Effects of lipid levels on sensorial characteristics of duck breast meat

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Introduction

Intramuscular fat (IMF) is involved in determining meat quality, particularly nutritional and sensory characteristics and conservation ability (Rabot, 1998). As lipid levels in poultry meat are low (about 1 to 2% in breast meat of turkey and chicken, Rabot, 1998), the relationship between lipid levels and sensory characteristics has received little attention. However, lipid levels are higher in duck meat than in chicken and turkey meat (Baéza *et al*., 2002).

Different genotypes of ducks are used to produce meat around the world, including common ducks such as Pekin ducks (*Anas platyrhynchos*), Muscovy ducks (*Caïrina moschata*) and crossbred ducks such as mule ducks (crossbreed between a common female and a Muscovy male, hinny ducks being the reverse crossbreed). Overfeeding significantly increases lipid levels in duck meat (Auvergne, 1992). Using different duck genotypes (Muscovy, Pekin, mule and hinny) combined with two feeding levels (ad libitum *vs* overfeeding) Chartrin *et al.* (2006) were able to obtain a wide range of lipid levels in breast muscle (from 2.26 to 7.57%). In the present study, this same model was used to analyze the influence of IMF levels on the sensory attributes of duck breast meat: flavour, juiciness and tenderness evaluated by sensory analysis and objective measurement of shear force values, cooking loss and colour.

Material and methods

To avoid sex and age effects, we reared only males and we slaughtered all birds at 14 weeks of age, which is the usual slaughter age for overfed birds in France. Male ducks from four different genotypes were used: Pekin and Muscovy ducks and their crossbred mule and hinny ducks. The ducks (42 per genotype) originated from the same sires and dams and were provided by Grimaud (Roussay, France). They were all reared under the same conditions at the Experimental Station for Waterfowl Breeding (INRA, Artiguères, France). They were fed ad libitum from hatching to 6 weeks of age. From 6 to 12 weeks of age, they were fed a restricted diet at levels appropriate to ingestion ability of each genotype (200-250 g per duck at the beginning, increasing to 360-380 g at the end of this period). At 12 weeks of age, 21 ducks per genotype were overfed for 14 days at the maximum of their ingestion potential with corn and corn meal (Chartrin *et al.*, 2006). Contemporaneously, 21 ducks per genotype were maintained on the growing diet ad libitum (Chartrin *et al.*, 2006).

Ducks were weighed and slaughtered under commercial conditions 12 h after their last meal at 14 weeks of age. The right breast muscle was excised and weighed immediately after plucking and two samples were removed. One sample was frozen and stored at -20°C prior to chemical analysis. The second sample was vacuum packed, stored at 4°C for 24 h then frozen in ethanol and stored at -20°C until texture analysis. After 24 h of storage at 4°C, the left breast muscle was excised from the carcass. Meat colour (CIELAB system: L*, a*, b*) was determined in the middle part of the inner side with a Miniscan TM spectrocolorimeter (Hunterlab, Noisy le Grand, France). This breast was then vacuum packed, frozen and stored at -20°C until sensory analysis.

Water and total lipid contents were determined according to AOAC (1984) and Folch *et al.* (1957), respectively. Texture and cooking loss were determined according to Zanusso *et al.* (2003). For sensory analysis, breast muscles were thawed at 4°C for 24 h. Breast meat was then grilled (2 to 4 min on each side at 170°C depending on weight), cut into 12 pieces and presented to 12 trained panellists.

Five sensory attributes were judged on a continuous scale (0 to 10) for juiciness, tenderness, stringiness, duck flavour and overall flavour.

The effects of genotype, overfeeding levels and their interaction were analyzed using the GLM procedure of SAS (1989). Means were compared using Tukey's test.

Results and discussion

Breast muscle containing high lipid levels was paler and had greater yellowness intensity (Tables 1 and 2). Correlations between L*, a*, b* values and lipid level were + 0.49, + 0.20 and + 0.47, respectively (P < 0.05). Salichon *et al.* (1998) reported that breast muscle of overfed mule ducks was paler and had higher b* values than breast muscle of ad libitum-fed ducks. Fernandez *et al.* (2003, 2004) also reported that paler breast muscle of overfed mule ducks and geese contained higher lipid levels. In general, during overfeeding ducks ingest high amounts of maize containing liposoluble xanthophylls that accumulate in tissues and contribute to their **colour**. In addition, other factors influence meat colour. Overfed and ad libitum-fed Muscovy ducks had paler breast muscle, higher muscle weight and b* values, and lower a* values, despite lower lipid levels than the other genotypes (Table 1). In this study, it can be hypothesized that the greater muscle development in Muscovy ducks induced dilution of heminic pigments (myoglobin and hemoglobin). However, in this study we found no significant correlation between a* values and breast muscle weight. Fernandez *et al.* (2003) previously reported that heavier breast muscle of overfed mule ducks was also paler and had higher a* and b* values. Comparing the four overfed genotypes, Larzul *et al.* (2002) also reported that breast muscle of Muscovy ducks had the highest L* value. Muscovy ducks reach maximum growth rate later than the other genotypes (Chartrin *et al*., 2006). As heminic pigment levels in duck muscles increase with age (Baéza *et al.*, 2002) it can be hypothesized that, unlike other duck genotypes, these levels might have not reached their maximum in Muscovy ducks.

Cooking loss was greater in breast muscle containing high lipid levels (Table 2), but these criteria were not correlated with meat **juiciness**. In fact breast muscle of overfed Muscovy ducks obtained the lowest juiciness scores and those of ad libitum-fed Pekin ducks obtained the highest juiciness scores (data not shown). In our study measurements of cooking loss and juiciness scores were not obtained with the same cooking procedures, which might partly explain the differences found between criteria. Girard *et al.* (1993) also reported that breast muscle from ad libitum-fed ducks was judged juicier than breast muscle of overfed ducks. In contrast, breast muscle containing greater lipid levels was also judged juicier in overfed "Landaise" geese (Baéza *et al.*, 1998), and high IMF levels were associated with high juiciness scores in pork (Fernandez *et al.*, 1999). In our study, juiciness was positively correlated with water levels in breast muscle (+ 0.21, P < 0.05) and negatively correlated with muscle weight (- 0.27, P < 0.01). Other factors might control meat juiciness.

Tenderness measured by trained panellists was correlated with shearing energy value (- 0.33, P < 0.001). In our study, higher tenderness scores were obtained for breast muscle containing higher lipid levels (Table 2), but overfeeding that induced a significant increase in breast lipid levels had no significant effect on this sensory attribute (data not shown). Girard *et al.* (1993) also reported that breast muscle of ad libitum-fed ducks was judged more tender than breast muscle of overfed ducks. In contrast, in overfed "Landaise" geese, breast muscle containing higher lipid levels had the highest tenderness scores (Baéza *et al.*, 1998) and high IMF levels were associated with high tenderness scores in pork (Fernandez *et al.*, 1999). In fact, in our study, tenderness was strongly and negatively correlated with muscle weight (- 0.60, P < 0.001), breast muscle from Muscovy and Pekin ducks obtaining the lowest and the highest tenderness scores, respectively. Larzul *et al.* (2002) showed that breast muscle from overfed Muscovy ducks had higher collagen levels (4.82 *vs* 4.30 mg/g of muscle), and lower collagen solubility (13 *vs* 19%) than breast muscle from Pekin ducks. Chartrin *et al.* (2005) reported that the cross-sectional area of muscle fibres was greater in breast muscle from Muscovy ducks than in breast muscle from Pekin ducks, and this criterion is generally negatively correlated with tenderness. Muscovy ducks also had the highest scores for stringiness, confirming a possible effect of fibre size in the determination of these criteria (data not shown).

Flavour was more pronounced with high lipid levels in breast meat (Table 2). Girard *et al.* (1993) reported that breast muscle from overfed ducks had a more pronounced flavour than breast muscle from ad libitum-fed ducks. In overfed “Landaise” geese, breast muscle exhibiting greater lipid levels obtained the highest flavour scores (Baéza *et al.*, 1998) and high lipid levels were associated with high flavour scores in pork (Fernandez *et al.*, 1999). The correlation between lipid levels and flavour obtained in our study was low (0.257, $P < 0.001$), but only IMF were taken into account whereas under usual cooking conditions breast muscle keeps its skin and subcutaneous lipids, the levels of which are quite high in overfed ducks. Subcutaneous lipids migrate to poultry meat during cooking (Rabot, 1998). The lowest flavour scores occurred in Muscovy ducks (data not shown). This could be explained by lower lipid and phospholipid levels in their breast muscle, as previously demonstrated by Chartrin *et al.* (2006) under similar experimental conditions, as phospholipids mainly contribute to the aroma of cooked meat (Mottram and Edwards, 1983).

TABLE 1. Effects of feeding levels and genotype on the colour, total lipid and water levels (g/100 g muscle) in *Pectoralis major* muscle from ducks slaughtered at 14 weeks of age (mean ± SE)

Genotype	Feeding level	n	Breast muscle colour			Water content	Lipid content
			L*	a*	b*		
Pekin	Overfed	11	41.5 ± 4.3	13.8 ± 1.0	13.6 ± 2.0 b	72,1 ± 1,6 cd	6,4 ± 1,2 a
	Ad libitum fed	20	30.9 ± 1.4	13.7 ± 1.3	8.2 ± 1.3 d	72, 6 ± 0,8 cd	3,9 ± 0,5 c
Mule	Overfed	21	41.2 ± 3.7	14.2 ± 1.2	14.3 ± 2.0 ab	72,7 ± 1,0 c	4,3 ± 0, 8 c
	Ad libitum fed	20	31.9 ± 1.8	13. 8 ± 1.0	8.9 ± 1.4 d	74,0 ± 0,6 b	2,8 ± 0,4 de
Hinny	Overfed	21	42. 9 ± 1.6	14.1 ± 1.6	15.0 ± 1.9 a	72,1 ± 1,2 d	4,9 ± 1,0 b
	Ad libitum fed	20	32.2 ± 1.9	13.9 ± 1.7	9.2 ± 2.2 d	74,0 ± 0,8 b	2,7 ± 0,4 de
Muscovy	Overfed	15	43.6 ± 3.1	12.8 ± 0.9	14.7 ± 2.0 ab	73,28 ± 0,98 c	3,1 ± 0,5 d
	Ad libitum fed	17	35.0 ± 2.1	13.7 ± 0. 9	11.4 ± 1.1 c	75,0 ± 0,9 a	2,6 ± 0,5 e
Feeding level effect			p<0,0001	0,9137	p<0.0001	p<0.0001	p<0.0001
Genotype effect			p<0,0001	0,0363	p<0.0001	p<0.0001	p<0.0001
Interaction			0,2304	0,1690	0.0190	0.0157	p<0.0001

a-e: significant difference between groups for one criterion
L* = luminance (values comprised between 0 = black and 100 = white), a* = positive values for redness, b* = positive values for yellowness.

TABLE 2. Effects of lipid levels on physico-chemical characteristics and sensory attributes of breast muscle from 14-week-old ducks (mean ± SE)

Lipid classes (g per 100 g of meat)	1.7 to 3.05	3.06 to 4.37	> 4.37	P values
Number of samples	56	54	35	
Breast weight (g)	329 ± 58 a	275 ± 72 b	254 ± 50 b	< 0.0001
Lipid levels (g per 100 g of meat)	2.58 ± 0.35 c	3.71 ± 0.45 b	5.56 ± 1.1 a	< 0.0001
Water levels (g per 100 g of meat)	74.29 ± 0.87 a	73.01 ± 0.90 b	71.84 ± 1.16 c	< 0.0001
L*	34.38 ± 3.91 c	36.71 ± 6.32 b	41.75 ± 3.94 a	< 0.0001
a*	13.59 ± 1.11	13.76 ± 1.48	14.05 ± 1.16	0.2367
b*	10.42 ± 2.41 c	11.64 ± 3.53 b	14.21 ± 2.54 a	<

				0.0001
Cooking loss (%)	14.95 ± 1.63 a	16.29 ± 2.31 b	17.77 ± 2.95 c	< 0.0001
Shear force value (N)	52.14 ± 11.65	49.64 ± 9.03	51.83 ± 10.94	0.4215
Working value (J)	180.64 ± 47.17	169.88 ± 37.18	168.06 ± 32.92	0.2489
Tenderness	4.56 ± 0.48 b	5.04 ± 0.51 a	5.14 ± 0.45 a	< 0.0001
Juiciness	4.20 ± 0.38 b	4.38 ± 0.35 a	4.28 ± 0.39 ab	0.0413
Stringiness	4.23 ± 0.36 a	4.02 ± 0.48 b	3.94 ± 0.30 b	0.0012
Overall flavour	4.41 ± 0.43 b	4.64 ± 0.49 a	4.72 ± 0.37 a	0.0018
Duck flavour	4.96 ± 0.32 b	5.03 ± 0.33 ab	5.15 ± 0.28 a	0.0170

a-c: significant difference between groups for one criterion

Conclusion

Increasing lipid levels in breast muscle increased lightness, yellowness, cooking loss, tenderness and flavour, with correlation coefficients of 0.49, 0.47, 0.54, 0.43 and 0.28, respectively. However, breast meat colour and tenderness were mainly influenced by genotype.

References

AOAC, 1984. Official Methods of Analyis, 14th edn., Arlington, VA, Association of Official Chemists.

Auvergne, A., 1992. Thèse de Doctorat, INP Toulouse, France, 252 pp.

Baéza E., Guy G., Salichon M. R., Rousselot-Pailley D., Klosowska D., Elminowska-Wenda G., Srutek M., Rosinski A., 1998. Arch. Geflügelk. 62 (4), 169-175.

Baéza E., Dessay C., Wacrenier N., Marché G., Listrat A., 2002. Brit. Poult. Sci. 43, 560-568.

Chartrin P., Bernadet M. D., Guy G., Mourot J., Duclos M. J., Baéza E., 2005. Reprod. Nutr. Dev. 45, 87-99.

Chartrin P., Bernadet M.D., Guy G., Mourot J., Duclos M.J., Baéza E., 2006. Anim. Res. 55, 231-244.

Fernandez X., Monin G., Talmant A., Mourot J., Lebret B., 1999. Meat Sci. 53, 59-65.

Fernandez X., Auvergne A., Renerre M., Gatellier P., Manse H., Babilé R., 2003. Anim. Res. 52, 567-574.

Fernandez X., Leprettre S., Dubois J. P., Babilé R., 2004. 6èmes Journées de la Recherche sur les Palmipèdes à Foie Gras, Arcachon (France), 7-8/10/04, 199-202.

Folch J., Lees M., Sloane Stanley G.H., 1957. J. Biol. Chemist. 226, 497-509.

Girard J. P., Culioli J., Denoyer C., Berdagué J. L., Touraille C., 1993. Arch. Geflügelk. 57, 9-15.

Larzul C., Imbert B., Bernadet M. D., Guy G., Rémignon H., 2002. 5èmes Journées de la Recherche sur les Palmipèdes à Foie Gras, Pau (France), 9-10/10/02, 29-32.

Mottram D.S., Edwards R. A., 1983. J. Sci. Food Agric. 34, 517-522.

Rabot C., 1998. Thèse de Doctorat, INA-PG, Paris, 156 pp.

Salichon M.R., Guy G., Rousselot-Pailley D., Wacrenier N., Blum J.C., Baéza E., 1998. 3èmes Journées de la Recherche sur les Palmipèdes à Foie Gras, Bordeaux (France), 27-28/10/98, 127-131.

SAS. 1989. In: SAS/STAT user's guide, SAS Institute Inc., Cary, NC.

Zanusso J., Rémignon H., Guy G., Manse H., Babilé R., 2003. Reprod. Nutr. Dev. 43, 105-115.

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