MEAT QUALITY OF THREE CHICKEN GENOTYPES REARED ACCORDING TO THE ORGANIC SYSTEM

QUALITÀ DELLA CARNE DI POLLO DI TRE GENOTIPI ALLEVATI SECONDO IL METODO BIOLOGICO

C. CASTELLINI, C. MUGNAI and A. DAL BOSCO

Dipartimento di Scienze Zootecniche, Università di Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy

ABSTRACT

The meat quality of three poultry genotypes with differing growth rates (fast-growing Ross; medium and slow-growing Kabir and Robusta maculata, respectively) was compared. All the birds were reared according to the organic production system which requires a paddock with grass pasture (4 m^2/bird) and a slaughter age greater than 81 d. The trial was carried out on 100 female chickens per strain. The meat quality was affected by the different degree of maturity of the strains at slaughter age, which was 70% for Ross, 52 % for Kabir and 78% for Robusta maculata. Ross and Kabir were slaughtered at 81 d, whereas Robusta maculata, required 120 d to reach a commercial weight (>2 kg). The meat of all the three genotypes showed good qualitative traits. The main differences of the three genotypes regarded moisture, lipid, pH_u, colour, iron, oxidative stability and overall acceptance. Compared with Kabir and Robusta maculata Ross meat had more fat, lower pH_u and iron, and was paler. The oxidative stability during display (24-96 h at 4° C) and acceptance were the worst. Kabir chickens, being the least mature strain, had the highest moisture content with a high cooking loss. The slower-growing genotypes showed a good adaptation to the extensive rearing conditions, while the fast-growing genotype showed unbalanced muscle response to the greater activity and the oxidative stability of the meat was reduced.

RIASSUNTO

È stata confrontata la qualità della carne di tre genotipi di pollo aventi una diversa capacità di crescita (Ross a crescita rapida, Kabir e Robusta maculata a crescita media e lenta, rispettivamente). I polli sono stati allevati con il metodo biologico che richiede la presenza di un paddock esterno inerbito (4 m^2/capo) ed un'età di macellazione non inferiore ad 81 d. La prova è stata eseguita su 100 femmine di ciascun tipo genetico. La qualità della carne ha risentito del diverso grado di maturità all'età di macellazione che è stato del 70% per il Ross, 52% per il Kabir e 78% per la Robusta maculata. Quest'ultima rispetto agli altri due, macellati a 81 d, ha richiesto 120 d per raggiungere un peso commerciale (>2 kg). Le caratteristiche qualitative della carne di tutti i genotipi sono state buone. Le differenze più rilevanti hanno riguardato il contenuto di acqua, di grassi e di ferro, il pH_u, il colore, la stabilità ossidativa e la gradevolezza. La carne dei polli Ross, rispetto a quella dei Kabir e dei Robusta maculata, è risultata più grassa, con pH e ferro più basso, più pallida, meno gradevole; ha inoltre presentato una minore stabilità ossidativa durante la conservazione (24-96 ore a 4° C). I polli Kabir, stante la loro minor maturità, hanno fornito carni più ricche di acqua e con maggiori perdite di cottura. I genotipi meno produttivi hanno mostrato un buon adattamento alle condizioni estensive di allevamento mentre i polli Ross hanno risposto meno bene alla maggior disponibilità di spazio che ha contribuito a diminuire la stabilità ossidativa della carne.

Key words: broilers, meat quality, organic production, strain

INTRODUCTION

Organic livestock farming is defined by basic guidelines (EC, 1999) which came in effect in August 2000 and that guarantee high standard for animal welfare and sanitary aspects of the products.

As far as the qualitative characteristics of the carcass and meat are concerned, there is a controversy whether the organic system results in better production than conventional ones due to the numerous factors involved. Among these factors the strain plays an important role. According to the guidelines, more rustic strains are preferred due to their slower growth rate and better adaptation to poorer living conditions. It is also thought (RAUW *et al.*,1998) that animals genetically selected due to high production efficiency are more at risk for behavioural, physio-biological and immunological problems. For these reasons geneticists have selected strains with the desired traits. One such strain is the Kabir hybrid, selected in Israel, whose positive characteristics are resistance to environmental stress and disease and good adaptation to poor diets (ZVI KATZ, 1995). Many pure breeds also have a slow growth and good rusticity, making them suitable for organic production; another advantage for using them would be to the risk of avoid them going extinct. Robusta maculata, obtained during the 1950s at an experimental station in northern Italy, is rustic and has dual qualities, egg laying (140-160 eggs/year) and meat production (about 4 kg adult body weight).

Few studies exist on the response of these genotypes to the organic production system. LEWIS *et al*. (1997) and FARMER *et al*. (1997) compared data on a slow-growing type (used in France for producing the Label Rouge) and a commercial hybrid (Ross), reared under extensive conditions that can be considered comparable to an organic system. GRASHORN (1999) investigated the meat quality of commercial and slow-growing strains reared in intensive, semi-extensive and extensive systems.

The aim of this paper was to compare the quality of the meat obtained from three different genotypes raised under the organic production system.

MATERIALS AND METHODS

Animals, housing and feeding

Three-hundred female chickens of Ross, Kabir and Robusta maculata strains were reared separately (3 groups of 100 birds each) under brooder lamps for three weeks at the experimental farm of the Animal Production Department (University of Perugia). The environmental temperature ranged from 15 °C to 25 °C and the relative humidity ranged from 65 to 75%. At 21 days-of-age each group of chickens was allocated to its own covered shelter (10 m^2, 0.10 m^2/bird) with straw litter and with access to a grass paddock (4 m^2/bird); feeders were available both outdoors and indoors. The trial was carried out from April to July 2001.

The chickens were fed *ad libitum* the same starter (1-21 d) and finisher (22 d to slaughter) diets containing more than 80% certified organic ingredients, bought from a national supplier. The ingredients were ground and mixed in the feed plant of the Animal Production Department. The characteristics of the diets are presented in Table 1.

Ross and Kabir chickens were reared for 81 days, which is the minimum specified according to EC regulations, whereas Robusta maculata was reared for 120 days to reach commercial weight (>2,000 g). The degree of maturity of each strain is expressed as the ratio between the weight at different ages and the adult weight.

Twenty birds per group, each weighing ± 10% of the population mean, were slaughtered in the department processing plant 12 hours after feed withdrawal. Broilers were not transported and were electrically stunned before killing.

Sample collection and analytical determinations

The birds were killed by manual exsanguination, plucked and eviscerated. Immediately before slaughter, blood samples were collected in heparinized vacutainers and centrifuged at 1,500 x g for 10 min at 4 °C, in order to measure the antioxidant capacity using the Oxy-adsorbent test produced by Diacron ® s.r.l. (Italy) (CESARONE *et al.*, 1999).

An aliquot of blood plasma was analysed for α-tocopherol determination. The α-tocopherol was measured according to SCHUEP and RETTENMEIER (1994) by adding 500 μL of distilled water and 1 mL ethanol to 500 μL of sample and then vortexing for 10 sec. Successively, 0.2 mL hexane and butylhydroxytoluene (0.01%) were added and the mixture was carefully shaken and centrifuged. An aliquot of supernatant (0.8 mL) was taken and injected into the HPLC (CM 4000, Milton Roy, Riviera Beach, FL, USA), using a silica column (Beckman, Fullerton, CA, USA). Fluorescence detection was performed with a spectrofluorimeter (excitation and emission wavelength of 292 nm and 330 nm, respectively).

From the refrigerated carcasses (24 hours at 4 °C), the *pectoralis major* (breast) and *peroneous longus* (drumstick) muscles were excised and the skin and external fat were removed. Muscle samples (approximately 50 g) were taken used immediately for sensory and analytical determinations and while others were taken during storage to quantify the oxidative processes.

Ultimate pH (pH_u) was measured with a Knick digital pHmeter (Broadly Corp., Santa Ana, CA, USA) after homogenization of 1 g of raw muscle for 30 sec in 10 mL of 5 M iodoacetate (KORKEALA *et al.*, 1986).

The water-holding capacity (WHC) was estimated by placing 1 g of whole muscle on tissue paper inside a tube and centrifuging for 4 min at 1,500 x g. The water remaining after centrifugation was quantified by drying the samples at 70 °C overnight. WHC was calculated as follows: (weight after centrifugation - weight after drying) / initial weight x 100 (CASTELLINI *et al.*, 1998).

The cooking loss (CL) was measured on samples of about 20 g placed in open aluminium pans and cooked in an electric oven (pre-heated to 200 °C) for 15 min to an internal temperature of 80 °C. The CL was estimated as the percentage of the weight of the cooked samples, (cooled for 30 min to about 15 °C and dried on the surface with a paper towel), with respect to the weight of the raw samples.

Shear force was evaluated on cores (1.25 cm Ø; 2 cm length) obtained from the mid-portions of the roasted samples by cutting them perpendicularly to the direction of the fibre, using an Instron, model 1011, equipped with a Warner-Blatzler meat shear apparatus.

The colour parameters (L*, a*, b*) were measured using a tristimulus analyser (Minolta Chroma meter CR-200), with the CIELAB colour system (1976).

Chemical analyses of diet and meat were done according to AOAC methods (1995).

The extent of lipid oxidation was evaluated after different storage periods (24, 48, 72, 96 h) as TBA-RS (Thiobarbituric Acid Reactive Substances) according to the modified method of KE *et al*. (1977). Samples were placed on plastic trays (600 cm^3), over-wrapped with PVC film and displayed at 4 °C under continuous cool white fluorescent light (2,300 lux). Ten grams of minced muscles were homogenised for 2 min with 95.7 mL of distilled water and 2.5 mL of 4N HCl. The mixture was distilled until 50 mL was obtained. Then, 5 mL of the distillate and 5 mL of TBA reagent (15% trichloroacetic acid, 0.375% thiobarbituric acid) were heated in a boiling water bath for 35 min. After cooling under running tap water for 10 min, the absorbance was measured at 531 nm against a blank of 1 mL double distilled water and 2 mL TBA/TCA solution. TBA-RS values were obtained by multiplying the optical density by

7.843. The amount of TBA-RS was expressed as malondialdehyde equivalents (mg MDA/kg muscle).

The total and haeme iron content in the muscles were determined according to the SCHRICKER *et al.* (1982) and O'BRIEN *et al.* (1992) procedures, respectively.

The fatty acid composition was determined on lipids extracted from muscle samples (about 5 g) in a homogeniser with 20 mL of 2:1 chloroform:methanol (FOLCH *et al.*, 1957), followed by filtration through Whatman No. 1 filter paper. Fatty acids were quantified as methyl esters with a Mega 2 Carlo Erba gas chromatograph, model HRGC (Milano, Italy), using a D-B wax capillary column (25 mm ∅, 30 m long). Their percentages were quantified with Chrom-Card software and the mean value of each fatty acid was used to calculate total saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids.

Sensory analyses

A sensory panel test was conducted on samples of *pectoralis major* muscle (immediately after its removal), roasted without salt or spices. The roasted samples were immediately sliced into eight pieces and randomly offered to eight trained panelists during four successive sessions. The traits assessed were overall acceptability, initial and final tenderness, initial and final juiciness and fibrousness. The 5-point scale proposed by CROSS *et al*. (1986) was used: 1 = very disagreeable, very tough, very dry, very fibrous; 2 = moderately disagreeable, slightly tough, dry, fibrous; 3 = slightly agreeable, tender, slightly juicy, moderately fibrous; 4 = agreeable, very tender, juicy, traces of fibrousness; 5 = very agreeable, extremely tender, very juicy, without fibre.

Statistical analyses

Data were analysed with a linear model (SAS/STAT, 1990 - procedure GLM) including the effect of breed. Significance of differences was evaluated by the multiple t-test.

RESULTS AND DISCUSSION

Live weight and degree of maturity

The genotypes showed very different precocities, as indicated by the great differences in the absolute live weight at a fixed age, and the time needed to attain the same degree of maturity (Figure 1). e.g. the slow-growing chickens, Kabir and Robusta maculata, needed about 75 d and 82 d respectively to reach 50% of the final body weight, whereas the fast-growing Ross chicken needed only 56 d.

Ross chickens had a very fast growth rate even though increased locomotion (low animal density) and reduced the nutritional quality of the feed (intake of grass pasture) if the organic rearing system reduced their growth potential. CASTELLINI *et al.* (2002b) showed that birds having access to pasture eat some grass which increases fibre intake and reduced digestibility of other nutrients.

At 81 days Ross birds weighed 2,942 g, which is about 70% of the degree of maturity.

At the same age Kabir chickens had a live weight of only 2,031 g (52% of the degree of maturity), whereas Robusta maculata needed 120 d to achieve a marketable weight (> 2,000 g) which at this age was 2,185 g or 78% of the degree of maturity.

These productive performances are the result of the selection programs used to obtain the different strains. The Ross hybrid underwent strong selection pressure to reduce the rearing period and therefore the cost of production. Kabir was selected to produce even under poor conditions (environment, rough diet, etc), and a slower-growing genotype was obtained. Robusta maculata, a slow-growing breed, was not particularly selected for growing performance, but also for having a good aptitude for egg production (ARDUIN *et al*., 1998). The feed efficiency was 3.0, 3.3 and 3.9 and the mortality rate was 12%, 9% and 4% respectively, in Ross, Kabir and Robusta maculata chickens (data not shown).

Chemical and physical characteristics of the breast and drumstick muscles

The different degrees of maturity of the three genotypes accounts, in parts for the different characteristics of the two muscles analysed (Tables 2 and 3).

As expected from the low degree of maturity (52%), Kabir chickens had the least mature meat, the lowest protein and the highest moisture content. Presumably, this high water content negatively affected both the water holding capacity and the cooking loss of the meat.

In spite of the differences in age and degree of maturity the meat of Kabir and Robusta maculata was leaner, than that of a fast-growing strain) and muscle fibres had similar metabolisms (> pH_u) in agreement with PLAVNIK and HURWITZ (1983). The higher pH_u did not significantly affect the tenderness, as observed by HULOT and OUHAYOUN (1999), even if it shows a trend with lower values in the two above-mentioned strains.

It is known, that rapid growth enhances late maturing tissues (i.e. fat) and that a higher body weight is associated with increased glycolytic energy metabolism and with higher acidification (OUHAYOUN, 1998). OUHAYOUN and DALLE ZOTTE (1993) affirmed that the ultimate pH of the muscles is lower in heavy rabbits, but greater acidification does not lead to increase in cooking loss. We also observed an analogous trend, in the three chicken strains used in this study.

However, the higher pH_u can also be correlated with greater movement which improves oxidative metabolism and increases the number of mitochondria in α-white fibres and hence turns them into α-red fibres (OUHAYOUN and DALLE ZOTTE, 1993).

The similar degree of maturity of Robusta maculata and Ross (78 and 70%, respectively), reduced the genetic differences for many traits, including moisture and protein content, water-holding capacity and cooking loss.

Shear force did not differ between strains and each of them had very tender meat.

The three genotypes showed differences in the colour parameters and iron levels of both muscles (Table 3). The Ross meat was lighter and less red due to the lower pH value. Muscle pH has been shown to affect both the light reflectance and the chemical reactions of myoglobin (RICHARDSON and MEAD, 1999; WARRIS, 2000).

The low level of iron and redness of the Ross meat was similar to that reported by BERRI *et al.* (2001), in lines selected for rapid growth and large breast yield, which had a lower haeme pigment content in the paler, less red breast meat. On the other hand LE BIHAN-DUVAN *et al.* (1998) found high heritability coefficients (h^2) between pH and colour parameters, and after selecting for rapid growth rate (13 generations), obtained less red and yellow meats.

In vivo antioxidant capacity and oxidative processes in *pectoralis major* muscle

The Ross chickens had the lowest antioxidant capacity (P<0.01), whereas the other two strains had similar values (Table 3). The alpha-tocopherol level was analogous for the 3 strains. Such a condition affected oxidative processes in fresh and stored breast. In spite of the lower amount of iron, the TBA-RS values (Figure 2) were always higher (P<0.01) in Ross meat, reaching a final value of 4.40 (P<0.01), whereas in Kabir and Robusta maculata the final values were 3.35 and 3.10, respectively.

The better oxidative status of these two strains is also due to greater grass ingestion as observed by CASTELLINI *et al.* (2002a) and to the different response of the muscle fibres to activity. The selection for rapid growth and muscle mass (mainly breast) induces a higher proportion of glycolytic fibres (DRANSFIELD and SOSNICKI, 1999). Clearly, these genotypes do not adapt to a greater space allowance and are not suited for continuous movement.

The selection of meat-type animals has caused a dramatic reduction of their locomotory activity, particularly during the finishing period (BIZERAY *et al.*, 2000). At the same time, rearing under intensive housing systems, which provides all the physiological needs (feed, water, temperature), further reduces movement (REITER and BESSEI, 1996).

In a previous work, CASTELLINI *et al.* (2002b) observed that Ross, in comparison to Robusta maculata, spent less time walking and preferred to stay indoors rather than outdoors.

The higher oxidative metabolism of slow-growing chickens is magnified under conditions that favour to motor activity. This accounts for the higher *in vivo* antioxidant capacity of Kabir and Robusta maculata, because higher oxidative metabolism increases free-radical production and the body develops a more efficient mechanism to control the free radicals (ALESSIO *et al.*, 2000), and to protect myocytes against oxidants (POWERS and LEEUWENBURGH, 1999).

In turn, the lower levels of oxidants in Kabir and Robusta maculata muscle reduced the oxidative processes in the meat after 24 h or 96 h of storage.

Compared with the commercial meat broiler all three genotypes showed higher TBA-RS values (TBA-RS about 1.8: CASTELLINI *et al.*, 2002a) which can be due to higher oxidative metabolism and to the increase of Fe. During storage, cell deterioration frees Fe ions which catalyse lipid peroxidation (STANLEY, 1991).

The above-mentioned trend of oxidative processes reduces the shelf life of meat produced by chickens reared under an organic system, suggesting that it best to consume the whole carcass instead of its parts or as minced meat. It is known that handling, increase of temperature, light and metal ions, which can be freed from cutting blades during processing, increase the free radical production and affect peroxide processes (MORRISSEY *et al.*, 1998).

Fatty acid profile of breast and drumstick muscles

The major fatty acid percentages in breast and drumstick were not affected by strains (Table 4) and the values indicate that suitable dietary strategies are needed to modify the acidic profile of meat. 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).

Sensory analyses

The panelists (Figure 3), showed an overall preference (P<0.05) for those of Robusta maculata and Kabir, in comparison to Ross. Significant differences were also observed for juiciness: Kabir had the lowest value for initial juiciness, presumably due to the high cooking loss that reduced the moisture content; for final juiciness Robusta maculata had the lowest value in relation to the low level of fat in its meat. It is known (CROSS *et al*., 1978) that initial juiciness is affected by water being freed by mastication, while final juiciness depends on the lipids that promote salivation.

The capacity of a panel to discriminate meat from slow- *vs.* fast-growing genotypes is largely debated (RICHARDSON and MEAD, 1999). Several authors have reported significant differences but the effect of genotype often interacts with the age: eg. slow-growing chickens require a longer rearing period. FARMER *et al.* (1997), who reported a significant discrimination of meats from various poultry genotypes, had the interaction of age-genotype.

CONCLUSIONS

Robusta maculata and Kabir genotypes reared under an organic production system, expressed their natural behavioural patterns, showing good motor activity and good adaptation to poor environmental conditions. Their antioxidant capacity was higher and the oxidative processes of the meat were lower compared with Ross. The sensorial quality of the meat was good.

The growth rate of Robusta maculata was slow; the reached commercial maturity only at 120 d of age while Kabir chickens reached a marketable weight at 81d, their low degree of maturity negatively affected the moisture and protein contents of the meat, and cooking loss.

Ross chickens showed a high growth potential and gave meat with good nutritional quality, except for a low iron content. The mortality rate was high and the oxidative stability of the meat was low, presumably due to less motor activity and a lower intake of grass (containing antioxidants). These factors probably contributed to the lower overall acceptance during the panel test.

Robusta maculata and other slow-growing breeds in danger of extinction, should be considered for extensive production in order to assure their preservation. However this strain requires a fattening period that is too long, even if the rearing of both sexes could be more advantageous. It would be advisable to use a cross between females of this breed with males of a heavier genotype, in order to improve the growth rate.

Overall the results show that the environment-genotype interaction is also very important also for the qualitative characteristics of the meat; differences between fast- or slow-growing chickens could also be a consequence of different behaviour and muscle metabolism.

More detailed study on the muscle response of different genotypes to motor activity is required.

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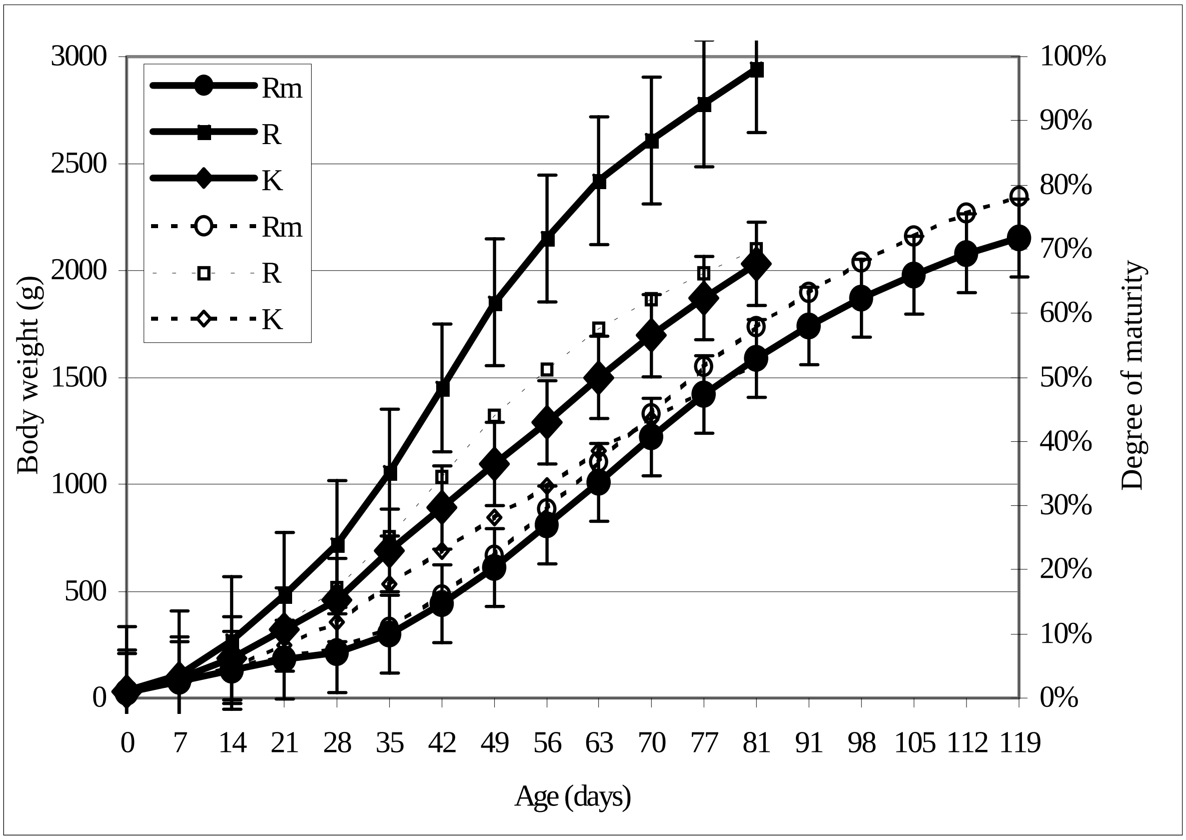
Table 1 – Formulation (%), chemical composition (% d.m.) and energetic value of the diets.

Ingredients		*Starter*	*Finisher*
Maize	%	52.0	46.0
Full fat soybean	“	30.5	12.5
Wheat	“	-	20.0
Soybean meal*	“	9.0	14.0
Alfalfa meal	“	2.8	2.8
Fish meal	“	3.0	2.0
Vitamin-mineral premix**	“	1.0	1.0
Dicalcium phosphate		1.0	1.0
Sodium bicarbonate		0.5	0.5
NaCl		0.2	0.2
Chemical composition			
Crude protein	% d.m.	22.65	19.10
Ether extract	“	7.95	4.98
Crude fibre	“	4.67	4.01
Ash	“	5.76	5.59
NDF - Neutral Detergent Fibre	“	10.74	10.11
ADF – Acid Detergent Fibre	“	5.58	4.67
Cellulose	“	4.22	3.56
ADL – Acid Detergent Lignin	“	1.03	1.11
Hemicellulose	“	5.16	5.05
Metabolizable energy	MJ kg^{-1}	12.75	13.03

* from conventional crops.

** Added per kg: Vit. A 11.000 IU; Vit. D_3 2.000 IU; Vit. B_1 2.5 mg; Vit. B_2 4 mg; Vit. B_6 1.25 mg; Vit. B_{12} 0.01 mg; α-tocopheryl acetate 50 mg; Biotin 0.06 mg; Vit. K 2.5 mg; Niacine 15 mg; Folic acid 0.30 mg; Panthotenic acid 10 mg; Choline 600 mg; Mn 60 mg; Fe 50 mg; Zn 15 mg; I 0.5 mg; Co 0.5 mg.

Figure 1 – Body weights of birds (95% upper and lower limits) and degree of maturity.



Solid line = body weight; dotted line = actual body weight/adult weight.
R= Ross; Rm = Robusta maculata; K =Kabir

Table 2 – Chemical-physical characteristics of breast and drumstick

Strain		Ross	Kabir	Robusta maculata	SE
BREAST					
Moisture	%	75.73^{a}	77.18^{b}	76.01^{a}	1.82
Protein	“	22.76^{b}	21.51^{a}	22.71^{b}	1.52
Fat	“	0.81^{c}	0.67^{b}	0.49^{a}	0.19
Ash	“	0.70	0.64	0.79	0.74
Gross energy	MJ kg d.m.$^{-1}$	20.98^{b}	20.05^{a}	20.59^{ab}	1.42
pH_u		5.75^{a}	5.84^{b}	5.82^{b}	0.10
Water holding capacity	%	53.49^{b}	46.34^{a}	53.65^{b}	9.23
Cooking loss	“	33.32^{a}	37.07^{b}	33.28^{a}	5.80
Shear force	kg/cm^2	2.69	2.56	2.66	0.96
DRUMSTICK					
Moisture	%	76.89^{a}	78.19^{b}	77.19^{a}	1.48
Protein	“	19.28^{b}	18.34^{a}	19.32^{b}	1.40
Fat	“	2.99^{b}	2.64^{a}	2.49^{a}	0.35
Ash	“	0.84	0.83	1.00	0.83
Gross energy	MJ kg d.m^{-1}	22.31^{c}	21.32^{ab}	21.98^{bc}	1.26
pH_u		6.03^{a}	6.14^{b}	6.14^{b}	0.15
Water holding capacity	%	57.45^{b}	48.68^{a}	57.08^{b}	10.32
Cooking loss	“	34.02^{a}	39.65^{b}	34.23^{a}	6.65
Shear force	kg/cm^2	3.12	2.96	3.07	0.83

Values in the same raw followed by different superscript litters differ at $P<0.05$.

Table 3 – Antioxidant capacity, α-tocopherol, colour, amount of iron of breast and drumstick muscles.

Strain		Ross	Kabir	Robusta maculata	SE
Antioxidant capacity	ηmol HClO/mL	528^{A}	750^{B}	725^{B}	84
Serum α-tocopherol	mg L^{-1}	17.2^{a}	18.3^{b}	19.0^{b}	1.7
BREAST					
L*		60.03^{c}	51.68^{a}	57.67^{b}	3.76
a*		4.71^{a}	5.75^{b}	5.71^{b}	1.45
b*		5.58^{a}	4.94^{a}	7.69^{b}	2.45
Fe total	mg kg^{-1}	4.15^{A}	6.54^{B}	6.45^{B}	2.56
Fe haeme	“	1.89^{A}	2.94^{B}	2.90^{B}	1.03
DRUMSTICK					
L*		54.63^{bc}	47.13^{a}	52.71^{b}	3.72
a*		5.98^{A}	14.46^{B}	13.86^{B}	8.96
b*		5.29^{a}	4.55^{a}	6.73^{b}	2.05
Fe total	mg kg^{-1}	6.93^{A}	9.62^{B}	9.48^{B}	2.57
Fe haeme	“	3.12^{A}	4.32^{B}	4.26^{B}	1.29

Values in the same raw followed by different superscript litters differ at P:<0.01 and P<0.05.

Figure 2 – TBA-RS in *pectoralis major* during 96 h of display (95% upper and lower limits).

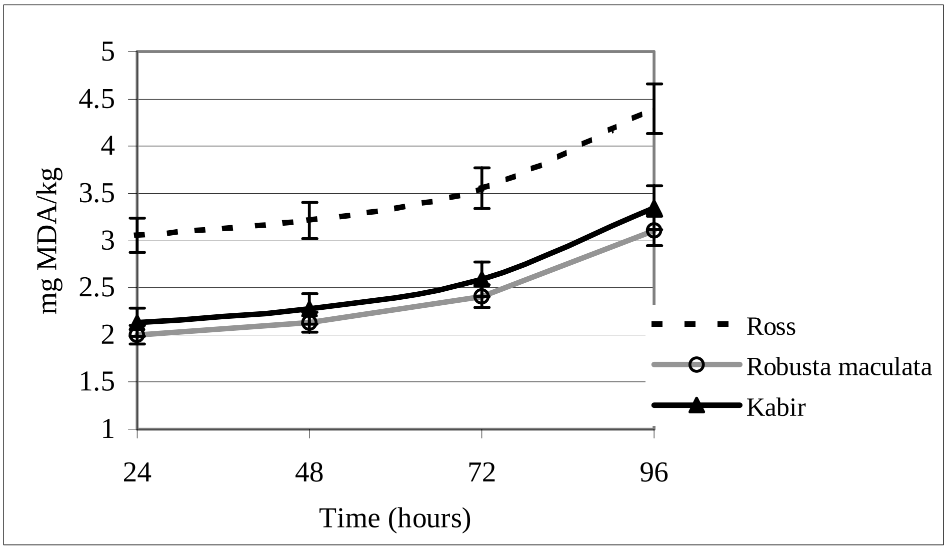
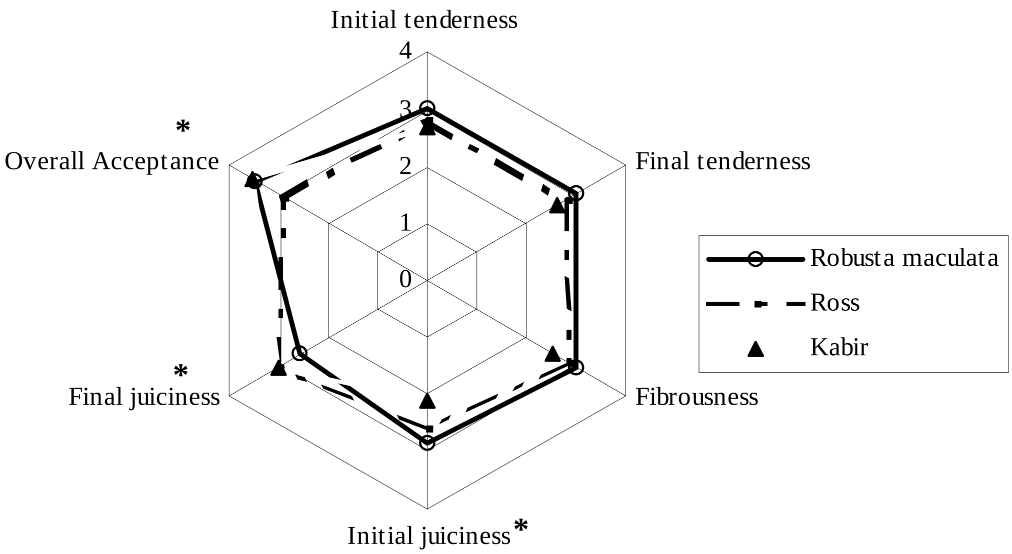


Table 4 – Percentage of major fatty acids in breast and drumstick muscles.

Strain	Ross	Kabir	Robusta maculata	SE
BREAST				
Σ SFA	38.05	38.62	38.77	3.12
Σ MUFA	29.41	29.15	29.22	3.25
Σ PUFA	32.54	32.23	32.01	2.95
C20:5(n-3) EPA	0.57	0.53	0.54	0.22
C22:6(n-3) DHA	1.92	1.83	1.89	0.81
Σ (n-3)	5.16	5.11	5.08	0.51
DRUMSTICK				
Σ SFA	36.43	37.01	36.54	2.78
Σ MUFA	31.73	31.96	31.79	3.20
Σ PUFA	31.84	31.03	31.67	2.86
C20:5(n-3) EPA	0.36	0.34	0.35	0.18
C22:6(n3) DHA	1.26	1.20	1.23	0.72
Σ (n-3)	4.81	4.69	4.78	0.45

Figure 1 – Sensory analysis of breast muscle.



Level of significance: *: P<0.05.