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Fat and fatty acid composition of cooked meat from UK retail chickens labelled as from organic and non-organic production systems

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Running title: Fatty acids in organic vs. normal chicken meat

Keywords: chicken meat: fat: fatty acids: conventional vs. organic

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14 **Abstract**

15

16 This study compared fat and fatty acids in cooked retail chicken meat from conventional and
17 organic systems. Fat contents were 1.7, 5.2, 7.1 and 12.9 g/100 g cooked weight in skinless breast,
18 breast with skin, skinless leg and leg with skin respectively, with organic meat containing less fat
19 overall ($P<0.01$). Meat was rich in *cis*-monounsaturated fatty acids although organic contained less
20 than conventional meat (1850 vs. 2538 mg/100 g; $P<0.001$). Organic meat was also lower
21 ($P<0.001$) in 18:3 n-3 (115 vs. 180 mg/100 g) and whilst it contained more ($P<0.001$)
22 docosahexaenoic acid (30.9 vs. 13.7 mg/100 g) this was due to the large effect of one supermarket.
23 This system by supermarket interaction suggests that poultry meat labelled as organic is not a
24 guarantee of higher long chain n-3 fatty acids. Overall there were few major differences in fatty
25 acid contents/profiles between organic and conventional meat that were consistent across all
26 supermarkets.

27

28 **Keywords: chicken meat; fat; fatty acids; conventional vs. organic**

29

30 **1. Introduction**

31

32 Consumption of poultry meat in the UK has increased very considerably over the last 60 years from
33 about 15 g/person/week in 1950 (MAFF, 2001) to around 469 g/person/week including poultry
34 meat dishes recently (Bates et al., 2014). There have been concerns that modern chicken meat
35 contains considerably more fat than was the case some years ago (Wang, Lehane, Ghebremeskel
36 and Crawford, 2009), although there are few truly comparative studies to support this and the recent
37 National Diet and Nutrition Survey (Bates et al., 2014) confirmed that chicken and turkey meat and
38 meat products contribute only 6 - 7% of dietary fat intake. Poultry meat does however have a very

39 variable fat content depending on which part of the bird's body the meat is derived and whether
40 skin is included (Givens, Gibbs, Rymer and Brown, 2011).

41

42 There has been interest in the role of poultry meat as a dietary source of long chain n-3
43 polyunsaturated fatty acids (PUFA), mainly eicosapentaenoic acid (EPA, 20:3 n-3) and
44 docosahexaenoic acid (DHA, 22:6 n-3). Intake of these fatty acids is below the recommended value
45 of 450 mg/d (SACN/COT, 2004) in large parts of the UK population, primarily due to a low intake
46 of oily fish (Givens and Gibbs, 2006). Givens and Gibbs (2006, 2008) estimated that the then
47 current consumption of chicken meat would provide about 27 mg of EPA + DHA per day. This was
48 based on average EPA (15 mg/100g) and DHA (35 mg/100g) concentrations in meat reported in
49 research papers dating from 1990s to 2000 which may not have been representative of retail meat,
50 and a more recent study has reported much lower concentrations in cooked retail chicken meat
51 (Givens et al., 2011). Givens et al. (2011) also found that meat from free range birds had
52 significantly lower concentrations of EPA and total n-3 fatty acids than meat from conventionally
53 reared birds, suggesting that perhaps differences in management practices between the two systems,
54 such as diet composition, may have an effect. Demand for organic poultry, another type of
55 production system, has increased across all social groups in the UK since 1995 with the exception
56 of 2007-2008 owing to the recession (Dangour, Dodhia, Hayter, Allen, Lock and Uauy, 2009; Soil
57 Association, 2010). Organic production systems need to conform to certain regulations (European
58 Commission, 2008) which place restrictions on the ingredients which can be included in the birds'
59 diet, which may in turn influence the fatty acid composition of the meat.

60

61 The review of Minihane, Givens and Gibbs (2008) concluded that there were few truly comparative
62 data on the fat and fatty acid content of retail chicken meat from organic versus conventional
63 production systems. Moreover, the available studies were not representative of meat sold in the UK

64 and most studies analysed fresh rather than cooked meat. The main objective of the current study
65 was to compare the fat and fatty acid content of cooked meat from retail chickens labelled as being
66 derived from conventional or organic production systems.

67

68 **2. Materials and methods**

69

70 *2.1 Chickens and sampling*

71

72 Two low-cost, fresh, chilled non-organic (assumed to be intensive) reared, dressed broiler chickens
73 and two fresh, dressed, chilled birds labelled as from organic production of near identical weight
74 (1.5-1.6 kg) were purchased from each of three leading supermarkets in February 2011 (Table 1).
75 All packaging and any giblets and loose internal fat were removed and all 12 birds were weighed.
76 Without adding anything, each bird was placed in a roasting bag (Bacofoil Flavour Seal Roasting
77 Bags; Wrap Film Systems Ltd, Telford, Shropshire, UK) and cooked breast upwards in a pre-
78 heated oven set at 180°C for 20 minutes per 500g followed by an additional 20 minutes according to
79 the Roasting Bag instructions. After cooking, birds were removed from the bags and any juices
80 were allowed to drain away. After cooling, breast meat and legs were dissected from the body. One
81 breast and one leg had the skin removed. All edible meat (i.e. excluding connective tissue) from
82 thigh and lower leg was removed from both legs. This process thus provided a total of 48 samples;
83 six skinless breasts, six breasts with skin, six sets of skinless leg meat and six sets of leg meat with
84 skin for both conventional and organically produced birds. Prepared meat samples were stored in
85 labelled, sealed polythene food bags at 1-2°C for a short period following which each sample was
86 homogenised twice in a bench-top meat mincer (Tre Spade Type 12EL/160 ELG, F.A.C.E.M. SpA,
87 Turin, Italy) and then stored at -20°C prior to analysis. During storage one sample (organic breast
88 meat with skin) was slightly damaged and was not analysed.

89

90 *2.2 Fat and fatty acid analysis*

91

92 For total fat and fatty acid analysis, thawed meat samples were freeze-dried over a period of three
93 days, followed by grinding to a fine powder using a pestle and mortar. The powdered samples were
94 stored in labelled, sealable polythene food bags at -20°C until analysed. Total fat was quantified by
95 extraction of the oil from the freeze-dried material (4.0-4.6 g) with light petroleum ether (boiling
96 range 40-60°C) using a 'Soxhlo' apparatus (Brown and Mueller-Harvey, 1999) at room temperature.

97

98 A modified one-step methylation method (Sukhija and Palmquist, 1988) was used to extract and
99 methylate the fatty acids in the freeze dried material. Briefly, approximately 300 mg freeze dried
100 sample was incubated at 60°C for 3h in the presence of 2 ml toluene (containing 1 mg/ml
101 heneicosanoic acid methyl ester (Sigma Aldrich, Poole, UK) as an internal standard) and 3 ml fresh
102 methylation reagent (0.4 M H₂SO₄ in methanol). After allowing cooling to room temperature 5 ml
103 neutralising solution (0.43 M K₂CO₃) was added. Following thorough mixing and centrifugation the
104 upper toluene layer was transferred to a clean tube and left to settle for 30 min at room temperature
105 in the presence of 1 g Na₂SO₄ to remove methanol residues prior to analysis. Resulting fatty acid
106 methyl esters (FAME) were then separated using a gas chromatograph equipped with a flame
107 ionization detector (Varian 3400, Varian Inc., Palo Alto, CA). Automatic injection of 2 µL was
108 used, with a split injection ratio of 50:1. Hydrogen was the carrier gas (constant pressure of 270
109 kPa) through a 100 m fused silica capillary column (i.d. 0.25mm) coated with a 0.2 µm film of
110 cyanopropyl siloxane (CP-SIL 88, Varian Inc., Palo Alto, CA). Injector and detector temperatures
111 were maintained at 255°C. Temperature programming was employed involving an initial oven
112 temperature of 70°C held for 4 minutes, then an increase of 8°C per minute to 110°C, followed by
113 an increase of 5°C per minute to 170°C and held for 10 minutes, with a final increase of 3°C per

114 minute to 240°C and held for 8 minutes. FAME were identified using retention times cross
115 referenced against external mixed standards (GLC463 Nu-Chek-Prep Inc, Elysian, MN and O4754,
116 O9881, E4762, V1381, Sigma-Aldrich Company Ltd., Dorset, UK). FAME were then quantified
117 using the peak area from the known concentration of heneicosanoic acid FAME added to the
118 process at the beginning of the methylation stage.

119

120 *2.3 Statistical analysis*

121

122 The effect of conventional compared with organic production system, meat type (breast, and leg,
123 with or without skin) and supermarket of origin on fat and fatty acid concentrations in meat were
124 determined by analysis of variance using a fixed effect general linear model (Mintab 16.0; Minitab
125 Inc., State College, PA, USA). Tukey's pairwise multiple comparison test was used to identify
126 which treatments were significantly different from each other when the significance was $P < 0.05$.

127

128 **3. Results**

129

130 Table 2 reports the fat and fatty acid concentrations in the cooked chicken meat. Overall, total fat
131 content was higher ($P < 0.01$) in conventionally produced meat than organic, with leg meat
132 containing higher ($P < 0.001$) concentrations of fat than breast meat. The inclusion of skin with
133 breast and leg meat also increased ($P < 0.05$) fat content of these meat types by factors of 3.0 and 1.8
134 respectively. For fat content, there was a production system x supermarket interaction ($P < 0.001$), as
135 a result of Supermarket 3 having more than double the fat content in its conventional meat than
136 organic (8.7 vs. 4.1 g/100 g, $P < 0.05$), whereas differences for the other supermarkets were much
137 smaller and non-significant ($P > 0.05$).

138

139 Overall, the concentrations of six fatty acids were significantly affected by production system. Four
140 (*cis*-9 16:1; *cis*-9 18:1; 18:3 n-3; 20:3 n-6) were higher ($P<0.05$) in conventionally produced meat
141 than organic meat whereas two (20:4 n-6 and DHA) were lower ($P<0.001$). These results led to
142 higher concentrations of total *cis*-monounsaturated fatty acids (MUFA) ($P<0.001$) and total n-3
143 PUFA ($P<0.01$) in conventional meat and higher concentrations of EPA+DHA ($P<0.01$) and EPA +
144 docosapentaenoic acid (DPA, 22:5 n-3) + DHA ($P<0.05$) in organic meat. The concentrations of
145 EPA, DPA and DHA were however, highly influenced by the production system x supermarket
146 interaction ($P<0.001$). Detailed examination showed that only in Supermarket 1 were these fatty
147 acids significantly ($P<0.05$) higher in organic than conventional meat. Moreover, the differences for
148 Supermarket 1 were very large with concentrations for EPA, DPA and DHA of 7.82, 18.9 and 6.73
149 mg/100 g respectively in conventional meat and 24.6, 35.6 and 72.4 mg/100 g in organic meat.
150 Other production system x supermarket interactions reflected generally less marked disagreements
151 between supermarkets on the relative values of conventional vs. organic meat. Meat type had a
152 major influence on fatty acid concentration with values largely reflecting the effects seen for fat
153 content of breast vs. leg meat and the inclusion or not of skin.

154

155 Table 3 reports fatty acid profile (g/100 g total fatty acids) of the lipid in the cooked chicken meat
156 and shows that *cis*-MUFA were most abundant. Ten fatty acids (14:0, 16:0, 16:1 *cis*-9, 18:0, 18:1
157 *cis*-9, 18:2 n-6, 18:3 n-3, 20:0, 24:4 n-6, DHA) were affected ($P<0.05$) by production system with
158 total saturated fatty acids (SFA) being of lower concentration in fat from conventional than organic
159 meat ($P<0.001$) although the production system x supermarket interaction indicated that was only
160 the case for Supermarkets 2 and 3. Overall, lipid from conventional meat was higher in *cis*-MUFA
161 ($P<0.001$), predominantly 18:1 *cis*-9, and 18:3 n-3 (both $P<0.001$), whilst lipid from organic meat
162 was richer in total n-6 polyunsaturated fatty acids (PUFA), EPA+DHA and EPA+DHA+DPA (all
163 $P<0.001$). However significant production system x supermarket interactions ($P<0.001$) had high

164 influence on the interpretation of EPA and DHA since significantly higher values were only seen in
165 the organic meat fatty acid profile for Supermarket 1. Supermarket 1 differences in DHA were most
166 marked, with values of 0.161 and 1.43 g/100 g total fatty acids for conventional and organic
167 respectively ($P < 0.001$). Overall, the higher SFA and mainly n-6 PUFA concentrations in fatty acid
168 profile from organic meat were balanced by higher *cis*-MUFA concentrations in lipid from the
169 conventional meat.

170

171 **4. Discussion**

172

173 With the large increase in consumption of chicken meat over the last 60 years, and more recently a
174 rise in organic chicken production, information on its nutritional composition and any effect of
175 production system is a priority. There are however few published data on the total fat and fatty acid
176 contents of cooked broiler meat and similarly little comparative information on the effect of organic
177 versus conventional production (Minihane et al., 2008). The total fat contents of the meat in the
178 current study are in good agreement with those reported by Givens et al. (2011) for meat from
179 conventional and free range birds with the wide range of values (1.3 to 13.8 g/100 g) being
180 primarily a function of meat source (breast, leg) and skin inclusion. The variation in fat content is
181 not reflected in the declared fat contents of whole birds which is therefore of very limited nutritional
182 value to the consumer. Overall, whilst the total fat concentration in the conventional meat was
183 significantly ($P < 0.01$) greater than in the organic meat with mean fat contents across all meat types
184 of 7.4 and 6.1g/100 g respectively, this was influenced by Supermarket 3 which had the highest (8.7
185 g/100g) and lowest (4.1 g/100g) fat content of conventional and organic meat respectively. Husak,
186 Sebranek and Bregendahl (2008) reported lower fat contents of organic than conventional US retail
187 meat possibly due, in part at least, to greater locomotive and other outdoor activity by the organic
188 birds than their housed counterparts (Andrews, Omed and Phillips, 1997; Branciari et al., 2009).

189 Givens et al. (2011) did not see a significant difference in total fat content of retail meat from free
190 range and conventional broilers, suggesting that other factors such bird genotype may also influence
191 fat deposition.

192

193 The review of Minihane et al. (2008) identified only eight truly organic vs. conventional study
194 comparisons for fatty acids in chicken meat with most studies reporting only fatty acid profile
195 (Castellini, Mugnai and Dal Bosco, 2002) or fatty acids in phospholipid and neutral lipids fractions
196 (Jahan and Paterson, 2007) and not in whole edible cooked meat. Fat from organic meat in the
197 present study contained a higher concentration of SFA (mainly 16:0), n-6 PUFA (mainly 18:2) and
198 long chain n-3 PUFA (notably EPA and DHA) but a lower concentration of *cis*-MUFA than meat
199 from conventionally produced birds. However there were interactions with supermarket for all these
200 fatty acids. This was particularly notable for DHA where the higher value for Supermarket 1
201 outweighed non-significant differences for the other two supermarkets. This suggests that the bird
202 diet used in the two production systems by the supplier of Supermarket 1 were substantially
203 different in EPA and DHA content. More long chain n-3 PUFA in the profile of organic meat was
204 reported by Castellini et al. (2002) although their study used the same diets for both the organic
205 (free range) and intensively produced birds, with higher *cis*-PUFA and DHA concentrations in
206 lipids from organic meat being attributed to differences in grass ingestion by the organic birds, as
207 found in another study (Ponte et al., 2008). Husak et al. (2008) also reported significantly more *cis*-
208 PUFA and less *cis*-MUFA in lipid of meat from organic than conventional retail chickens. Grass
209 ingestion seems unlikely to explain the differences seen for Supermarket 1 in the present study as
210 18:3 n-3 was present at lower ($P<0.001$) concentrations in the organic meat profile, and this fatty
211 acid is the predominant fatty acid in grass lipid (Hawke, 1973).

212

213 The reason for the greater concentrations of DHA in the lipid from the Supermarket 1 organic meat
214 is unclear. It is known however, that EU rules governing dietary ingredients permitted for organic
215 birds (European Commission, 2008) often make it difficult to achieve sufficiently high dietary
216 protein quality, so to overcome this, diets for organic meat poultry have in recent times often
217 included small but permitted amounts of fish meal (E. Snow, Personal Communication). This would
218 seem to be the most likely explanation although dietary information for the birds analysed was not
219 known. It has also been shown that earthworms, which could be available to organically-reared
220 birds, contain EPA, DPA and DHA although EPA was the most abundant (Shibahara, Yamamoto,
221 Kinoshita and Miyatani, 2003).

222

223 An objective of the present study was to re-assess the contribution of poultry meat to intake of EPA
224 and DHA by UK adults and whether this differs between meat from organic and conventional
225 production systems. Earlier estimates of EPA and DHA intake by Givens and Gibbs (2006) used
226 average concentrations of EPA, DHA and DPA in poultry meat of 15.0, 35.0 and 15.0 mg/100 g
227 respectively. These values were based on research papers which may not have reflected
228 contemporary commercial broiler production although they match reasonably the values for
229 conventional leg meat with skin in the present study. Overall, the present results suggest that a 250
230 g portion of conventional and organic chicken skinless breast meat cooked in a roasting bag under
231 the conditions used in this study would supply 58 and 84 mg EPA + DHA respectively, however the
232 apparent advantage of the organic meat was due only to very much higher DHA concentrations
233 (~10 times higher than conventional) in all meat types from Supermarket 1. For example, mean
234 values of 4.0 and 57.5 mg DHA/100g were measured in conventional and organic skinless breast
235 meat respectively. This shows that the organic label is not a guarantee of higher concentrations of
236 long chain n-3 PUFA. Like the findings of Wang et al. (2009) and Givens et al. (2011), the present
237 study demonstrated that DPA concentrations in the meat were often higher than both EPA and

238 DHA. The factors which influence the deposition of DPA in meat are unclear, but like DHA, DPA
239 was only significantly higher in organic meat from Supermarket 1 suggesting a link between the
240 deposition of both fatty acids.

241

242 The role of dietary DPA is unclear although some recent studies suggest it may be beneficial to
243 human health. Howe, Buckley and Meyer, (2007) reported that the few human intervention trials
244 that have been performed with DPA-rich supplements all found that DPA was equally, if not more,
245 beneficial in reducing the risk of cardiovascular diseases than EPA or DHA. Sun et al. (2008) also
246 found higher plasma EPA and DPA (but not DHA) concentrations were associated with a lower risk
247 of nonfatal myocardial infarction. Given the trends in chicken meat consumption, further
248 clarification of the health effects of DPA relative to EPA and DHA is required.

249

250 The present study has weaknesses. The sample number was not large and it was also limited to
251 supermarkets in the Reading area and only one cooking method was used. Despite these issues, to
252 our knowledge this is the only study of its type. Future studies covering a larger geographical area
253 and the effect of different cooking methods/temperatures would therefore be desirable.

254

255 **5. Conclusions**

256

257 Meat from retail chickens in the declared weight range 1.4 to 1.6 kg is likely to have a fat content of
258 approximately 1.7, 5.2, 7.7 and 12.9 g/100 g cooked weight in skinless breast, breast with skin,
259 skinless leg and leg meat with skin respectively, with meat from organic production being of
260 slightly lower fat content. Chicken meat was a rich source of *cis*-MUFA although the organic meat
261 contained less than conventional. A lower total n-3 PUFA concentration in the organic meat was
262 due to lower 18:3 n-3 although in contrast, the organic meat contained more EPA and DHA than

263 conventional meat. The higher EPA and DHA in the organic meat was however, the result of a large
264 difference for only one supermarket and means that poultry meat labelled as organic is not a
265 guarantee of higher long chain n-3 PUFA. Overall, there was little evidence that meat from organic
266 chickens had fatty acid profiles which would be classified as healthier than that from conventionally
267 produced birds and the marked rearing system x supermarket interactions suggest different lipids
268 have been used in diets for organic birds supplied to different supermarkets. The interpretation of
269 the findings is clearly limited by the study being relatively small, although to our knowledge this is
270 the only study of its type. Further larger scale studies covering a larger geographical area and
271 different cooking methods/temperatures are therefore needed to extend the current work.

272

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274

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279

280

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282

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349 **Table 1.** Details of purchased chickens

Supermarket	Bird number	Production system ¹	Declared fat content (g/100g) ²	Declared weight (kg)	Cost (£/kg)
1	1	C	9.5	1.45	2.76
	2	C	9.5	1.45	2.76
	3	O	8.6	1.434	5.99
	4	O	8.6	1.46	5.99
2	5	C	4.8	1.58	2.67
	6	C	4.8	1.5	2.67
	7	O	5.3	1.448	3.98
	8	O	6.6	1.52	6.06
3	9	C	ND ³	1.6	3.09
	10	C	ND	1.45	3.09
	11	O	12.5	1.595	5.48
	12	O	12.5	1.5	5.48

350 ¹C, conventional; O, organic; ²on label, assumed to be of whole carcass; ³ND, not declared

Table 2. Effect of conventional (C) or organic (O) production system (PS), meat type (MT) and supermarket (S) on fat and fatty acid content of cooked chicken meat (values are least square means; mg/100 g cooked tissue).

	Breast meat, no skin		Breast meat with skin		Leg meat, no skin		Leg meat with skin		Overall effects:					
	C	O	C	O	C	O	C	O	SED [†]	PS	MT	S	PS x MT	PS x S
Total fat (g/100g tissue)	2.1 ^{de}	1.3 ^e	5.6 ^{bc}	4.9 ^{cd}	8.0 ^b	6.2 ^{bc}	13.8 ^a	11.9 ^a	0.88	**	***	*	NS	***
14:0	10.4 ^c	9.6 ^c	25.9 ^b	23.5 ^{bc}	33.8 ^b	31.9 ^b	55.6 ^a	59.7 ^a	4.65	NS	***	NS	NS	***
16:0	522 ^c	470 ^c	1201 ^b	1070 ^{bc}	1567 ^b	1373 ^b	2541 ^a	2478 ^a	177.3	NS	***	*	NS	***
16:1 <i>cis</i> -9	86.3 ^{de}	63.4 ^e	246 ^{cd}	176 ^{cde}	342 ^{bc}	257 ^c	552 ^a	486 ^{ab}	51.7	*	***	***	NS	***
18:0	202 ^{de}	201 ^e	350 ^{cd}	363 ^c	498 ^{bc}	520 ^b	716 ^a	790 ^a	46.3	NS	***	NS	NS	**
18:1 <i>cis</i> -9	814 ^e	554 ^e	2071 ^{cd}	1412 ^{de}	2751 ^{bc}	1897 ^{cd}	4518 ^a	3535 ^b	304.2	***	***	**	NS	***
18:2 <i>cis</i> -9,12 (n-6)	352 ^c	399 ^c	815 ^{bc}	910 ^{bc}	1267 ^b	1307 ^b	1975 ^a	2415 ^a	197.9	NS	***	**	NS	**
18:3 <i>cis</i> -6,9,12 (n-6)	2.4 ^c	2.2 ^c	5.0 ^{bc}	4.4 ^{bc}	8.0 ^b	7.1 ^b	12.1 ^a	12.5 ^a	1.22	NS	***	NS	NS	**
18:3 <i>cis</i> -9,12,15 (n-3)	46.6 ^{cd}	30.0 ^d	123 ^c	76.8 ^{cd}	207 ^b	122 ^c	344 ^a	230 ^b	24.3	***	***	NS	*	*
20:0	1.4 ^b	1.8 ^b	1.8 ^b	2.8 ^b	3.1 ^b	3.8 ^b	5.7 ^{ab}	10.0 ^a	1.73	NS	***	NS	NS	NS
20:1 <i>cis</i> -8	0.70 ^b	0.61 ^b	2.4 ^{ab}	1.9 ^{ab}	2.2 ^{ab}	2.4 ^{ab}	3.0 ^{ab}	4.4 ^a	0.866	NS	***	*	NS	NS
20:1 <i>cis</i> -11	2.3	1.4	5.6	5.4	3.4	8.0	4.7	11.5	4.42	NS	NS	NS	NS	NS
20:2 <i>cis</i> -11,14 (n-6)	11.0 ^{bc}	6.9 ^c	14.6 ^b	13.2 ^{bc}	16.9 ^{ab}	17.0 ^{ab}	21.2 ^a	21.9 ^a	1.97	NS	***	**	NS	NS
20:3 <i>cis</i> -8,11,14 (n-6)	14.9 ^{bc}	11.9 ^c	15.7 ^{abc}	14.0 ^{bc}	19.9 ^{ab}	16.6 ^{abc}	21.5 ^a	19.8 ^{ab}	1.99	*	***	*	NS	***
20:4 <i>cis</i> -5,8,11,14 (n-6)	49.8 ^c	62.7 ^{bc}	49.1 ^c	70.8 ^{bc}	86.8 ^{ab}	106.4 ^a	87.3 ^{ab}	105.6 ^a	9.34	***	***	*	NS	*
22:0	2.4 ^{bcd}	2.1 ^{cd}	3.4 ^{abcd}	1.7 ^d	5.4 ^{abc}	4.9 ^{abcd}	5.5 ^{ab}	5.9 ^a	1.03	NS	***	NS	NS	NS
22:1 <i>cis</i> -13	2.3	1.1	2.5	1.0	1.7	3.6	4.7	6.2	1.65	NS	**	*	NS	NS
22:2 <i>cis</i> -13,16 (n-6)	0.73	0.89	0.91	1.3	2.0	2.2	1.8	1.1	0.911	NS	NS	NS	NS	NS
22:4 <i>cis</i> -7,10,13,16 (n-6)	11.8 ^b	9.7 ^b	11.2 ^b	12.5 ^b	19.2 ^a	18.9 ^a	18.9 ^a	19.3 ^a	1.87	NS	***	***	NS	**
EPA (n-3) ¹	9.5	8.5	9.0	10.6	11.4	13.9	12.1	18.9	4.62	NS	NS	**	NS	***
DPA (n-3) ²	19.0 ^{ab}	16.3 ^b	17.1 ^b	20.4 ^{ab}	28.7 ^{ab}	30.3 ^a	28.6 ^{ab}	31.8 ^a	4.01	NS	***	NS	NS	***
DHA (n-3) ³	13.7 ^{ab}	25.2 ^{ab}	12.2 ^b	24.5 ^{ab}	14.7 ^{ab}	36.4 ^{ab}	14.4 ^{ab}	37.5 ^a	7.58	***	NS	***	NS	***
24:0	1.9	1.8	2.6	1.8	3.0	1.9	5.7	2.1	1.35	NS	NS	NS	NS	NS
24:1 <i>cis</i> -15	1.3	0.61	1.5	1.1	0.92	1.7	1.3	1.6	0.361	NS	NS	**	*	**

	Breast meat, no skin		Breast meat with skin		Leg meat, no skin		Leg meat with skin		Overall effects:					
	C	O	C	O	C	O	C	O	SED	PS	MT	S	PS x MT	PS x S
Total SFA ⁴	738 ^{cd}	684 ^d	1582 ^b	1461 ^{bc}	2108 ^b	1933 ^b	3323 ^a	3343 ^a	222.3	NS	***	NS	NS	***
Total <i>cis</i> -MUFA ⁴	990 ^e	677 ^e	2501 ^{cd}	1722 ^{de}	3324 ^{bc}	2338 ^{cd}	5439 ^a	4325 ^{ab}	372.4	***	***	**	NS	***
Total <i>cis</i> -PUFA ⁴	533 ^c	574 ^c	1074 ^{bc}	1159 ^{bc}	1683 ^b	1679 ^b	2538 ^a	2915 ^a	231.8	NS	***	**	NS	**
Total n-6 PUFA	443 ^c	493 ^c	911 ^{bc}	1026 ^{bc}	1420 ^b	1475 ^b	2138 ^a	2595 ^a	204.7	NS	***	**	NS	**
Total n-3 PUFA	88.9 ^e	79.9 ^e	162 ^{cde}	132 ^{de}	262 ^{bc}	203 ^{cd}	399 ^a	318 ^{ab}	31.4	**	***	*	NS	***
EPA+DHA	23.2	33.6	21.2	35.0	26.1	50.3	26.5	56.4	11.97	**	NS	***	NS	***
EPA+DPA+DHA	42.1 ^{ab}	49.9 ^{ab}	38.3 ^b	55.4 ^{ab}	54.8 ^{ab}	80.6 ^{ab}	55.2 ^{ab}	88.2 ^a	15.37	*	*	***	NS	***

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355 ^{a,b,c,d,e} Means within a row with no superscripts or those with a common superscript are not significantly different ($P < 0.05$)

356 [†]Standard error of the difference from Tukey’s pairwise comparison

357 * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

358 ¹EPA, 5,8,11,14,17-ecosapentaenoic acid (20:5 n-3)

359 ²DPA, 7,10,13,16,19-docosapentaenoic acid (22:5 n-3)

360 ³DHA, 4,7,10,13,16,19-docosahexaenoic acid (22:6 n-3)

361 ⁴SFA, saturated fatty acids

362 ⁵MUFA, monounsaturated fatty acids

363 ⁶PUFA, polyunsaturated fatty acids

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Table 3. Effect of conventional (C) or organic (O) production system (PS), meat type (MT) and supermarket (S) on fatty acid profile of cooked chicken meat (values are least square means, g/100 g fatty acids).

	Breast meat, no skin		Breast meat with skin		Leg meat, no skin		Leg meat with skin		Overall effects:					
	C	O	C	O	C	O	C	O	SED [†]	PS	MT	S	PS x MT	PS x S
14:0	0.42 ^c	0.46 ^{bc}	0.48 ^{abc}	0.52 ^{ab}	0.45 ^{bc}	0.52 ^{ab}	0.47 ^{abc}	0.55 ^a	0.027	***	**	NS	NS	***
16:0	21.7 ^{ab}	22.5 ^{ab}	22.5 ^{ab}	23.5 ^a	21.2 ^b	22.3 ^{ab}	21.8 ^{ab}	22.9 ^{ab}	0.56	**	*	***	NS	***
16:1 <i>cis</i> -9	3.4 ^{bc}	2.8 ^c	4.4 ^{ab}	3.8 ^{abc}	4.6 ^a	3.9 ^{abc}	4.7 ^a	4.3 ^{ab}	0.35	**	***	***	NS	***
18:0	8.6 ^{ab}	10.1 ^a	6.9 ^{cd}	8.1 ^{bc}	6.8 ^{cd}	8.9 ^{ab}	6.2 ^d	7.7 ^{bc}	0.46	***	***	***	NS	***
18:1 <i>cis</i> -9	33.2 ^b	25.5 ^d	38.0 ^a	30.9 ^{bc}	37.3 ^a	30.0 ^c	38.6 ^a	32.0 ^{bc}	0.93	***	***	***	NS	***
18:2 <i>cis</i> -9,12 (n-6)	14.8 ^e	19.2 ^{abcd}	15.6 ^{de}	20.4 ^{abc}	17.6 ^{bcde}	21.5 ^{ab}	17.5 ^{cde}	22.4 ^a	1.24	***	**	***	NS	***
18:3 <i>cis</i> -6,9,12 (n-6)	0.095	0.105	0.096	0.097	0.110	0.115	0.110	0.115	0.0122	NS	NS	NS	NS	NS
18:3 <i>cis</i> -9,12,15 (n-3)	1.8 ^{cd}	1.3 ^d	2.3 ^{bc}	1.7 ^{cd}	2.8 ^{ab}	1.9 ^{cd}	3.0 ^a	2.1 ^c	0.21	***	***	NS	NS	**
20:0	0.058	0.090	0.043	0.071	0.042	0.057	0.053	0.089	0.0260	*	NS	NS	NS	NS
20:1 <i>cis</i> -8	0.029	0.028	0.049	0.044	0.030	0.036	0.030	0.037	0.0142	NS	NS	*	NS	NS
20:1 <i>cis</i> -11	0.099	0.065	0.142	0.126	0.042	0.110	0.043	0.101	0.0743	NS	NS	NS	NS	NS
20:2 <i>cis</i> -11,14 (n-6)	0.492 ^a	0.354 ^{ab}	0.300 ^{ab}	0.294 ^{ac}	0.240 ^b	0.287 ^{ab}	0.190 ^b	0.216 ^b	0.0711	NS	**	NS	NS	NS
20:3 <i>cis</i> -8,11,14 (n-6)	0.644 ^a	0.574 ^a	0.305 ^b	0.297 ^b	0.282 ^b	0.270 ^b	0.189 ^b	0.181 ^b	0.0473	NS	***	NS	NS	NS
20:4 <i>cis</i> -5,8,11,14 (n-6)	2.2 ^b	3.4 ^a	0.96 ^{cd}	1.6 ^{bcd}	1.2 ^{bcd}	1.9 ^{bc}	0.76 ^d	1.1 ^{bcd}	0.331	***	***	**	NS	***
22:0	0.089	0.097	0.069	0.040	0.077	0.083	0.048	0.058	0.0233	NS	NS	NS	NS	NS
22:1 <i>cis</i> -13	0.087	0.047	0.058	0.027	0.020	0.053	0.044	0.052	0.0274	NS	NS	NS	NS	NS
22:2 <i>cis</i> -13,16 (n-6)	0.034	0.040	0.016	0.025	0.032	0.045	0.014	0.014	0.0211	NS	NS	NS	NS	NS
22:4 <i>cis</i> -7,10,13,16 (n-6)	0.51 ^a	0.52 ^a	0.23 ^b	0.29 ^b	0.28 ^b	0.35 ^{ab}	0.17 ^b	0.21 ^b	0.061	NS	***	**	NS	***
EPA (n-3) ¹	0.397 ^a	0.389 ^a	0.165 ^b	0.219 ^{ab}	0.155 ^b	0.205 ^b	0.109 ^b	0.150 ^b	0.0562	NS	***	***	NS	***
DPA (n-3) ²	0.81 ^a	0.82 ^a	0.33 ^b	0.45 ^b	0.41 ^b	0.49 ^b	0.25 ^b	0.29 ^b	0.0847	NS	***	NS	NS	*
DHA (n-3) ³	0.56 ^b	1.2 ^a	0.22 ^b	0.52 ^b	0.21 ^b	0.55 ^b	0.12 ^b	0.31 ^b	0.171	***	***	***	NS	***
24:0	0.087	0.089	0.055	0.039	0.046	0.034	0.045	0.020	0.0212	NS	**	NS	NS	NS
24:1 <i>cis</i> -15	0.069 ^a	0.037 ^{ab}	0.031 ^{ab}	0.026 ^{ab}	0.013 ^b	0.029 ^{ab}	0.012 ^b	0.016 ^b	0.0153	NS	**	*	NS	**

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	Breast meat, no skin		Breast meat with skin		Leg meat, no skin		Leg meat with skin		Overall effects:					
	C	O	C	O	C	O	C	O	SED	PS	MT	S	PS x MT	PS x S
Total SFA ⁴	31.0 ^{abc}	33.3 ^a	30.0 ^{bc}	32.3 ^{ab}	28.6 ^c	31.9 ^{ab}	28.6 ^c	31.4 ^{abc}	0.91	***	**	***	NS	***
Total <i>cis</i> -MUFA ⁵	40.3 ^b	31.1 ^c	45.8 ^a	37.6 ^b	45.0 ^a	36.8 ^b	46.5 ^a	39.0 ^b	1.20	***	***	***	NS	***
Total <i>cis</i> -PUFA ⁶	22.4 ^{bc}	28.0 ^a	20.5 ^c	25.9 ^{ab}	23.4 ^{abc}	27.6 ^a	22.4 ^{bc}	27.1 ^{ab}	1.52	***	NS	***	NS	***
Total n-6 PUFA	18.8 ^{cd}	24.2 ^{ab}	17.5 ^d	23.0 ^{abc}	19.8 ^{bcd}	24.4 ^a	18.9 ^{cd}	24.2 ^{ab}	1.39	***	NS	***	NS	***
Total n-3 PUFA	3.6 ^{ab}	3.8 ^a	3.0 ^{ab}	2.9 ^{ab}	3.6 ^{ab}	3.2 ^{ab}	3.5 ^{ab}	2.8 ^b	0.29	NS	**	***	NS	***
EPA+DHA	0.96 ^{ab}	1.6 ^a	0.38 ^{bc}	0.74 ^{bc}	0.36 ^{bc}	0.76 ^{bc}	0.23 ^c	0.46 ^{bc}	0.210	***	***	***	NS	***
EPA+DPA+DHA	1.8 ^{ab}	2.4 ^a	0.71 ^{cd}	1.2 ^{bcd}	0.77 ^{cd}	1.2 ^{bc}	0.48 ^d	0.75 ^{cd}	0.224	***	***	***	NS	***

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371 ^{a,b,c,d,e} Means within a row with no superscripts or those with a common superscript are not significantly different ($P < 0.05$)

372 [†]Standard error of the difference from Tukey's pairwise comparison

373 * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

374 ¹ EPA, 5,8,11,14,17-ecosapentaenoic acid (20:5 n-3)

375 ² DPA, 7,10,13,16,19-docosapentaenoic acid (22:5 n-3)

376 ³ DHA, 4,7,10,13,16,19-docosahexaenoic acid (22:6 n-3)

377 ⁴ SFA, saturated fatty acids

378 ⁵ MUFA, monounsaturated fatty acids

379 ⁶ PUFA, polyunsaturated fatty acids

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