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► **To cite this version:**

Enrico Zanetti, Massimo de Marchi, Chiara Dalvit, Caroline Molette, Hervé Rémignon, et al.. Carcass characteristics and qualitative meat traits of three Italian local chicken breeds. *British Poultry Science*, 2010, 51 (05), pp.629-634. 10.1080/00071668.2010.521142 . hal-00638523

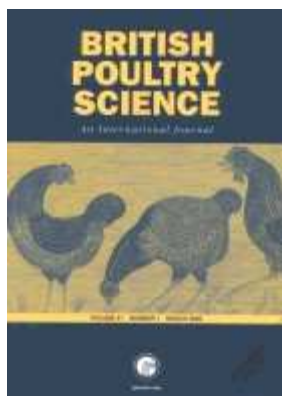
HAL Id: hal-00638523

<https://hal.science/hal-00638523>

Submitted on 5 Nov 2011

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Carcass characteristics and qualitative meat traits of three Italian local chicken breeds

Journal:	<i>British Poultry Science</i>
Manuscript ID:	CBPS-2009-258.R1
Manuscript Type:	Original Manuscript
Date Submitted by the Author:	08-Jan-2010
Complete List of Authors:	Zanetti, Enrico; University of Padova, Animal Science De Marchi, Massimo; University of Padova, Animal Science Dalvit, Chiara; University of Padova, Animal Science MOLETTE, Caroline; ENSAT, Zootechnie et Qualite des Produits Animaux Remignon, Herve; INPT, ENSAT-Animal Sciences; ENSAT, Zootechnie et Qualite des Produits Animaux Cassandro, Martino; University of Padova, Animal Science
Keywords:	Meat quality, Carcass characteristics , Local chicken breeds

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Manuscripts

CBPS-2009-258

Edited Lewis August 2010; MacLeod September 2010

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10 4 **Carcase characteristics and qualitative meat traits of three Italian local**
11 **chicken breeds**

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Running title: Meat quality of local chicken

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Accepted for publication: 22nd February 2010

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3 33 **Abstract** 1. An experiment involving 60 male chickens reared in an organic production system
4 was carried out in order to investigate carcass characteristics and qualitative meat traits of three
5 34 slow-growing Italian local breeds of chicken (Ermellinata, Padovana and Pépoi).
6 35
7 36 2. Chicks were randomly selected at hatch, raised together under the same conditions,
8 37 slaughtered at 190 d of age, dissected for carcass traits, and meat (breast and thigh) stored for
9 38 subsequent analysis of quality parameters.
10 39
11 36 3. Ermellinata chickens were significantly different from Padovana and Pépoi chickens for live,
12 40 carcass and thigh weights. Breeds were also different for breast muscle protein content
13 41 (Ermellinata > Pépoi and Padovana), shear force (Padovana < Ermellinata and Pépoi) and
14 42 cooking loss (Pépoi > Padovana and Ermellinata) values.
15 43
16 40 4. The CIE system values of lightness (L*), redness (a*), and yellowness (b*) evidenced a
17 44 distinctive darker meat and lighter skin colour of Padovana breast meat.
18 45
19 42 5. Polyunsaturated fatty acids composition of breast meat was similar among the analysed
20 46 breeds. Ermellinata had significantly higher saturated but significantly lower monounsaturated
21 47 fatty acid contents than the other two breeds.
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30 48 INTRODUCTION

31 49 Consumer interest is growing in specialty poultry products, particularly in Europe. Examples
32 50 exist in France, with 'Label Rouge' (Westgren, 1999) and Poulet de Bresse, and in Italy with
33 51 Padovana chicken (De Marchi *et al.*, 2005). Production systems require extensive rearing
34 52 conditions with outdoor access. Despite a higher retail price than conventional poultry
35 53 products, these types of chicken have aroused lively interest in national markets (Westgren,
36 54 1999; Fanatico and Born, 2001). In Italy, among those slow-growing genotypes there are
37 55 several local chicken breeds that showed interesting meat quality traits (*e.g.* colour and
38 56 flavour) (De Marchi *et al.*, 2006a). Fast-growing meat strains of chicken are characterised by
39 57 a very low degree of adaptation and resistance to natural environment (Reiter and Bessei,
40 58 1996); in contrast, the slow-growing strains can fully benefit from organic system (pasture
41 59 availability, older age). Several studies have investigated differences in the sensory quality of
42 60 meat from fast- and slow-growing birds, but there was a wide variation in breed (purebred,
43 61 broiler or layer), slaughter age and production system (standard, extensive or organic)
44 62 (Touraille *et al.*, 1981; Brown *et al.*, 2008; Jaturasitha *et al.*, 2008; Sandercock *et al.*, 2009).
45 63 This has produced contrasting results regarding consumer preference and acceptance, but
46 64 reports have generally been more favorable for slower-growing birds than conventional
47 65 products.

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3 66 In the Veneto region of Italy, the increasing interest in the conservation of bovine, ovine
4 and poultry local breeds (De Marchi *et al.*, 2006a,b; Dalvit *et al.*, 2008, 2009; Zanetti *et al.*,
5 67 2010) is due to historical, social and economical reasons. A few breeds of chicken, Padovana
6 68 (PA), Ermellinata (EA), and Pépoi (PI), which are typically reared in extensive systems, provide
7 69 interesting alternatives to commercial broilers. The recent development of organic animal
8 70 production and consumer requests for food safety and sustainable systems of production might
9 71 encourage the use of local chicken breeds for several niche markets. Previous research has been
10 72 focused on the carcass characteristics and quality meat traits of the Padovana breed of chicken
11 73 (De Marchi *et al.*, 2005) because it has been in great demand.
12 74

13 75 The interest in local genotypes has increased noticeably in the last decade, mostly
14 76 because biodiversity conservation and management has become an important issue for the
15 77 international scientific community (Fao, 2007). Productive performance analysis and
16 78 phenotypic traits, together with genetic diversity, reproductive and adaptative performances,
17 79 and historical interest, are therefore highly relevant to the inclusion of local breeds in
18 80 conservation programmes (Ruane, 1999).
19 81

20 82 The objective of this research was to describe carcass characteristics and qualitative
21 83 meat traits of three local Italian chicken breeds at maturity, as well as at a light, medium or
22 84 heavy body weight.
23 85

24 86 MATERIALS AND METHODS

25 87 **Animals, diets and experimental procedures**

26 88 A trial was conducted at the Duca degli Abruzzi Agricultural High School in Padova. Three
27 89 slow-growing genotypes were compared, Pépoi (PI), Padovana (PA) and Ermellinata (EA),
28 90 and categorised according to the weight they reached at 190 d (market weight): PI had a live
29 91 weight of 1400 -1600 g, PA a live weight of 2000 - 2200 g and EA a live weight of 2800 -
30 92 3000 g (De Marchi *et al.*, 2006a). Twenty 30-d male birds were obtained from each breed and
31 93 housed together in an indoor pen (5 birds/m²) which had access to a grass paddock (4
32 94 m²/bird). All birds were provided with a grower diet (210 g CP/kg, 50 g/kg lipids, 40 g/kg
33 95 fibre, 70 g/kg ash, and 13.39 MJ ME/kg) from 2 d before the trial commenced until slaughter
34 96 at 190 d. Ingredients for the grower diet were maize flour, toasted soybean meal, maize gluten
35 97 meal, maize gluten, soybean oil, dicalcium phosphate, calcium carbonate, sodium chloride
36 98 and DL-methionine. Feed and water were supplied *ad libitum*. The diets were crumbled
37 99 vegetable diet without animal products, antibiotics or coccidiostats. A total of 60 birds (20
38 males for each breed) were slaughtered at 190 d of age. Feed was withdrawn 18 h prior to
39 slaughter, and the birds weighed, electronically stunned, plucked and eviscerated.

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2
3 100 The carcasses were cooled in a tunnel, refrigerated at 4° C for 24 h and weighed. The breast
4
5 101 and thigh meat from all chickens were then harvested and processed for meat quality
6
7 102 parameters determination. Other breast meat samples were also collected and stored at -20°C
8
9 103 for further analyses.

10 104 **Analytical determinations**

11 105 Breast (*Pectoralis superficialis*) and thigh (*Peroneus longus*) muscle pH were measured 24 h
12
13 106 *post-mortem* using a Delta Ohm HI-8314 pH-meter (Delta Ohm, Padova Italy). Colour,
14
15 107 tenderness and cooking loss were also determined 24 h *post-mortem*. Colour parameters were
16
17 108 measured using a Minolta CM-508c (illuminate: D65, observer: 10°) on thigh and breast skin
18
19 109 and on breast meat. Breast meat colour was taken immediately after skin removal. Readings
20
21 110 were performed at the same anatomical positions for all breast and thigh samples. For each
22
23 111 sample, three measurements were performed and the final value for each chicken was the
24
25 112 average of those readings. Skin colour of breast and thigh and meat colour of breast were
26
27 113 expressed in the CIELab colour space by reporting L*, a* and b* values (CIE, 1978).

28 114 Cooking loss percentage (CL%), expressed as the ratio of the weight before and after
29
30 115 cooking, was measured on the left part of the breast muscle without the skin using 2-cm thick
31
32 116 samples sealed in a polyethylene bag and heated in a water bath to an internal temperature of
33
34 117 70°C for 40 min (ASPA, 1996). Shear force (SF) on breast muscle was measured on 5
35
36 118 cylindrical cores, 1.13 cm in diameter and taken parallel to muscle fibres, using a TA-HDi
37
38 119 Texture Analyser (Stable Macro System, London, Great Britain) with a Warner-Bratzler shear
39
40 120 attachment (10 N load cell, crosshead speed of 2 mm/s) and interpreted using texture expert
41
42 121 software (ASPA, 1996).

43 122 All chemical analyses were performed on the right breast, without skin, and were in
44
45 123 accordance with AOAC (1990) standards. Moisture was determined after drying at 102°C for
46
47 124 16 h, ash was determined after mineralisation at 525°C for 6 h and total lipids analysed by
48
49 125 extraction with petroleum ether (Soxhlet method). Protein content was estimated by
50
51 126 difference. For the determination of total fatty acids composition, lipids were extracted
52
53 127 according to the method of Folch *et al.* (1957). A 5-g homogenised meat sample was blended
54
55 128 twice with extraction solvent chloroform/methanol (1:2, v/v), filtered, placed in separator
56
57 129 funnels and mixed with saline solution (0.88% KCl). After separation in two phases, the
58
59 130 methanol aqueous fraction was discarded and the lipid chloroform fraction washed with
60
131 distilled water/methanol (1:1, v/v). Following a further filtration and evaporation in a rotary
132 evaporator, lipid extracts were prepared for trans-esterification in n-Heptane according by
133 Christie (1982) and transferred to test tubes for subsequent gas chromatographic analysis,

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2
3 134 which was conducted on a Thermo Quest (model 8000 Series Top, Milan, Italy) instrument
4
5 135 equipped with a Omegawax 250 capillary column (length 30 m, internal diameter 0.25 mm,
6
7 136 Supelco, Bellafonte, PA, USA).

8 9 137 **Statistical analysis**

10 138 Data were subjected to ANOVA by the GLM procedure considering breed as a fixed effect
11
12 139 using SAS[®] software (1997, SAS Institute, Cary, NC). For breed effect, a multiple
13
14 140 comparison of means was performed using the Bonferroni's test ($P < 0.05$).

15 16 141 **RESULTS**

17 142 The least square means of carcass composition, pH values, breast chemical composition,
18
19 143 shear force and cooking loss values are shown in Table 1. Final live weights of the three
20
21 144 breeds at 190 d of age (just before slaughter) were significantly different. Ermellinata had
22
23 145 heavier live, carcass and thigh weights than PA and PI, while PI had lighter breast weight
24
25 146 than PA and EA. Breast weight and total dressing did not differ statistically for PA and EA,
26
27 147 while the incidence of breast on carcass weight was similar for PA and PI. Dressing
28
29 148 percentage was greater for PA and EA than PI, while PA and PI had greater breast percentage
30
31 149 than EA. Table 1 near here

32 150 Dry matter, protein and lipid contents of the breast muscle differed only slightly
33
34 151 among breeds (Table 1). Maximum shear force values for PA birds, as measured on cooked
35
36 152 breast muscle, were significantly different from the other breeds (Table 1). The pH values
37
38 153 measured in the breast muscle were significantly higher for PA than the other two breeds,
39
40 154 while, the thigh pH of PI birds had the highest values. The PA breed showed the highest
41
42 155 tenderness followed by EA and PI, while cooking loss values were higher for PI breed relative
43
44 156 to PA and EA birds. Tables 2 & 3 near here

45 157 Breast and thigh colour values are shown in Table 2. PA breed showed a significantly
46
47 158 higher L* value of breast skin than PI or EA, while the PI showed significantly lower a* and
48
49 159 b* values than PA or EA. The L* value of thigh skin for PI was significantly higher than
50
51 160 either PA or EA, a* indices were not significantly different for the three breeds, while the b*
52
53 161 index was significantly higher for EA than either PI or PA. The breast meat colour for PA had
54
55 162 a significantly lower L* value than for EA or PI, while EA b* values were significantly lower
56
57 163 than PA or PI.

58 164 Raw breast meat (without the skin) fatty acid compositions are shown in Table 3.
59
60 165 Ermellinata breed had a significantly higher content of saturated (SFA) but lower amount of
166
167 166 monounsaturated (MUFA) fatty acids than either PA or PI. There were no significant
differences between breeds for n-3 and n-6 polyunsaturated fatty acids. Ermellinata differed

1
2
3 168 from the other breeds because of a higher C_{16:0} content and a lower production of C_{18:1cis n-9} and
4
5 169 C_{18:2cis n-6} fatty acids (Table 4). There were no significant differences in DPA nor CLA fatty
6
7 170 acids among breeds but PI breast meat had a significantly higher content of DHA than PA.

Table 4
near here

171 DISCUSSION

10 172 The EA, PA and PI chickens exhibited medium, light and very light carcass weights
11
12 173 respectively. The dressing and breast percentages of PA were slightly lower than those
13
14 174 reported for the same breed by De Marchi *et al.* (2005). Dressing percentages for PA, EA and
15
16 175 PI breeds were also slightly lower than those reported for local Thai chicken genotypes
17
18 176 (Jasurasitha *et al.*, 2008) and markedly lower than that reported for commercial broilers
19
20 177 (Havenstein *et al.*, 2003; Cortinas *et al.*, 2004). These results indicate that the Italian local
21
22 178 chicken breeds have relatively low carcass weights, and inferior dressing and breast
23
24 179 percentages to other meat-type genotypes.

25 180 Contrastingly, the pH values were higher than expected; possible reasons are slaughter
26
27 181 stress and a higher content of oxidative muscle fibre in other common slow-growing genotypes
28
29 182 (Dransfield and Sosnicki, 1999). Regarding the first hypothesis, it is likely that the old
30
31 183 unselected breeds have a more aggressive and alert behaviour than the modern broilers
32
33 184 (Jaturasitha *et al.*, 2004; Debut *et al.*, 2005); this higher sensibility to the stressful conditions
34
35 185 before slaughter can lead to poor glycogen content in muscle at the time of death. However, no
36
37 186 other information is available concerning muscle fibre analysis for these breeds. Nevertheless,
38
39 187 the breast pH values of the PA breed were lower than those reported previously by De Marchi *et*
40
41 188 *al.* (2005) for the PA breed.

42 189 Dry matter, protein and lipid contents of the breast muscles differed slightly among
43
44 190 breeds. The chemical composition of the PA breed breast was consistent with values reported
45
46 191 by De Marchi *et al.* (2005). The dry matter and protein contents of these three local Italian
47
48 192 breeds were similar to those reported for other organic chickens (Castellini *et al.*, 1994;
49
50 193 Castellini *et al.*, 2002). In contrast, protein, lipids and ash contents were higher for the Italian
51
52 194 local breeds than for Thai indigenous chickens or normal commercial broilers (Wattanachant
53
54 195 *et al.*, 2004). As expected, local chicken muscle contains a high proportion of protein and low
55
56 196 fat and ash contents, which agrees with previously reported findings from Wattanachant *et al.*
57
58 197 (2005). The PA and EA breeds showed a greater cooking loss compared with the values
59
60 198 reported by De Marchi *et al.* (2005) and Rizzi *et al.* (2007).

199 Low L* values are associated to a higher ultimate pH value because of the weak light
200 scattering in high-pH chicken meat (Swatland, 2008). The darker breast muscle of the PA
201 breed can thus reflect differences in the muscle fibre composition and in the glycogen content

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3 202 of the muscle. For this reason, the analysis of breast meat L* values were also conducted
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5 203 using the fixed effect of breed and the effect of pH as co-variate. In the preliminary analysis,
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7 204 the interaction between breed and pH was not significant. Furthermore, the PA had the lowest
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9 205 L* value of breast meat.

10 206 The fatty acid composition of the breast meat in this study was similar to that reported
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12 207 by De Marchi *et al.* (2005) and Castellini *et al.* (2006) for Ross 205 and Kabir chickens reared
13
14 208 in an organic rearing system. The observed differences in SFA and MUFA among the three
15
16 209 breeds in this study can be attributed only to their genetic make-up, because diets and rearing
17
18 210 system were identical for all breeds throughout the experimental period. Even the highest
19
20 211 saturated fatty acid contents of the EA breed were still lower than those reported for organic
21
22 212 (38%) and Thai local chickens (62%) (Wattanachant *et al.*, 2004). Among SFA, palmitic
23
24 213 (C16:0) and stearic (C18:0) acids were the most abundant, as generally observed in chicken
25
26 214 breast meat.

27 215 In conclusion, the study demonstrated significant differences in meat quality traits
28
29 216 among the three breeds studied, for example in carcass yield, colour, tenderness and fatty acid
30
31 217 composition. From a consumer point of view, each breed offers unique features. Besides a
32
33 218 greater traditional interest and a high historical and cultural value, the tenderness of the PA meat
34
35 219 and its distinctively darker colour differentiated it from the other breeds. In contrast, none of the
36
37 220 meat quality traits of EA and PI showed the meat of these breeds to be significantly distinctive
38
39 221 from other meat-type genotypes. Additionally, adaptability features, traits of scientific and
40
41 222 economic interests, cultural/historical value, strong links to local traditions and its ability to
42
43 223 generate incomes from tourism justify the efforts for their conservation and characterisation
44
45 224 (Ruane, 1999). The commercialisation and capitalisation of local markets represent an
46
47 225 opportunity for future added value and development of these local genetic resources.
48
49 226 Alternative strategies, such as the use of crosses of these breeds with more productive
50
51 227 commercial breeds, are currently under evaluation to enhance their use for niche and regional
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324 **Table 1.** Least square means of carcass composition, pH values, breast chemical
 325 composition, shear force and cooking loss values of Ermellinata, Padovana and Pèpoi slow-
 326 growing chicken at 190 d of age

	Breed			r ²	Res MS
	Padovana	Ermellinata	Pèpoi		
- Live weight (LW), g	2144 ^b	2718 ^a	1434 ^c	0.89	187
- Carcass weight (CW), g	1346 ^b	1726 ^a	879 ^c	0.88	125
- Breast weight (BW), g	225 ^a	243 ^a	140 ^b	0.72	29
- Thigh weight (TW), g	478 ^b	667 ^a	322 ^c	0.89	50
Dressing (CW/LW), %	63 ^a	64 ^a	61 ^b	0.27	1.59
Breast (BW/CW), %	17 ^a	14 ^b	16 ^a	0.27	1.88
Thigh (TW/CW), %	35 ^c	38 ^a	36 ^b	0.39	1.60
Breast meat pH	6.18 ^a	5.97 ^b	5.99 ^b	0.21	0.18
Thigh meat pH	6.19 ^b	6.15 ^b	6.30 ^a	0.16	0.15
<i>Breast muscle chemical composition</i>					
- Dry matter (%)	24.85 ^b	26.18 ^a	25.45 ^{ab}	0.26	0.95
- Total proteins (%)	23.23 ^b	24.65 ^a	23.89 ^b	0.11	0.79
- Total lipids (%)	0.61 ^a	0.29 ^b	0.48 ^{ab}	0.37	0.28
- Ash (%)	1.08	1.12	1.10	0.20	0.05
Shear Force (N)	12.51 ^a	16.76 ^b	15.84 ^b	0.19	3.82
Cooking loss (%)	18.20 ^b	19.31 ^b	22.34 ^a	0.29	2.81

327 ^{a,b,c} Within a row, means not sharing a common superscript are significantly different at *P*
 328 <0.05.

329 **Table 2.** *Breast and thigh colour values of Ermellinata, Padovana and Pépoi slow-growing*
 330 *chicken at 190 d of age.*

Item	Breed			r ²	Res MS
	Padovana	Ermellinata	Pepoi		
Skin colour					
Breast					
- L*	62.41 ^a	56.96 ^b	59.20 ^b	0.32	3.27
- a*	-2.15 ^a	-2.42 ^a	-3.07 ^b	0.25	0.69
- b*	1.91 ^a	1.06 ^a	-1.47 ^b	0.21	2.84
Thigh					
- L*	62.08 ^b	62.35 ^b	63.81 ^a	0.15	1.89
- a*	-2.19	-1.99	-2.47	0.08	0.69
- b*	-1.97 ^c	3.94 ^a	0.01 ^b	0.62	1.94
Meat colour					
Breast					
- L*	46.00 ^a	48.41 ^b	49.84 ^b	0.35	2.38
- a*	-1.42	-1.72	-1.39	0.11	0.42
- b*	-0.45 ^a	-1.64 ^b	0.04 ^a	0.14	1.75

331 ^{a,b} Within a row, means not sharing a common superscript are significantly different at
 332 $P < 0.05$.

333 **Table 3.** *Least square means of raw breast (without skin) fatty acid composition of*
 334 *Ermellinata, Padovana and Pépoi slow-growing chicken at 190 d of age*

	Breed			r ²	Res MS
	Padovana	Ermellinata	Pépoi		
Breast muscle	% of total analysed fatty acid				
Total SFA	33.88 ^b	35.59 ^a	32.82 ^b	0.46	1.29
Total MUFA	23.45 ^a	20.21 ^b	24.92 ^a	0.39	2.55
Total PUFA	40.24	41.38	40.09	0.05	2.71
Total n-6 FA	36.63	37.74	36.23	0.08	2.27
Total n-3 FA	3.60	3.64	3.85	0.02	0.73
n-6/n-3	10.51	10.93	9.66	0.06	2.19

335 ^{a,b} Within a row, means not sharing a common superscript are significantly different at
 336 $P < 0.05$.

337 SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated
 338 fatty acid; FA: fatty acid.

Table 4. Least square means of raw breast (without skin) detailed fatty acid composition of Ermellinata, Padovana and Pépoi slow-growing chicken at 190 d of age

Fatty acid	Breed			r ²	Res MS
	Padovana	Ermellinata	Pépoi		
Breast muscle	% of total analysed fatty acid				
C6:0	0.02	0.02	0.01	0.18	0.02
C8:0	0.06 ^b	0.10 ^a	0.11 ^a	0.40	0.03
C10:0	0.06	0.08	0.07	0.08	0.02
C12:0	0.03	0.02	0.02	0.08	0.02
C14:0	0.44 ^a	0.29 ^b	0.28 ^b	0.28	0.12
C15:0	0.09	0.08	0.07	0.08	0.02
C16:0	20.65 ^a	21.40 ^a	19.50 ^b	0.34	1.13
C17:0	0.28 ^a	0.25 ^{ab}	0.24 ^b	0.16	0.04
C18:0	11.51 ^b	12.64 ^a	11.86 ^b	0.27	0.81
C20:0	0.08 ^{ab}	0.06 ^b	0.09 ^a	0.15	0.04
C21:0	0.01	0.01	0.01	0.10	0.01
C22:0	0.01 ^b	0.01 ^b	0.02 ^a	0.21	0.02
C10:1 n-1	0.05	0.04	0.04	0.05	0.02
C14:1 n-1	0.01	0.01	0.01	0.01	0.01
C16:1 n-9	0.20	0.16	0.18	0.09	0.05
C16:1 n-7	0.39	0.34	0.46	0.08	0.17
C17:1 n-9	0.03	0.07	0.11	0.09	0.10
C17:1 n-7	0.01 ^b	0.01 ^{ab}	0.02 ^a	0.38	0.01
C18:1 n-7 trans	0.04	0.03	0.02	0.13	0.02
C18:1 n-9 trans	0.01 ^b	0.02 ^{ab}	0.02 ^a	0.17	0.01
C18:1 n-9 cis	20.69 ^a	17.79 ^b	21.53 ^a	0.33	2.38
C18:1 n-7 cis	1.73 ^b	1.46 ^c	2.18 ^a	0.68	0.21
C20:1 n-9	0.19 ^a	0.13 ^b	0.22 ^a	0.34	0.05
C18:2 n-6 trans	0.01	0.01	0.01	0.04	0.01
C18:2 n-6 cis	25.25 ^a	21.79 ^b	21.84 ^b	0.18	3.52
C18:3 n-6	0.08 ^a	0.04 ^b	0.05 ^b	0.32	0.03
C18:3 n-3	0.93 ^a	0.56 ^b	0.61 ^b	0.26	0.28
CLA	0.01	0.01	0.01	0.06	0.01
C20:2 n-6	0.45 ^a	0.39 ^b	0.43 ^{ab}	0.15	0.05
C20:3 n-6 cis	0.41 ^b	0.73 ^a	0.54 ^b	0.43	0.16
C20:4 n-6	9.06 ^b	13.11 ^a	11.78 ^{ab}	0.19	3.64
C22:1 n-9 cis	0.01	0.01	0.01	0.03	0.01
C20:5 n-3 cis	0.06	0.05	0.08	0.03	0.06
C22:2 n-6	0.17	0.29	0.22	0.10	0.16
C22:4 n-6	0.01	0.03	0.01	0.14	0.04
C22:5 n-6	1.19	1.33	1.36	0.04	0.34
C24:1 n-9 cis	0.30	0.29	0.34	0.02	0.13
C22:5 n-3 DPA	1.19	1.37	1.26	0.04	0.41
C22:6 n-3 DHA	1.42 ^b	1.66 ^{ab}	1.90 ^a	0.13	0.53

^{a,b} Within a row, means not sharing a common superscript are significantly different at $P < 0.05$.