



## PAPER

## Comparison of meat quality and fatty acid profile in slow-growing chicken genotypes fed diets supplemented with *Origanum vulgare* or *Melissa officinalis* leaves under the organic system

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### Abstract

This study was conducted to compare the meat quality and selected fatty acids profile of two different slow-growing broiler genotypes (Hubbard S757; S757 and Hubbard Grey Barred JA; GB-JA) fed diets supplemented with dry oregano (*Origanum vulgare* L., OV; 10 g/kg basal diets) or lemon balm leaves (*Melissa officinalis* L., MO; 10 g/kg basal diets) under organic housing system. It is concluded that slow-growing genotypes had no effect on L\* parameter of the breast, thigh and abdominal fat meat quality. Two hundred and forty chicks were allocated randomly into 4 experimental groups according to a 2×2 factorial arrangement. Birds were raised until 98 days in order to achieve an acceptable market live weight. The b\* colours of breast and thigh meat were significant different among genotypes and also a\* colour of breast meat of GB-JA increased (P<0.05). Slow-growing female broilers produced a higher dry matter content and lower fat content of breast meat as compared with males. There were the higher concentrations of linoleic (C18:2n-6) acid and the lower concentrations of linolenic acid (C18:3n-3) in genotypes fed with supplemented dry oregano or lemon balm leaves diet. Sex affected total

unsaturated fatty acids (UFA) composition, polyunsaturated fatty acid (PUFA) and linoleic acid, were higher in slow growing males breast meat as compared with females breast meat. These results suggested that the slow-growing genotypes might had influenced the colour of breast and thigh meat, although overall meat quality was not affected under the organic system.

### Introduction

The organic farming is expanding by increasing consumer awareness of animal welfare, product quality, and environmental issues. The recent organic poultry production has become a growing segment of the poultry industry. The EC regulation 1804/99 and the Network for Animal Health and Welfare in Organic Agriculture's final recommendation (Hovi *et al.*, 2003) suggest to use local, slow-growing breeds for their higher rusticity and capacity to use in outdoor areas and pasture (Bosco *et al.*, 2012). Slow-growing birds are more adapted to natural systems, and the quality of their meat is more appropriate for a specialty or gourmet market (Castellini *et al.*, 2002b; Fanatico *et al.*, 2005). There are several legislative criteria for organic broiler production such as low flock density, use of organic feed, prohibition of preventive treatments, and access to outside area (Herman *et al.*, 2002). Moreover, slow-growing breeds well adapted to free range and organic conditions and the minimum age at slaughter is 81 days (Overbeke *et al.*, 2006). Some of the most important factors affecting the quality of poultry meat are origin, different housing systems and duration of growth. In this case, selecting the appropriate genetic type of the birds becomes a major problem. S757 (Slow growth, commercial crossbreeding of S77 X JA 57 with a live weight of 2050 to 2300 g at age of 81 days) and GB-JA (differentiated growth, commercial crossbreeding of Grey Barred X JA 57 Ki with 1560 to 2300 g at a minimum age of 48 to 56 days) improved by Hubbard's for the genetic response to the markets requiring broilers (Hubbard, 2013).

Organic system, without any confinement can also reduce stress, increase comfort and bird welfare with outdoor or free-range system. Furthermore, it may lead to products with better taste and flavour compared with conventionally produced broiler chicken (Fanatico *et al.*, 2006; Dou *et al.*, 2009; Bogosavljevi - Boškovi *et al.*, 2010). Based on these advantages, information about the quality of organic

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growing broiler.

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poultry meat is a necessary argument to get the consideration of a specific quality product for local, national, and supranational authorities. Meat quality can be improved by incorporating natural herb and herb products (*e.g.*, extracts, oils, leaves) based on the active ingredients with antioxidants in the animal diets. The most well-known herbs of the Labiatae family are Oregano (Cervato *et al.*, 2000; Botsoglou *et al.*, 2002) and lemon balm (Heilerová *et al.*, 2003; Dastmalchi *et al.*, 2008) are important sources of natural antioxidants. These herbs contains some chemical compounds such as flavonoids and phenolic compounds that have already been successfully used to increase the oxidative stability of meats because of shelf-life and meat quality when supplemented in chicken diets (Lahucky *et al.*, 2010). These have been shown to alter the negative effects of stress on quality characteristics of chicken meat (Young *et al.*, 2003; Symeon *et al.*, 2010). Therefore, detail research is necessary to determine the suitability of different slow-growing genotypes fed with dietary herbal supplement by organic and natural production systems that provide outdoor access with regard to overall meat quality and meat fatty acids profile. Moreover, it is also

necessary to investigate the effect of the supplement dry herb leaves in organic systems on the quality with better consumer acceptance. According to our knowledge, the comparison of the meat quality and fatty acids profile of two different slow-growing genotypes fed with supplementation of dry oregano (OV) or lemon balm leaves (MO), (natural antioxidants), in compound feed has not been reported in the organic rearing system. Breeding and feeding strategy required for achieving good meat quality from slow-growing genotypes still needs to be evaluated. With this background, the objective of this research is to determine the meat quality from male and female slow-growing chickens obtained by commercial crossbreeding of meat-type S757, GB-JA and whether this is influenced by genotype and supplemented dry herb leaves.

## Materials and methods

### Animal and organic housing system

The study was carried out at Cumhuriyet University, Sivas, located in the central Anatolian region of Turkey. Two hundred and forty slow-growing chickens consisting of equal numbers of S757 and GB-JA strains were utilized for the investigation. In this study, 240 male and female day old chicks were weighed, identified with a wing number and randomly allocated to 4 treatment combinations with three replications consisting a 2 genotypes (S757, GB-JA) and 2 diets (10 g OV kg<sup>-1</sup> basal diet, + 10 g MO kg<sup>-1</sup> basal diet) with factorial arrangement in a complete randomized design. The experiment was approved by the Animal Ethics Committee (Cumhuriyet University, Turkey: 20.06.2011/50).

There were 12 chicken mobile housings (1.5×1.5 m), each containing 20 birds per replication with 10 birds (m<sup>2</sup>)<sup>-1</sup> stocking density placed in each of the 100 m<sup>2</sup> grazing area. Moving shelters are secure and allow chickens access to sunlight and fresh air, while allowing them to forage and scratch the ground for food. It is made from wood and includes adequate (Turkish Regulation, 2010) drinkers, feeders, heater and perch.

The research was carried out according to the principles and implementation of regulation on organic agriculture published by the Republic of Turkey, Ministry of Food, Agriculture and Livestock (Turkish Regulation, 2010). Initially, 14 day-old chicks were housed in mobile housing, feed and water were provided *ad libitum*, and they were not allowed go out

for grazing. After this period, the chicks were allowed to go out and graze freely and all basal feed and water were provided between the hours 07.00-19.00 *ad libitum* for all the chicks during the experimental period. Natural day length lighting was provided for chickens from first days to slaughter age with no additional lighting. Ceramic heaters were used for heating by Far Infrared Rays and do not spread light. Starter (0-28 days), grower (29-81 days) and finisher (82-98 days) diets were formulated to provide adequate levels of all nutrients to broilers (Table 1). All birds used in the experiment were cared according to applicable recommendations described by Sirri *et al.* (2011). The basal diets were supplemented with levels of OV and MO to provide 10 g kg<sup>-1</sup> of total OV and MO in the diet from the first 15 day. The certified organic feed materials were used. Creating artificial poultry pasture, *Lotus corniculatus* (50%) and *Bromus inermis* (50%) were used by mixing. Organically grown herbs of oregano OV or lemon balm MO were harvested and the leaves were separated from the twigs. The herb material consisted of leaves

that were spread out on a concrete floor and were allowed to dry for a period of 3-4 days under room temperature.

The 48 birds (fasted for 10 h with free access to water) were slaughtered without stunning under Turkish slaughter procedure (these birds were slaughtered under conditions acceptable to the appropriate ethics committee) by severing the throat and major blood vessels in the neck in local processing plant in organic system. The carcasses, obtained after defeathering, eviscerating were refrigerated for 24 h. Then, the left and right breast muscle removed from the carcass by an experienced slaughterhouse employee. These muscles obtained from 12 chickens in each experimental group were used for physical and chemical analysis. The left skinless breast muscle was used for chemical analysis and stored at -20°C until analysis. Before the chemical analysis, the chickens were thawed at 4°C for 48 h.

**Table 1. Ingredients and composition of experimental organic diets.**

	0-28 days	29-81 days	82-98 days
Ingredients, %			
Barley	3.45	4.50	4.50
Vegetable oil	4.36	5.00	5.00
Wheat bran	5.00	5.00	5.00
White wheat	12.40	4.00	4.00
Rye	3.00	4.00	4.00
Corn	40.00	20.00	20.00
Triticale	-	22.00	32.00
Oat	2.10	5.00	-
Fish meal	7.30	5.00	-
Soybean meal	20.00	22.00	22.00
Dicalcium phosphate	1.10	2.10	2.10
Limestone	0.74	0.80	0.80
Salt	0.30	0.30	0.30
Vitamin-mineral premix <sup>o</sup>	0.25	0.30	0.30
Calculated nutrients composition			
Metabolizable energy, MJ/kg	13.00	12.72	12.91
Dry matter, g/kg	899.00	903.00	901.00
Crude protein, g/kg	197.00	201.00	180.00
Crude ash, g/kg	4.70	5.90	4.80
Lysine, g/kg	10.80	10.60	8.50
Methionine + Cystine, g/kg	6.60	6.70	5.90
Threonine, g/kg	7.30	7.20	6.20
Calcium, g/kg	10.00	11.60	9.00
Sodium, g/kg	1.90	1.80	1.50
Tryptophan, g/kg	2.40	2.60	2.50
Linoleic acid, g/kg	31.9	32.1	31.3

<sup>o</sup>Each kg of vitamin-mineral premix contained: vitamin A, 4,400,000 U; vitamin D<sub>3</sub>, 1,600,000 U; vitamin E, 20,000 mg; vitamin K<sub>3</sub>, 1600 mg; vitamin B<sub>1</sub>, 1200 mg; vitamin B<sub>2</sub>, 3200 mg; vitamin B<sub>3</sub>, 20,000 mg; vitamin B<sub>5</sub>, 6000 mg; vitamin B<sub>6</sub>, 1600 mg; vitamin B<sub>9</sub>, 800 mg; vitamin B<sub>12</sub>, 8 mg; biotin, 80 mg; antioxidant dry, 50,000 mg; Cu, 6000 mg; Fe, 20,000 mg; Mn, 48,000 mg; Se, 80 mg; Zn, 40,000 mg; Co, 80 mg; 1,500 mg.

## Meat quality parameters and colour measurements

Water holding capacity (WHC), pH and colour were measured in the right part of the skinless breast muscle (*Pectoralis major*) at 24 h *post-mortem*. The pH was determined by a spear tip probe attached to a Hanna FC202D pH meter. The electrode was calibrated in buffers at between pH 4.00 and 7.00 at room temperature. Colour parameter of skinless breast muscle was measured using a colorimeter (Minolta CR 600, Minolta GmbH, Langenhagen, Germany). The colorimeter was calibrated using the standard white ceramic reference (illuminant C). The average of 5 measurements were recorded for lightness ( $L^*$ ), redness ( $a^*$ ), and yellowness ( $b^*$ ) of the muscle. In order to evaluate the colour changes of the breast, thigh meat and abdominal fat colour readings were taken over 24 h aging time at 4°C and used to calculate psychometric colour terms involving hue angle (hue,  $\tan^{-1} b a^{-1}$ ), chroma ( $C^*$ ,  $\sqrt{a^{*2} + b^{*2}}$ ) and colour difference over time ( $\Delta E^*$ ,  $(L^2 + a^{*2} + b^{*2})^{1/2}$ ). The WHC was estimated (Castellini *et al.*, 2002a) by centrifuging 1 g of muscle placed on tissue paper inside a tube for 4 min at 1500 × g. The water remaining after centrifugation was determined by drying the samples at 70°C overnight. WHC was calculated using the formula as given below:  $WHC = (\text{weight after centrifugation} - \text{weight after drying}) / (\text{initial weight} \times 100)^{-1}$ . The concentrations of fat, protein, ash and dry matter (DM) were demonstrated according to the standard procedure of AOAC (2000). The dry matter con-

tent was determined by drying at 103°C for 16 h. The ash content was analyzed after combustion at 600°C for 24 h. Protein ( $N \times 6.25$ ) was measured by the Kjeldahl method. Fat was analyzed after acid hydrolysis and extraction in Soxtec System.

## Fatty acid analysis

Fatty acid profile was demonstrated with 12 animals in each experimental group through methyl ester preparation by transmethylation according to the procedure of the Turkish Standards Institute (1996). Fatty acid methyl esters (FAME) were analyzed using an Agilent 7890 A gas chromatograph equipped with a flame ionization detector and fused silica capillary column (60 m × 0.25 mm) with 0.25 μm of CP Sil-88. The column temperature was programmed to start at 175°C (maintained for 10 min) followed by a 3°C min<sup>-1</sup> until it increase to 220°C (maintained for 20 min). The injection port and detector were maintained at 250 and 280°C, respectively. The carrier gas was helium and hydrogen (54 mL min<sup>-1</sup>) and split ratio was 1 50<sup>-1</sup>. Identification was accomplished by comparing the retention times of peaks from samples with those of FAME standard mixtures. The peak areas were determined by the CG-300 computing integrator. Fatty acids were expressed as relative percentages of the fatty acids identified.

## Statistical analysis

Statistical analyses and the significance of the mean scores between the groups for meat

quality and selected fatty acids profile parameters were determined using the variance analysis method including the effects of genotype, herb leaves, sex and genotype and their interaction. The statistical analysis was conducted using the SPSS 16.0 (Inc. Chicago, IL, USA) computer software program. Treatment effects were considered to be significant at  $P < 0.05$ . Data were expressed as mean values with pooled standard errors.

## Results and discussion

The effects of two different genotypes fed dietary dry oregano or lemon balm leaves on breast meat, thigh meat, abdominal fat colour ( $L^*$ ,  $a^*$  and  $b^*$ ) hue angle, chroma and  $\Delta E^*$  value in slow-growing chickens are presented in Tables 2 and 3 respectively.

Slow-growing genotypes had no effect on  $L^*$  parameter of the breast, thigh and abdominal fat meat quality (Table 2). In terms of the colour difference apparent by instrumental means, the main effect of genotype GB-JA was only to make the breast muscle redder ( $a^*$ ) (5.15;  $P < 0.05$ ) than that of S757 genotype (3.32). A strong effect of genotype was observed on  $b^*$  values ( $P < 0.05$ ) of breast meat and thigh meat. The breast muscle and thigh muscle of GB-JA genotype had a higher  $b^*$  value (17.86 *vs* 15.46 and 14.29 *vs* 11.97) when compared with that from S757 genotype. Likewise the thigh muscle from dry OV leaf was more yellow (14.25 *vs* 12.02) compared

Table 2. The effects of genotype and herb supplement on meat colour ( $L^*$ ,  $a^*$ ,  $b^*$ ).

Genotype	Herb	Sex	Breast meat			Thigh meat			Abdominal fat		
			$L^*$	$a^*$	$b^*$	$L^*$	$a^*$	$b^*$	$L^*$	$a^*$	$b^*$
GB-JA	OV	F	59.03	6.17	18.83	62.16	5.22	15.97	63.90	8.73	34.29
		M	62.71	5.54	18.42	61.74	5.46	14.56	64.71	10.47	32.67
	MO	F	54.84	4.32	18.16	56.40	4.87	14.08	68.56	10.35	37.07
		M	54.99	4.56	16.05	61.47	5.42	12.56	64.05	10.17	32.05
S757	OV	F	57.21	2.95	16.34	62.82	4.40	14.69	66.18	9.58	33.66
		M	54.24	3.68	15.91	57.18	5.88	11.75	65.58	9.83	35.42
	MO	F	56.51	3.25	16.81	57.52	4.77	10.40	63.62	8.90	32.66
		M	55.55	3.43	12.78	58.91	3.88	11.02	65.42	7.62	26.40
Pooled SEM			0.80	0.36	0.52	0.99	0.26	0.51	0.61	0.45	0.66
Genotype			ns	*	*	ns	ns	*	ns	ns	ns
Herb			ns	ns	ns	ns	ns	*	ns	ns	ns
Sex			ns	ns	ns	ns	ns	ns	ns	ns	*
GxH			ns	ns	ns	ns	ns	ns	ns	ns	**
HxS			ns	ns	ns	ns	ns	ns	ns	ns	*

GB-JA, Hubbard Grey Barred JA; S757, Hubbard S757; OV, *Origanum vulgare*; MO, *Melissa officinalis*; F, female; M, male; GxH, genotype x herb; HxS, herb x sex. \* $P < 0.05$ ; \*\* $P < 0.01$ ; ns, not significant.

with dry MO leaf group. The relatively high values of yellowness of breast and thigh meat, comparatively with different observations reported in literature might be due to the access of outdoor and the natural pigments present in the legume-based pasture (Ponte *et al.*, 2004; Grashorn and Serini, 2006).

Genotype and environmental condition such as feed and housing conditions might affect meat colour (Du and Ahn, 2002; Saláková *et al.*, 2009). The L\* value indicates the degree of paleness and is associated with poor meat quality; pale, soft, and exudative meat is an increasing problem in the poultry industry. The mean values of lightness (L\*) or paleness value recorded in the present study for breast muscles are higher than those reported by Fanatico *et al.* (2005) in slow-growing genotype (from S and G Poultry) with age of 81 days (49.6), by Fanatico *et al.* (2007) in slow-growing genotype (S & G Poultry, Clanton, AL, USA) with age of 91 and 84 days (51.04 vs 52.19). However higher L\* values (60.39, 68.02, 61.71 and 94.08) were reported by Castellini *et al.* (2002a), Husak *et al.* (2008), Mikulski *et al.* (2011), ekerolu and Dikta (2012). The findings of the current study are consistent with finding of Castellini *et al.* (2002a), Grashorn and Serini (2006), Fanatico *et al.* (2005), Mikulski *et al.* (2011), Almási *et al.* (2012) and Küçükylmaz *et al.* (2012) they found breast meat from slow-growing broilers was lighter, less red, and more yellow than meat from faster-growing indoor broilers. Therefore, it could also be attributed that increased physical

activity can also alter muscle fat and colour. In contradiction, Mikulski *et al.* (2011) illustrated that L\*, a\* and b\* values of thigh meat in slow-growing broiler with age of 65 days were 51.40, 10.29 and 12.64, respectively.

The effect of sex, genotype-herb leaves and herb leaves-sex interactions in abdominal fat were observed on b\* values. In terms of b\* value female abdominal fat was more yellow (34.42 vs 31.64) compared with males in organic system. The sex effect is likely related with fat content, as females have more fat than males (Havenstein *et al.*, 2003; Fanatico *et al.*, 2005). Moreover, the older birds have redder meat due to higher content of myoglobin reported by Gordon and Charles (2002). The birds were also raised for longer period (89 days) and therefore had access to pasture for more time. The yellowness of the broilers may be related to increase foraging of plant material. The interaction effects of factors on any of the studied other parameters (L\*, a\*, b\* of breast, thigh muscle and L\*, a\* of abdominal fat) were not significant (P>0.05). Slow-growing genotypes had no effect on hue angle of the breast, thigh and abdominal fat meat quality (Table 3). The breast and thigh muscle of GB-JA genotype had a higher (P<0.05) chroma value (18.78 and 15.31 vs 15.90 and 12.95) compared with those of S757 genotype. Likewise the thigh muscle chroma value from dry OV leaf was higher (15.28 vs 12.98) than that of dry MO leaf group (P<0.05). The effect of sex, genotype-herb leaves and herb leaves-sex interactions in abdominal fat were

observed on chroma values (P<0.05). In terms of chroma value, female abdominal fat was superior (35.78 vs 33.11) when compared with males. It could be important to note that ΔE\* value as an indicator of the total colour difference. The genotype, herb leaves, sex and their interaction effects were not observed on ΔE\* value (P>0.05), except genotype x herb leaves interaction (P<0.05). The physical traits of breast and thigh meat and chemical composition of breast meat is given in Table 4. The pH value of breast meat, thigh meat and the WHC value of breast meat were not affected by genotype, herb leaves, sex and their interactions (P>0.05). The pH value of GB-JA and S757 breast muscle were recorded as 5.97 and 6.16 at 24 h, respectively. These values are higher than the values relative to slow-growing broiler (5.53, 5.56 and 5.55) as reported by Fanatico *et al.* (2007), Wang *et al.* (2009), ekerolu and Dikta (2012).

In the current study, pH values of breast and thigh meat are in good agreement with previous research of Mikulski *et al.* (2011) who found 5.74 and 6.14 respectively. Alvarado *et al.* (2005) and Raach-Moujahed *et al.* (2011) also found that outdoor access resulted in higher pH (5.96 and 6.10). However, the high value of pH in our experiment are in line with the finding of Husak *et al.* (2008), who found that breast meat from organic broilers had a higher pH than conventional broilers.

On the other hand, pH values of breast and thigh meat were lower than those reported by Castellini *et al.* (2002b) in the other genotypes

**Table 3. The effects of genotype and herb supplement on meat colour.**

Genotype	Herb	Sex	Breast meat			Thigh meat			Abdominal fat		
			Hue	Chroma* <sup>5</sup>	ΔE* <sup>6</sup>	Hue	Chroma* <sup>5</sup>	ΔE* <sup>6</sup>	Hue	Chroma* <sup>5</sup>	ΔE* <sup>6</sup>
GB-JA	OV	F	1.24	20.02	62.39	1.24	16.92	64.47	1.32	35.42	73.16
		M	1.28	19.33	65.66	1.21	15.61	63.78	1.26	34.40	73.40
	MO	F	1.35	18.73	58.13	1.24	14.93	58.44	1.30	38.79	78.84
		M	1.33	17.02	57.79	1.16	13.77	63.05	1.27	33.75	72.57
S757	OV	F	1.40	16.63	59.67	1.28	15.41	64.85	1.30	35.04	74.97
		M	1.34	16.34	56.69	1.12	13.18	58.88	1.30	36.81	75.24
	MO	F	1.38	17.12	59.08	1.15	11.47	58.72	1.31	33.86	72.14
		M	1.30	13.49	57.22	1.23	11.75	60.18	1.29	27.51	71.02
Pooled SEM			0.20	0.54	0.81	0.15	0.53	0.97	0.10	0.71	0.71
Genotype			ns	**	ns	ns	*	ns	ns	ns	ns
Herb			ns	ns	ns	ns	*	ns	ns	ns	ns
Sex			ns	ns	ns	ns	ns	ns	ns	*	ns
GxH			ns	ns	ns	ns	ns	ns	ns	**	*
HxS			ns	ns	ns	ns	ns	ns	ns	*	ns

GB-JA, Hubbard Grey Barred JA; S757, Hubbard S757; OV, *Origanum vulgare*; MO, *Melissa officinalis*; F, female; M, male; Hue,  $\tan^{-1} b/a$ ; Chroma,  $\sqrt{(a^2 + b^2)}$ ; ΔE\*,  $(L^2 + a^2 + b^2)^{0.5}$ ; GxH, genotype x herb; HxS, herb x sex. \*P<0.05; \*\*P<0.01; ns, not significant.

(Ross, Kabir, Robust maculata) that had been organic reared. The lower pH of the organic chickens could be attributed with better welfare conditions that reduced the stress pre-slaughter (Castellini *et al.*, 2002a). In addition, the higher value could be related with late age of slaughtered birds (14 weeks), since meat from old age birds had consistently high pH values (Ponte *et al.*, 2008b). The rate and the extent of pH decline have a large impact on meat quality properties and variation in muscle pH is likely to affect colour and the ability of meat to hold water. Higher meat pH is more effective for retaining desirable colour and moisture absorption properties (Husak *et al.*, 2008; Raach-Moujahed *et al.*, 2011). When the meat pH is above the isoelectric point of myofibrillar proteins, water molecules are tightly bound, causing more light to be absorbed by the muscle, and meat appears darker in colour (Saláková *et al.*, 2009).

The WHC of different slow-growing broiler genotypes breast meat ranged from 66.08% to 71.46%. The WHC values obtained in the present study for breast muscles were higher than those reported by Castellini *et al.* (2002b) in three chicken genotypes (Ross, Kabir, Robust maculata) aged 81 days (53.49%, 46.34% and 53.65% respectively); Dou *et al.* (2009) in Gushi slow-growing genotype aged 35 days (56.90%); Wang *et al.* (2009) in Gushi chicken aged 112 days (56.90%), ekero lu and Dikta (2012) in Red-JA slow-growing genotype aged 60 days (23.08). Dabes (2001) claimed that lower WHC indicated losses in the nutritional value through exudates that were released and this resulted in drier and tougher meat. The

chemical characteristics of breast meat showed almost the same values of all nutrient composition among groups, but sex significantly affected the dry matter of breast meat ( $P < 0.05$ ; Table 4). The breast meat of females was higher (31.15 vs 29.99) in dry matter (lower moisture) compared with males ( $P < 0.05$ ). The results of the current chemical analyses of dry matter, protein and fat in breast muscle were within the limits reported by Holcman *et al.* (2003) on breast meat-plus-skin of slow-growing chickens. In addition, these findings are in agreement with previous related studies (Grashorn and Serini, 2006; Küçükyılmaz *et al.*, 2012) reporting that slow-growing broilers in organic systems had a higher meat fat content.

The other effect of main and interactions were not observed on dry matter value of breast meat. The protein, fat and ash contents of breast meat were not affected by genotype, herb leaves, sex and their interactions ( $P > 0.05$ ). Several authors indicated that there is not any significant effect of added herbs on the composition of meat products (Koreleski and Swiatkiewicz, 2007; Marcin áková *et al.*, 2011; Marcin ák *et al.*, 2011; Narimani-Rad *et al.*, 2011) in conventional confined systems. Castellini *et al.* (2006) did not find any significant differences in dry matter, protein and ash of the breast meat among two slow-growing genotypes (Ross and Kabir). The values of dry matter and protein for breast muscle were similar to the findings of Katogianni *et al.* (2008), who found 28.3% and 24.8%, respectively, for Redbro medium growing genotype aged 12 weeks in organic system. Furthermore

Mikulski *et al.* (2011) reported that dry matter, fat and protein of slow-growing broiler breast meat were 26.24%, 0.73% and 24.83% respectively. Conversely, Grashorn and Serini (2006) and Husak *et al.* (2008) emphasized higher protein contents in meats yielded from organically reared birds. Indeed, in the present study breast meat from slow-growing broilers had excessively higher lipid content (ranged from 5.90 to 8.21) with outdoor access compared with other studies (Castellini *et al.*, 2002b; Fanatico *et al.*, 2005; Katogianni *et al.*, 2008; Dou *et al.*, 2009; Mikulski *et al.*, 2011). The increase in the intramuscular fat content and the decrease in the protein content of breast muscles in slow-growing genotypes observed in this study showed contradiction with the findings Castellini *et al.* (2006), Pietrzak *et al.* (2006) and Tang *et al.* (2009) who observed a lower intramuscular fat content in slow-growing birds. These birds (S757 and GB-JA) were selected to reach their market live weight at an early age (70 and 77 days) and when the slaughter age is increased to minimum 81 days, as requested for organic production, the birds increase in fatness. This may be explained by differences in the genotypes and age or might be probably related with temperature. Temperature fluctuations may cause variation in fat deposition (Lu *et al.*, 2007); for instance, heat may increase abdominal fat, whereas less fat and meat are deposited in cold temperatures (Gordon and Charles, 2002). Moreover a higher intramuscular fat content may lead to increase WHC and then it could be accompany by higher meat juiciness in slow-growing broilers. The present study might

**Table 4. The effects of genotype and herb supplement on physical traits and nutrient compositions.**

Genotype	Herb	Sex	Physical traits			Nutrient compositions of breast meat			
			pH (Breast)	pH (Thigh)	WHC	Protein	Dry matter	Fat	Ash
GB-JA	OV	F	5.97	6.96	68.76	20.69	31.93	5.90	0.99
		M	5.88	6.77	71.46	21.67	29.54	6.39	1.03
	MO	F	6.00	6.57	70.46	22.30	31.39	8.21	0.99
		M	6.02	6.63	69.27	21.16	30.53	7.88	1.06
S757	OV	F	6.08	6.49	68.67	21.86	29.98	6.29	1.07
		M	6.23	6.97	69.87	22.23	29.62	7.18	1.03
	MO	F	6.07	6.65	69.72	21.61	31.28	7.34	1.04
		M	6.24	6.72	66.08	22.21	30.26	8.15	1.04
Pooled SEM			0.0482	0.0806	0.6253	0.18	0.28	0.39	0.12
Genotype			ns	ns	ns	ns	ns	ns	ns
Herb			ns	ns	ns	ns	ns	ns	ns
Sex			ns	ns	ns	ns	*	ns	ns
GxH			ns	ns	ns	ns	ns	ns	ns
HxS			ns	ns	ns	ns	ns	ns	ns

WHC, water-holding capacity; GB-JA, Hubbard Grey Barred JA; S757, Hubbard S757; OV, *Origanum vulgare*; MO, *Melissa officinalis*; F, female; M, male; Hue,  $\tan^{-1} b a^{-1}$ ; Chroma,  $\sqrt{(a^* + b^*)^2}$ ;  $\Delta E^*$ ,  $(L^2 + a^{*2} + b^{*2})^{0.5}$ ; GxH, genotype x herb; HxS, herb x sex. \* $P < 0.05$ ; \*\* $P < 0.01$ ; ns, not significant.

have resulted in nutrient deposition similar in different genotype fed supplemented dry oregano and lemon balm leaves. On the other hand, many variables, such as broiler genotype, age, sex, nutrition, rearing system, carcass dressing and type of meat, which can affect the nutritional value of meat.

Tables 5 and 6 report the data concerning the selected saturated (SFA) and unsaturated (UFA) fatty acids composition of breast meat. In this experiment, broiler genotypes fed supplemented dry oregano and lemon balm leaves had no significant impact on the fatty acid pro-

file of breast meat. The most abundant fatty acids observed in this study were palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1). As shown in Table 5, breast meat had the lowest percentage of SFA. They accounted for approximately two thirds of the total amount of fatty acids, in line with the results reported by other study (Sirri *et al.*, 2010).

The sex also (P<0.01) influenced the fatty acid composition of the breast meat in organic system. The effect of sex was observed on palmitic acid (C16:0), arachidic acid (C20:0) and total SFA values (P<0.05) of breast meat in

favor of female. Total SFA values of female was higher than that male (24.58 *vs* 22.93). The total mono unsaturated fatty acid (MUFA) concentrations in broilers are related either with the endogenous synthesis or to the gut absorption from the diet, showing the highest levels in genotypes; these MUFA concentrations were mainly represented by palmitoleic acid (C16:1) and oleic acid (C18:1). Poly unsaturated fatty acid (PUFA) is consisted of 47.6% of total UFA. Meat of slow-growing genotypes compared with commercial genotypes was characterized by a high concentration of total PUFA

**Table 5. The effects of genotype and herb supplement on content of selected saturated fatty acids (g (100 g)<sup>-1</sup> of total detected fatty acids) in breast meat.**

Genotype	Herb	Sex	SFA	Caprilic (8:0)	Myristic (14:0)	Pentadecanoic (15:0)	Palmitic (16:0)	Margaric (17:0)	Stearic (18:0)	Arachidic (20:0)
GB-JA	OV	F	24.17	0.0600	0.4767	0.1100	17.12	0.2167	6.33	0.2667
		M	22.46	0.0800	0.4267	0.1133	15.64	0.2500	6.12	0.2767
S757	MO	F	25.38	0.0775	0.4900	0.1133	18.03	0.2500	6.65	0.2625
		M	21.83	0.0775	0.4500	0.1050	15.65	0.2100	5.59	0.2767
	OV	F	24.26	0.0767	0.4883	0.1117	17.41	0.2300	6.09	0.2267
		M	23.57	0.0633	0.4667	0.1067	16.65	0.2300	6.19	0.2760
MO	F	24.50	0.0500	0.4683	0.1083	17.41	0.2250	6.41	0.2633	
	M	23.85	0.0867	0.4767	0.1083	17.03	0.2400	6.15	0.2667	
Pooled SEM			0.31	0.0057	0.0072	0.0021	0.2371	0.0063	0.9811	0.0048
Genotype			ns	ns	ns	ns	ns	ns	ns	ns
Herb			ns	ns	ns	ns	ns	ns	ns	ns
Sex			*	ns	ns	ns	**	ns	ns	*
GxH			ns	ns	ns	ns	ns	ns	ns	ns
HxS			ns	ns	ns	ns	ns	ns	ns	ns

SFA, saturated fatty acids; GB-JA, Hubbard Grey Barred JA; S757, Hubbard S757; OV, *Origanum vulgare*; MO, *Melissa officinalis*; F, female; M, male; GxH, genotype x herb; HxS, herb x sex. \*P<0.05; \*\*P<0.01; ns, not significant.

**Table 6. The effects of genotype and herb supplement on content of selected unsaturated fatty acids (g (100 g)<sup>-1</sup> of total detected fatty acids) in breast meat.**

Genotype	Herb	Sex	UFA	MUFA (C16:1)	Palmitoleic (C18:1)	Oleic	PUFA (18:2n-6)	Linoleic (18:3n-3)	α-Linolenic	P:S
GB-JA	OV	F	73.32	38.27	0.9650	36.95	35.05	33.74	1.0483	2.78
		M	75.07	38.64	0.9400	37.48	36.43	35.14	0.9550	3.35
S757	MO	F	70.24	38.43	0.7633	37.44	31.81	30.68	0.8450	2.84
		M	75.53	36.67	0.7083	35.67	38.86	37.36	1.0850	3.47
	OV	F	72.58	39.05	0.6550	38.17	33.54	32.30	0.9733	3.01
		M	73.42	38.04	0.6583	36.99	35.39	34.28	0.8350	3.12
MO	F	72.59	38.49	0.8260	37.51	34.10	32.81	1.0250	3.01	
	M	72.97	39.15	0.7917	38.05	33.82	32.58	0.8617	3.07	
Pooled SEM			0.44	0.28	0.1147	0.2520	0.60	0.5752	0.3679	0.38
Genotype			ns	ns	ns	ns	ns	ns	ns	ns
Herb			ns	ns	ns	ns	ns	ns	ns	ns
Sex			*	ns	ns	ns	*	*	ns	**
GxH			ns	ns	ns	ns	ns	ns	ns	ns
HxS			ns	ns	ns	ns	ns	ns	ns	*

UFA, unsaturated fatty acids (mono unsaturated fatty acids + poly unsaturated fatty acids); MUFA, mono unsaturated fatty acids; PUFA, poly unsaturated fatty acids; P:S, PUFA to SFA ratio, poly unsaturated fatty acids (saturated fatty acids)<sup>-1</sup>; GB-JA, Hubbard Grey Barred JA; S757, Hubbard S757; OV, *Origanum vulgare*; MO, *Melissa officinalis*; F, female; M, male; GxH, genotype x herb; HxS, herb x sex. \*P<0.05; \*\*P<0.01; ns, not significant.

(Marcinčáková *et al.*, 2011; Bosco *et al.*, 2012) both in the total content and in the different fractions (n-3 and n-6). However, there were higher concentrations of linoleic acid (C18:2n-6) and lower concentrations of  $\alpha$ -linolenic acid (C18:3n-3) in genotypes fed with supplemented dry oregano or lemon balm leaves diet than in those of Castellini *et al.*, (2002b), Mikulski *et al.* (2011) and Castellini *et al.* (2006) for genotypes reared in an organic housing system. The reports by Jahan *et al.* (2004) and Küçükylmaz *et al.* (2012) demonstrated that organic breast meat had lower contents of n-3 fatty acids, but a higher content of total PUFA and n-6 is in agreement with the current findings. Despite the increased consumption of fresh forage, lower levels of  $\alpha$ -Linolenic acid (C18:3n-3) in the meat of slow-growing genotypes could be explained by the higher conversion of this fatty acid in the long-chain derivatives. Total UFA and PUFA of males breast meat was higher than the female (74.25 vs 72.18 and 36.12 vs 33.62% respectively;  $P < 0.05$ ) and mainly linoleic acid (18:2n-6) was superior in males (34.84%;  $P < 0.05$ ). Moreover, it had higher contents of long chain PUFA (linoleic acid, C18:2n-6) but lower amounts of  $\alpha$ -linolenic acid (C18:3n-3) among all treatment. This trend is explained by the pasture intake of slow-growing broiler during natural daylight and using vegetable oil (sunflower) to basal diets. This experiment have demonstrated that the slow-growing broiler are more active and made better use of the outdoor pasture with similar to other study (Castellini *et al.*, 2009). Likewise linoleic acid (C18:2n-6) is the major fatty acid in feed, whereas  $\alpha$ -linolenic acid (C18:3n-3) is predominant in forage reported by Ponte *et al.* (2008a). Linoleic acid (n-6) values obtained in this study are consistent with Sirri *et al.* (2010, 2011) who found 33.6 and 35.07% in organic slow-growing broiler aged 96 days. On the contrary, the total  $\alpha$ -linolenic acid (n-3) of slow-growing genotypes breast meat was lower than those of Castellini *et al.* (2002b) and Sirri *et al.* (2011).

Poultry meat has been considered one of the main sources of PUFA, in particular n-3 PUFA, for human diets (Howe *et al.*, 2006; Ponte *et al.*, 2008a). The findings of current study on PUFA values of breast meat were in agreement with that of Castellini *et al.* (2002a, 2002b), who showed that higher levels of omega-3 and omega-6 fatty acids, and increased levels of total PUFA in free range birds.

The results of this study indicate that the differences in the fatty acid content of chicken breast is influenced by the sex; therefore, it

has demonstrated that in organic farming, chicken sex play an important role in the fatty acid composition of meat. Previous trials indicated that feeding on fresh grass and herbs would alter the intramuscular fatty acid profiles in broiler compared with more conventional regimens, resulting in a PUFA to SFA (P:S) ratio that have therefore become some of the most important parameters in evaluating the nutritional value and healthiness of foods (Jakobsen, 1995; Sirri *et al.*, 2011; Bosco *et al.*, 2012). At the same time, the recommended ratio of P:S should be increased to above 0.4 as by reported Wood *et al.* (2003). Since some meats naturally have P:S ratio of around 0.1, meat has been implicated in causing the imbalanced fatty acid intake of today's consumers. In this study, P:S ratio ranged from 3.47 to 2.78 and improved in breast meat and the male P:S ratio was superior than that female (3.25 vs 2.91). The P:S ratio of breast meat were higher than that reported by Küçükylmaz *et al.* (2012) in slow-growing Hubbard Red-JA genotype aged 81 days (1.36) in organic system.

Therefore, organic feeding broilers outdoors on pasture appears to be an interesting approach to improving the healthy image of organic broiler for the human health point of view.

## Conclusions

The meat of organic slow-growing GB-JA genotype was lighter, redder and more yellow in colour than the meat of S757 genotype. It seems that both genotypes of current study had a higher fat contents and a better water-holding capacity compared to literature mentioned above. Body conformation especially favoring the breast meat is the most valuable portion of the chicken carcass in the market, even small differences in breast meat quality among genotypes could have a significant impact in terms of consumer demands. The chemical composition (contents of dry matter, protein, fat and ash) of muscle from breast without skin in 89 days old chickens did not differ between slow-growing broilers fed supplemented dry oregano and lemon balm leaves under organic system. Even though genotypes fed supplemented dry oregano or lemon balm leaves to basal diets were not significant differences among the groups, both herbs varieties could be incorporated to diets of slow-growing in accordance with purpose specified in the literature. However, further research is needed to determine the threshold values for

the colour of slow-growing broilers reared in an organic system. As is known PUFA to SFA (P:S) ratio that have therefore become some of the most important parameters in evaluating the nutritional value and healthiness of foods.

In the light of the high P:S ratio obtained from this study, it could be said that organic slow-growing genotypes meat and products may be considered to be more favorable for human health.

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