PUFA LOSSES AFTER COOKING OF CHICKEN MEAT

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Summary

An experiment was conducted to assess the effect of supplying with fish or linseed oils on the performance, quality parameters and fatty acid (FA) composition of the meat of broiler chickens. Besides, it aimed to test the relative stability of the FA composition after cooking of the chicken meat. A diet with 4% of tallow plus 4% linseed oil (T1) or 4% fish oil (T2) was fed to the birds throughout the 5 wk growth period. After slaughtering of the animals, the FA profile of the raw samples was determined by means of gas chromatography, and also after cooking in a convector oven (180°C, 35 min). Carcass yield, percentage of valuable parts, texture, juiciness and grill losses of meat were determined as objective quality parameters.
Performance parameters were not significantly different among treatments, though a tendency towards a better transformation index was found in T1 fed animals ($p<0.09$). Objective quality meat parameters were not different when compared by treatments. As expected, differences in the FA profile of the samples were found among treatments, being the T1 samples the ones which scored with higher n-3 FA levels, because of its linolenic acid content, while T2 samples showed a higher proportion in n-3 long-chain (LC) polyunsaturated FA (PUFA) in form of eicosapentaenoic acid, docosapentaenoic acid, and docosahexaenoic acid. Processing of the samples had an important influence on the FA profile of the meat. PUFA content was significantly lower in cooked samples ($p<0.01$), thus affecting the relative percentage of saturated FA, which rose to the highest values after cooking. Changes in monounsaturated FA were unnoticeable. Losses in n-6 FA were mainly due to the fall of linoleic acid while almost all n-3 LC-PUFA experienced significant losses after cooking of the meat.

Introduction

Many interests dealing with n-3 fatty acids (FA) increases in chicken meat have enhanced the development of scientist research on the effect of different dietary FA composition on the FA deposition in the animal tissues (López-Ferrer *et al.*, 1999). The main source of n-3 long-chain polyunsaturated FA (LC-PUFA) are, undoubtlessly, of marine origin, but its use is restricted because of the many undesirable odours present in the final product (Hargis and Van Elswyck, 1993). Some terrestrianoils like linseed and rapeseed oils can certainly increase the n-3 FA levels in meat, but mainly as LNA, precursor of the whole n-3 family. However, all these n-3 FA have proved to be less stable at certain temperatures than saturated FA (SAT) and monounsaturated

FA (MUFA) are and they might certainly disappear or to be altered after cooking of the meat, but no research has still been performed on that field. With the aim of studying the increase in n-3 FA in the raw chicken meat and late FA changes after cooking under consumer conditions, the present experiment puts forward two diets on the basis of fish (FO) and linseed (LO) oils in a chicken growing period.

Material and Methods

A trial with 100 unsexed 1-d-old Cobb chicks, arranged in 10 boxes (10 birds per box) and distributed into 2 dietary treatments (5 boxes per treatment) was conducted in a farm at the Unterer Lindenhof research station of the University of Hohenheim. Animals were given *ad libitum* access to water and to the diets designed to cover all the nutritional requirements in growth (N.R.C., 1994), consisting of extruded soybean (36%), wheat (31%), starch (10%) and oat flour (5%) (CP: 25%; ME: 3200 kg/ kg). The diets were formulated by adding 4% of tallow and 4% of linseed oil (LO, T1) or fish oil (FO, T2) to the described basal diet (0.02% BHT as only antioxidant). The FA profile of the diets is shown in Table 1.

At the age of 5 wk, all the animals were weighed and sex-identified before being slaughtered at the poultry slaughterhouse of the research station. Weights of bled, scalded, plucked, eviscerated, and air-chilled carcasses after cutting off their heads, necks, and feet, and after removing of abdominal fat pad, obtained as described by López-Ferrer *et al.* (1999) to obtain ready-to-cook carcasses were recorded (15 birds per treatment). Carcasses were stored in a cool chamber at 0 to 2 C until the next day, when cutting of their parts was performed into commercial cuts as back, two leg-thigh, two wings and breast and then calculated as percentage of the carcass. The objective parameters of meat quality were conducted 48 h after slaughtering. These analyses included juiciness (Grau and Hamm, 1953), by using the modified method of the 'Braunschweiger Model' (Grashorn, 1995). Grill losses were determined by difference of weight on all the left breasts, before and after cooking them in a double-plated grill at 200C. Samples of meat were kept into the grill until 85 C of internal temperature was reached. Tenderness of cooked samples of breast (maximum shear force and total energy in cut) was measured using the Warner Brazler shear tool in an INSTRON Model 4301. 5 thighs per treatment (without skin) were cooked the same way and previously freeze-dried before the FA analyses were performed along with five raw freeze-dried thigh samples. The lipid extraction and FA composition of diets and tissues were performed and determined as described by López-Ferrer *et al.* (1999). Performance and analytical data were analysed using the ANOVA procedure (SAS,1996). For significant differences ($P<0.05$) means were compared by using the LSD method of the same statistical package.

Results and Discusion

Performance and Carcass yield parameters. Productive parameters (data not shown) hardly presented differences among treatments, though a tendency ($P<.10$) towards a better feed efficiency and higher final weights was observed in the animals fed T1, the more polyunsaturated diet, as already remarked by Zollitsch *et al.* (1997). Significant

differences among treatments were scarcely observed in the different cuts of the carcasses (Table 2), though still higher ($P<0.05$) thigh percentages were found in the animals fed T2. As reported by Zollitsch *et al.* (1997), increasing levels in the polyunsaturation of the diet and did not result in higher levels of the abdominal fat percentage, though their fat pad percentages scored higher than ours (2.3 *vs.* 1.3%), perhaps because of a longer growing period (43 *vs.* 38 d of age). It is not surprising that carcass yield values were greater for males than for females (M: 65.7 *vs.* F: 64.3%, $P<0.01$), and differences remained after cooling of the carcasses ($P<0.05$). Besides, the fat levels registered in male were significantly lower than in female chicks (M: 0.88 *vs.* F: 1.75%, $P<0.01$).

Quality meat parameters. Different levels in the grade and kind of polyunsaturation of the diets did not result in significant differences among treatments or sexes (data not shown). Only slight differences in juiciness among sexes were found: breasts of females showed a higher value in that parameter (M: 0.78 *vs.* F: 0.88, $P<0.05$).

Fatty acid composition. Tables 3 and 4 show the FA content of the chicken thigh samples. The little changes observed in the SAT content confirmed a certain maintenance of the saturation of the poultry tissues no matter the SAT levels of the intaken diets. The monounsaturated FA (MUFA) content -mainly as oleic acid- of the samples was found as lower with the inclusion of LO, when compared to the use of FO as the added fat, though the T1 diet showed similar levels in such FA when compared to the T2 diet. The double origin of the oleic acid in meat (direct depot from diet and *de novo* synthesis in liver and tissue) seems to be the main reason for such fact. The high level in palmitic acid (C16:0) of the T2 treatment might have been the basis of the higher amounts in oleic acid in T2 meat, through elongation and desaturation from it. On the other hand, the total PUFA content increased ($P<0.001$) when using LO (T1): both precursors of the n-3 and n-6 families, LNA and linoleic acid (LA), respectively, rose then with the highest values in thigh, still being LA the main PUFA present in the chicken tissue no matter the treatment used. The main rise of the n-3 LC-PUFA was only present ($P<0.01$) when FO was used, reaching nearly 5% of the total FA of the fat's thigh, mainly in form of DHA and EPA (2.07 and 1.12 for DHA and EPA, respectively). In contrast to the rise of the n-3 LC-PUFA when FO was used, it must be remarked how little the differences in the content of the n-6 LC-PUFA found among both treatments were. Arachidonic acid (AA), though proved as higher ($P<0.001$) in the T2 samples, remained almost unchanged and all the rest of n-6 LC-PUFA (data not shown) scarcely reflected any variation according to the treatment. Cooking of the meat had a significant effect on almost all the most important FA and main groups reported. No works dealing with the effect of cooking on the FA changes of poultry meat have been found, though some articles dealing with the effect of processing on lipid changes have certainly brought some interesting information. As described by Warnants *et al.* (1996) after processing of pork meat into salami (drying-smoking processes), the most stable FA have been proved to be the SAT group. It is not new that FA are oxidized during processing, but some are more stable than others -or less destroyed- and they appear in a higher proportion in the total fat of the processed product. This certainly seems to happen in the case of the SAT, always in a higher percentage after processing (R: 38.6 *vs.* C: 41.6%, $P<0.001$). As expected, cooking implied a great loss of the PUFA group, that resulted in a fall of its proportion in the total fat (R: 27.2 vs. C: 23.8%, $P<0.001$) of the processed meat. The most

important losses among the PUFA were experienced by those FA with more double binds: that is, DHA, EPA, DPA and C20:4 n3. Unexpectedly, LA (2 double binds) experienced a higher loss than LNA (3 double binds) did, that remained unchanged after cooking. That resulted in changes in the n6/n3 relationship according to the treatment. The interactions found in the n6/n3 relationship can be explained because of the different kinds of losses of FA present in the meat from different treatments. T2 experienced the most important losses among the n-3 LC-PUFA content and, in a lesser extent, in the LA amount. Losses experienced in the LO samples were almost restricted to LA, thus being the main cause of the different effect of processing on the FA content of T1 and T2 samples.

Attention should be paid to what we really eat. PUFA are proved to be easily introduced into the poultry products, but also to be rather susceptible to be destroyed -and disappear- after processing, even under non-agressive processing techniques when no antioxidants are added in the diets. Further research dealing with different kinds of procedures still have to be performed on n-3 modified products (eggs, meat) in order to guarantee the real intake in such nutritionally interesting FA.

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Table 1 - Fatty acid composition of experimental diets

Fatty Acid	T1[1]	T2
C16:0	23.42	30.26
C18:0	17.00	17.15
C18:1n9	13.87	12.26
C18:2n6	15.84	9.81
C18:3n3	28.08	1.37
C20:4n6	0.00	0.35
C20:5n3	0.00	3.35
C22:5n3	0.00	0.64
C22:6n3	0.00	5.49
SAT	41.16	51.03
MUFA	14.14	24.13
PUFA	44.37	22.21
n6	16.07	10.33
n3	28.30	11.87
n6 / n3	0.57	0.87

[1]T1: 4% linseed oil + 4% tallow (T)
T2: 4% fish oil + 4% T

Table 2 - Carcass yield parameters according to treatment and sex effects

Effect	Live weight, g	Carcass yield slaught. %	Abd. fat %	Cold carcass yield, %	thigh %	breast %	wings %
Tt x Sex							
[1]T1 M	2234.8	64.81 ^{b}	0.97	63.04 $_{ab}$	33.36	25.53	11.73
T1 F	1796.0	64.46 ^{b}	1.71	62.76 $_{b}$	32.11	25.59	11.86
T2 M	2010.8	66.58 ^{a}	0.80	64.46 $_{a}$	33.89	25.60	12.20
T2 F	1787.4	64.13 ^{b}	1.79	62.32 $_{b}$	33.39	24.51	12.19
Pooled SEM	26536.26	1.22	0.314	1.551	0.674	3.010	0.347
Treatment							
T1	2015.4	64.64	1.34	62.90	32.73	25.56	11.79
T2	1899.1	65.36	1.30	63.39	33.64	25.05	12.20
Sex							
Male	2122.8	65.7	0.88	63.75	33.63	25.57	11.97
Female	1791.7	64.3	1.75	62.54	32.75	25.05	12.02
Significance							
Tt	+	N.S.	N.S.	N.S.	*	N.S.	N.S.
Sex	***	**	**	*	*	N.S.	N.S.
Tt x Sex	N.S.	*	N.S.	+	N.S.	N.S.	N.S.

[1]T1: 4% linseed oil + 4% tallow (T); T2: 4% fish oil + 4% T; M - Male; F - Female

^{a,b,c,d} Values within the same column and section with no common superscript are significantly different, P<0.05 (*), 0.01 (**), or 0.001 (***)

$_{a,b,c,d}$ Values within the same column and section with a common subscript show a tendency, P<.10 (+)

Table 3 - Fatty Acid composition of samples of thighs

Effect	C16:0	C18:0	C18:1 n9	C18:2 n6	C18:3 n3	C20:4 n6	C20:5 n3	C22:5 n3	C22:6 n3
Tto x Proc									
[1]T1 - raw	29.58 [bc]	6.41	25.95 [c]	16.58 [a]	13.93	0.28	0.39 [c]	0.24 [c]	0.25
T1 - cooked	32.55 [a]	7.69	24.58 [c]	13.27 [b]	13.43	0.23	0.34 [c]	0.22 [c]	0.25
T2 - raw	28.99 [c]	8.54	29.26 [b]	12.87 [bc]	2.98	0.57	1.33 [a]	0.93 [a]	2.42
T2 - cooked	29.95 [b]	9.67	32.60 [a]	11.72 [c]	3.08	0.46	0.91 [b]	0.74 [b]	1.73
Pooled SEM	0.474	0.155	1.505	0.848	0.165	0.002	0.005	0.002	0.012
Treatment									
T1	31.07	7.05	26.27	14.93	13.68	0.25	0.37	0.23	0.25
T2	29.47	9.11	30.93	12.30	3.03	0.52	1.12	0.83	2.07
Process									
raw	29.28	7.47	27.61	14.73	8.45	0.43	0.86	0.58	1.33
cooked	31.25	8.68	29.59	12.50	8.26	0.34	0.62	0.48	0.99
Significances									
Tt	***	***	***	***	***	***	***	***	***
Proc	***	***	**	***	N.S.	***	***	***	***
Tt x Proc	**	N.S.	*	*	N.S.	N.S.	***	**	***

[1]T1 = 4% linseed oil + 4% tallow (T); T2 = 4% fish oil + 4% T

[a,b,c] Values within the same row with no common superscript are significantly different, P<.05 (*), .01 (**), or .001 (***)

[a,b,c] Values within the same row with a common subscript show a tendency, P<.10 (+)

Table 4 - Groups of main FA in samples of thighs

Effect	SAT	MUFA	PUFA	n 6	n 3	n6/n3
Tt x Proc						
[1]T1 - raw	37.44 [c]	30.27	32.12	17.10 [a]	15.02	1.14 [c]
T1 - cooked	41.43 [a]	30.12	28.09	13.79 [bc]	14.40	0.95 [d]
T2 - raw	39.84 [b]	37.60	22.18	14.04 [b]	8.14	1.73 [b]
T2 - cooked	41.81 [a]	38.56	19.46	12.63 [c]	6.84	1.84 [a]
Pooled SEM	0.466	1.047	2.010	0.990	0.263	0.004
Treatment						
T1	39.43	30.19	30.11	15.40	14.71	1.04
T2	40.83	38.08	20.82	13.33	7.49	1.78
Process						
raw	38.64	33.94	27.15	15.57	11.58	1.43
cooked	41.62	34.34	23.78	13.16	10.62	1.40
Significances						
Tt	***	***	***	***	***	***
Proc	***	N.S.	***	***	***	N.S.
Tt x Proc	**	N.S.	N.S.	*	N.S.	***

[1]T1 = 4% linseed oil + 4% tallow (T); T2 = 2% fish oil + 4% T

[a,b,c,d] Values within the same row with no common superscript are significantly different, P<0.05 (*), 0.01 (**), or 0.001 (***)

ALTERNATIVES TO ANTIBIOTIC GROWTH PROMOTORS: MANNAN OLIGOSACCHARIDES AND ORGANIC ACIDS

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Summary

Two alternatives to feed-grade antibiotic performance enhancers—mannan oligosaccharide (MOS) and a mixture of organic acids—were compared to an antibiotic (avilamycin) and an untreated control in broilers. The feed formulas contained low concentrations of essential amino acids to amplify any effect of the performance enhancers. Half of the broilers in each of the four treatment groups were raised on used litter to give the birds a microbial pathogen challenge.

At 14 days of age, broilers fed avilamycin were heavier than those fed either the untreated control, MOS, or the acid combination. However, by 35 days of age, the liveweight difference between avilamycin, MOS, and the organic acids disappeared. Compared to broilers fed the untreated control, all three additives improved feed conversion to a similar degree. Mortality was lowest in MOS-fed birds. It was concluded that MOS and avilamycin elicited similar improvements in broiler performance. During the first two weeks of the study, water intake was lowest for MOS-fed birds and highest for the organic acid-fed birds. At 35 days of age, the litter condition of the birds fed any of the additives was better than the control. Wet litter can result in birds with dirty feathers, leg problems, and breast blisters. Wet litter also increases the ammonia concentration in growout houses. High ammonia concentrations could cause respiratory problems in a flock leading to an increased carcase condemnation rate.

Introduction

Consumers and government regulators are increasing the pressure on animal producers to eliminate antibiotic performance enhancers in feed. Public fear is that the continued use of sub-therapeutic concentrations of antibiotics in animal feed will result in antibiotic resistant human pathogens. Recently, the European Union enacted a ban on