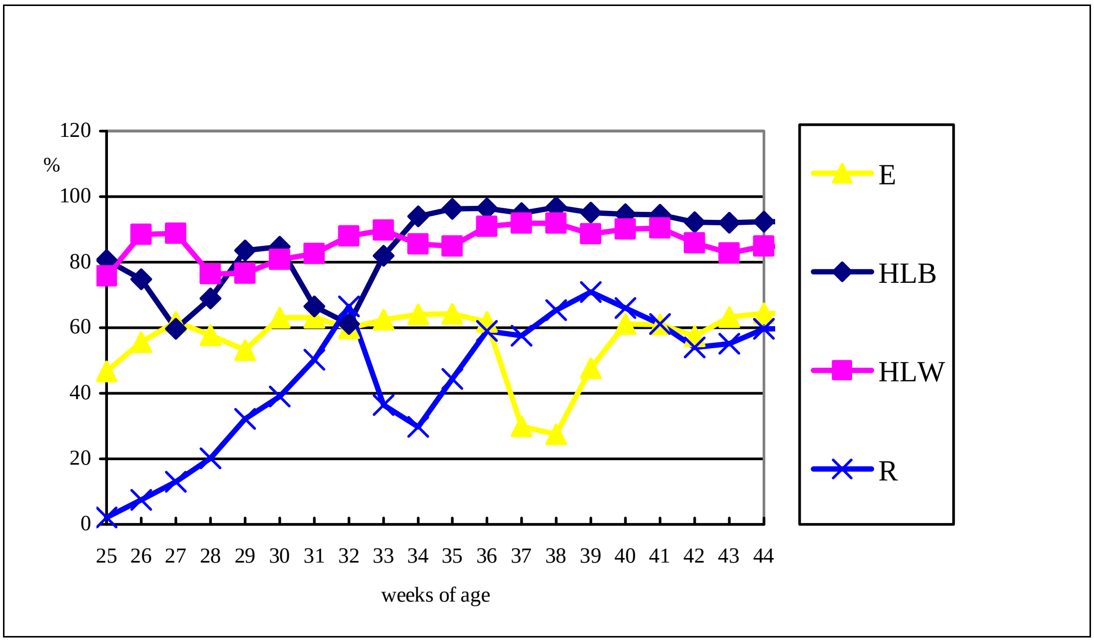

Table 1 shows some qualitative egg parameters according to the aging of the hens. With aging, the egg weight of the hybrid hens presented an increase of 16%, whereas the local breeds presented lower 11% positive variations. The different increase observed among the genotypes may be dependent on the genetic assessment of the hens and their different onset of laying that was delayed in the Italian groups, particularly in the RM subjects, which started laying at 25 weeks of age. An interaction between the environmental conditions (temperature, photoperiod) and the physiological response of the strains may have occurred, since they had a different productive aptitude - egg production for the hybrids, and dual-purpose production for the Italian hens.

Table 1. Hen-day egg production (25-44 weeks) and egg quality throughout the experimental period

		HLB	HLW	E	R
Hen-day egg production[1], %		85.1^{Aa}	85.3^{Aa}	56.5^{Bb}	42.2^{Cc}
Egg weight, g	-30 wks	56.1^{Cc}	54.3^{Cc}	51.3^{Cc}	52.5^{Cc}
	-34 wks	60.7^{Bb}	59.3^{Ab}	55.3^{Bb}	54.7^{BCc}
	-38 wks	65.1^{Aa}	60.9^{AbB}	53.2^{BCc}	57.4^{Bb}
	-42 wks	66.5^{Aa}	63.8^{Aa}	58.3^{Aa}	58.1^{Aa}
	SEM (d. f.)	4.55 (108)	4.60 (108)	5.57 (108)	3.48 (82)
Eggshell thickness, mm	-30 wks	0.376	0.342^{AaBb}	0.338^{Aa}	0.373^{AaBb}
	-34 wks	0.369	0.329^{Bbc}	0.339^{Aa}	0.343^{Cc}
	-38 wks	0.366	0.332^{AbB}	0.315^{Bb}	0.368^{Ab}
	-42 wks	0.364	0.347^{Aa}	0.322^{AaBb}	0.383^{a}
	SEM (d. f.)	0.728 (115)	0.748 (113)	1.06 (104)	0.809 (88)
Eggshell weight, g	-30 wks	6.48^{Bb}	5.72^{Bb}	5.15^{Bc}	5.67^{Bb}
	-34 wks	6.79^{AaB}	6.00^{Bb}	5.30^{AaBc}	5.92^{Bb}
	-38 wks	6.77^{AaB}	6.66^{Aa}	5.65^{Aa}	6.73^{Aa}
	-42 wks	6.91^{Aa}	6.60^{Aa}	5.60^{AaBb}	6.80^{Aa}
	SEM (d. f.)	0.556 (116)	0.550 (119)	0.620 (110)	0.558 (95)
Eggshell [2], %	-30 wks	11.4^{Aa}	10.3^{ABb}	10.0^{ABb}	11.0^{Bbc}
	-34 wks	10.7^{Bb}	9.97^{Bb}	9.81^{Bbc}	10.7^{Bc}
	-38 wks	10.5^{Bb}	10.8^{Aa}	10.5^{Aa}	11.6^{Aa}
	-42 wks	10.5^{Bb}	10.3^{ABb}	9.53^{Bc}	11.3^{AaBb}
	SEM (d. f.)	0.901 (116)	0.478 (119)	1.07 (110)	0.910 (95)
Yolk ash, % d. m.	-30 wks	3.16^{Bb}	3.35^{Bb}	3.73^{a}	3.41
	-42 wks	3.44^{Aa}	3.52^{Aa}	3.41^{b}	3.42
	SEM (d. f.)	0.060 (14)	0.088 (17)	0.274 (18)	0.102 (13)
Yolk n-6/n-3 ratio	-34 wks	13.8^{Aa}	14.1^{Aa}	13.4^{Aa}	13.9^{Aa}
	-42 wks	12.1^{Bb}	13.1^{Bb}	12.2^{Bb}	11.7^{Bb}
	SEM (d. f.)	0.190 (14)	0.293 (17)	0.490 (18)	0.514 (13)

$^{a, b, c}$: $P<0.05$; $^{A, B, C}$: $P<0.01$; [1] SEM=13.7 (d.f.=528); wks=weeks of age; [2] of egg weight.

It is worth mentioning that under organic conditions the environmental temperature changed widely throughout the experimental period according to seasonal conditions, whereas the photoperiod did not change (it was integrated with artificial light to maintain the oviposition rate); therefore the hens could have shown different responses to the environmental conditions according to their metabolic state.

Significant variations of the eggshell thickness throughout the oviposition period were observed according to the genotype: the HLW and RM eggs showed a drop in values at 34 weeks of age and the ER eggs one month later. The HLB showed a constant eggshell thickness throughout the experimental period. The main factors capable of affecting the eggshell thickness are the increasing egg weight with aging of the hens and the environmental conditions (Bell, 2002b). Under experimental rearing conditions, the eggshell thickness variations occurred in September and October after high temperature levels (30°C) and the animals were allowed to range under solar radiation. It should be noted that in the first phase of oviposition this parameter is quite stable in hybrid hens reared under conventional conditions.

The eggshell weight gradually increased in all groups; the rate of increase, when referred to initial and final values, was slightly lower than that of the egg weight in the HLW and ER groups, whereas it was much lower in the HLB, about half. The opposite was observed for the RM eggshell weight, which showed an increase less than twice that of the egg weight. One reason for the trend observed in HLB and RM eggs may be due to the initial weight of the egg and the eggshell (which were higher in the HLB strain mainly as a consequence of its more precocious onset of laying). The HLB hens showed a constant decrease in eggshell percentage from 34 weeks of age.

As far as the chemical composition of the yolk is concerned, the ash content showed an increase ($P<0.01$) in hybrids, whereas ER breed showed a decrease ($P<0.05$) and RM did not change. The n-6/n-3 ratio was significantly ($P<0.01$) lower in the yolks of eggs at 42 weeks of age in comparison to those at 32 weeks and the decrease was different among the genotypes: this result may be due to a possible interaction between strain and environment, in particular the utilisation of the diet and the thermal hygrometric conditions.

Table 2 shows some physical parameters of femur and tibia bones. The bone length of the four genotypes differed significantly ($P<0.01$) according to their body weight, since the local Italian breeds had higher somatic dimensions. The RM hens had femurs longer ($P<0.01$) than ER and hybrids, which had similar values. The RM tibia length was greater ($P<0.01$) than ER; local breeds showed higher values than hybrids, particularly respect to HLW ($P<0.05$).

As far as stress is concerned, HLW femurs ($P<0.05$) and tibiae ($P<0.01$) had the highest values. HLW femur stress was slightly ($P<0.05$) higher than RM.

Table 2. Physical and chemical characteristics of femur and tibia bone

		HLB	HLW	E	R	SEM (d. f.)
Length, cm	Femur	8.60^{BCc}	8.26^{Cc}	8.94^{Bb}	9.44^{Aa}	0,363 (34)
	Tibia	12.1^{Bbc}	11.9^{Bc}	12.4^{Bb}	13.3^{Aa}	0,496 (36)
Stress, N/mm^2	Femur	84^{ABb}	108^{Aa}	72^{Bb}	86^{ABb}	20.5 (34)
	Tibia	80^{Bb}	155^{Aa}	85^{Bb}	100^{Bb}	22.2 (36)
Modulus of elasticity, N/mm^2	Femur	3273^{Bb}	4552^{Aa}	1443^{Cc}	1390^{Cc}	951 (33)
	Tibia	4233^{Bb}	7192^{Aa}	3993^{BbC}	2328^{Cc}	1403 (34)

$^{a, b, c}$: $P<0.05$; $^{A, B, C}$: $P<0.01$

The modulus of elasticity in femurs was higher ($P<0.01$) in the HLW than in the HLB bones, and Italian groups showed lower ($P<0.01$) values without any difference between ER and RM hens. HLW tibia bones showed higher ($P<0.01$) modulus of elasticity than HLB; the local breeds had lower values, in particular the RM hens ($P<0.05$). These results agree with those of Crenshaw et al. (1981) and Schreiweis et al. (2003) who stated that bones with high stress also had high modulus of elasticity.

The results indicate that some egg quality parameters and physiological responses can be affected by the genetic assessment of the birds reared under organic conditions and throughout the first phase of productive cycle.

References

AOAC (1995) Official methods of analysis. 15th Ed. Association of Official Analytical Chemists; Washington, DC, USA.

BELL, D. (2002a) Modern breeds of chickens, in: COMMERCIAL CHICKEN MEAT AND EGG PRODUCTION, pp.31-40. Edited by D. D. Bell and W. D. Jr. Weaver, Kluwer Academic Publishers, USA.

BELL, D. (2002b) Formation of the egg, in: COMMERCIAL CHICKEN MEAT AND EGG PRODUCTION, pp.59-69. Edited by D. D. Bell and W. D. Jr. Weaver, Kluwer Academic Publishers, USA.

CRENSHAW, T.D., PEO, E.R., LEWIS, J. and MOSER, B.D. (1981) Bone strength as a trait for assessing mineralization in swine: a critical review of techniques involved. Journal of Animal Science: 53-3.

EUROPEAN UNION (1999) Pages 1-28 in EC n. 1804/99 of July 1999 supplementing regulation (EEC) n. 2092/91 on organic production of agricultural products. Off. J. Lett. 222 of 08/24/1999.

FLEMING, R. H., MCCORMACK, H. A., MCTEIR, L. and WHITEHEAD, C. C. (2006) relationships between genetic, environmental and nutritional factors influencing osteoporosis in laying hens. British Poultry Science 47: 742-755.

RIZZI, C., CHIERICATO, G. M. and BARUCHELLO, M. (2002) Prestazioni produttive di galline ovaiole appartenenti a due ibridi commerciali e a due razze autoctone allevate con metodo biologico. Riv. Avicoltura 6: 39-47.

SAS (2001) User's Guide. Version 8.02. SAS Inst., Inc., Cary, NC.

SCHREIWEIS, M.A., ORBAN, J.I., LEDUR, M. and HESTER, P. (2003) The use of densitometry to detect differences in bone mineral density and content of live White Leghorns fed varying levels of dietary calcium. Poultry Science 82: 1292-1301.

WHITEHEAD, C.C. and FLEMING, R.H. (2000) Osteoporosis in cage layers. Poultry Science 79: 1033-1041.