GENETIC VARIATION OF CHICKEN TECHNOLOGICAL MEAT QUALITY

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ABSTRACT

In poultry as in other animal species, several attributes of the meat such as colour, water-holding capacity or texture have become of major importance, since meat is nowadays offered to customers as parts or further-processed products rather than as whole carcasses. In the same time, a very high variability of the technological quality of poultry meat has been put in evidence, as indicated by recent results on chicken meat pH measured under commercial conditions. Recent results obtained on experimental divergent lines point out that selection for growth or abdominal fatness may lead to significant changes in meat quality attributes such as colour, pH or water-holding capacity. These experimental lines are valuable tools for genomic research aimed at identifying genes or markers useful for selection on meat quality. Meat quality can also be improved by a more classical approach of selection as indicated by the strong heritabilities obtained in a heavy commercial line for different breast meat indicators. The estimated genetic correlations suggested that ultimate pH could be a relevant selection criterion, because of its strong relationship with the colour, the water-holding capacity and the texture of the meat.

KEY WORDS: Chicken, Genetic parameters, Meat Quality, Meat pH

INTRODUCTION

In poultry as in other animal species, several technological parameters of meat have become of major importance, since meat is nowadays often offered to customers as parts or further-processed products rather than as whole carcasses. This highlights the importance of meat characteristics such as color, water-holding capacity and texture, which strongly influence yields during processing and sensorial quality of the raw and cooked meat. As described by Berri (2000), many factors including rearing and slaughtering conditions as well as bird characteristics may influence meat properties. The variation of ultimate pH within slaughter hatch was estimated recently by a French study on chicken meat processed in a commercial plant. It appeared very high since extreme values ranging from 5.4 to 6.5 could be detected within a same slaughter hatch (Brunel *et al.*, 2006). As already reported in the literature, such extreme pH values can lead to meat defects: high final pH produces dark, firm and dry (DFD) meat with a poor storage quality due to faster rate of off-odor production and accelerated microbiological growth (Allen *et al.*, 1998). On the contrary, low final pH produces meat with an improved shelf-life but a pale aspect and reduced water-holding capacity (Barbut, 1996, 1997). This highlights the need for homogenizing the quality of poultry meat, both by improving the rearing and slaughtering conditions, but also by adapting selection processes to the current cutting and processing practices. In this paper we will report recent results on the genetic variation of chicken meat quality, obtained either by comparing extreme divergent experimental lines or by estimating genetic parameters of meat traits within a commercial heavy line.

MEAT QUALITY VARIATION IN EXPERIMENTAL CHICKEN LINES DIVERGENTLY SELECTED FOR GROWTH OR BODY COMPOSITION

Even if they may present performances rather far from current commercial birds, experimental lines of chickens constitute quite interesting tools for identifying changes in bird characteristics that may have been induced by selection for growth or for body composition, applied in most commercial breeding programs. High Growth (HG) and Low Growth (LG) chicken lines from the Poultry Research Center (Nouzilly, FRANCE) have been divergently selected for growth rate at juvenile and adult ages (Ricard, 1975). Body weight, body composition and several breast meat parameters were recently characterized on a total of 53 HG and 56 LG male birds, bred under regular conditions and slaughtered at 9 weeks in the experimental facility of the Poultry Research center. Meat pH at 15 min post-slaughter (pH15), ultimate pH (pHu), meat colour (defined as the lightness L*, the redness a* and the yellowness b*) at 24 h post-slaughter, and drip loss after 2 days of storage were measured as described by Le Bihan-Duval *et al.* (1999) and Berri *et al.* (2005). As shown in Table 1, body weight at 9 weeks was 2.8 fold higher in HG than in LG line. A large correlated response was observed for abdominal fatness which was extremely low in LG line and higher in HG line (11.8 fold difference). Interestingly, these results indicated that HG chickens exhibited a less coloured breast meat with lower redness and yellowness, and higher lightness than LG birds. Post-mortem pH values also differed between the two lines, HG birds exhibiting lower pH15 and pHu values. The lower ultimate pH of HG bird was likely to contribute to the paler aspect of the meat since a negative phenotypic correlation of -0.54 was observed between pHu and lightness.

Table 1. Body weight, body composition and breast meat parameters (mean ± standard deviation) in the high growth (HG) and low growth (LG) lines, as well as in the high fat (HF) and low fat (LF) lines compared at 9 wks of age

Traits	LG (n=56)	HG (n=53)	line effect (p value)	LF (n=60)	HF (n=60)	line effect (p value)
Growth and body composition						
body weight (g)	683 ± 67	1922 ± 157	<.0001	2522 ± 193	2627 ± 162	<.001
abdominal fat percentage (%)	0.2 ± 0.2	2.5 ± 0.7	<.0001	1.4 ± 0.5	3.9 ± 0.7	<.001
breast yield (%)	10.44 ± 0.75	11.37 ± 0.84	<.0001	12.8 ± 0.9	11.5 ± 0.9	<.001
thigh yield (%)	22.03 ± 0.68	23.24 ± 0.86	<.0001	NA	NA	NA
Breast meat parameters						
lightness (L*)	45.6 ± 1.8	48.3 ± 3.2	<.0001	44.9 ± 2.6	47.4 ± 2.7	<.001
redness (a*)	1.6 ± 0.7	-0.2 ± 0.8	<.0001	-0.3 ± 0.7	-1.0 ± 0.7	<.001
yellowness (b*)	13.3 ± 1.4	9.4 ± 1.2	<.0001	9.3 ± 1.0	8.3 ± 1.3	<.001
pH15	6.33 ± 0.16	6.20 ± 0.22	0.0004	6.38 ± 0.21	6.36 ± 0.22	NS
pHu	6.14 ± 0.14	5.74 ± 0.09	<.0001	5.79 ± 0.12	5.66 ± 0.11	<.001
drip loss (%)	2.1 ± 1.5	2.3 ± 1.2	NS	1.1 ± 0.6	1.4 ± 0.6	<.05

NS = non significant; NA = non available

In addition to increasing performances of growth, to improve body composition by limiting carcass fatness and increasing cut-up yields has represented an important objective for poultry breeders. Experimental selection for carcass fatness was initiated at the end of the seventies by constituting two divergent lines with high (HF) or low abdominal fatness (LF) (Leclercq *et al.*, 1980). Meat quality and muscle characteristics were compared among the two lines at 9 wks of age, using the same procedures than those described for the LG and HG lines. As shown on Table 1, by comparison to LF line, HF line exhibited a 2.8 fold higher abdominal fat percentage. It also exhibited a slightly higher body weight (+5%) and a 10% lower breast yield. Breast muscle glycogen level at death was higher in the HF than in the LF line (111.6 *vs* 93.6 µM/g of fresh tissue). There was no difference between the two lines regarding the rate of early post-mortem pH drop estimated by the pH15 in breast. However, in accordance with its higher muscle glycogen level at death, the HF line exhibited a lower ultimate pH than the LF line. The consequence of this higher acidification for the HF line was a breast meat with higher drip loss during storage, and lighter (higher L*) and less coloured (lower a* and b*) aspect.

BREEDING FOR MEAT QUALITY: ESTIMATES OF GENETIC PARAMETERS IN A HEAVY CHICKEN LINE

Whereas meat quality has been selected in pig for a long time, including meat traits in poultry breeding is a much more recent focus. Genetic parameters for pH, colour and water-holding capacity of breast meat were firstly estimated in an experimental meat-type strain (Le Bihan-Duval *et al*., 1999, 2001). Quite significant heritabilities (h^2) ranging from 0.35 to more than 0.50 for the most heritable colour traits were obtained. Considering these promising results, a similar approach was conducted on a heavy commercial chicken line, by measuring a wider range of meat and muscle traits. A total of 608 pedigree birds issued from 15 sires and 64 dams were reared and slaughtered in controlled conditions at the Poultry Research Center. As shown in Table 2, strong heritabilities were confirmed for the different breast meat quality indicators.

Table 2. Heritability estimates for meat quality traits in a heavy commercial line

	N	**Mean±SD**	**h^2±SE**
Post-mortem metabolism			
pH 15 min post slaughter (pH15)	608	6.4 ± 0.1	0.30 ± 0.05
Glycolytic potential (µmol/g of muscle)	599	108.0 ± 17.7	0.43 ± 0.05
pH 24 h post slaughter (pHu)	596	5.6 ± 0.12	0.34 ± 0.06
Meat Parameters			
Lightness (L*)	598	54.9 ± 3.0	0.35 ± 0.05
Redness (a*)	595	-0.8 ± 0.7	0.25 ± 0.05
Yellowness (b*)	598	11.8 ± 1.6	0.31 ± 0.06
Drip loss (%)	598	1.6 ± 1.0	0.26 ± 0.04
Technological yield (%)	594	101.5 ± 2.5	0.35 ± 0.05
Shear force (N/cm²)	578	14.5 ± 3.0	0.34 ± 0.05
Thawing-cooking loss (%)	590	14.6 ± 4.8	0.26 ± 0.05

As in pigs, the rate of pH fall after the death and the ultimate pH appeared as key factors of the chicken meat quality. Indeed, according to the estimated genetic correlations, lower ultimate pH led to a paler, a more exsudative and a less tender breast meat. For the first time in the chicken, this study highlighted the fact that the muscle glycolic potential (representative of the resting muscle glycogen content at death) was closely related to the ultimate pH, as a negative genetic correlation of -0.97 was observed between the two traits. In accordance with several results now available in poultry, we showed, in this heavy commercial line, that the ultimate pH could be a relevant selection criterion because of its strong relationship with the colour, the water-holding capacity or the texture of the meat.

CONCLUSION

These studies pointed out significant changes in muscle biochemistry associated with selection for growth or abdominal fatness, and responsible for variation of meat quality attributes. The experimental lines of chickens are valuable tools for genomic research which are now in progress for identifying genes or markers useful for selection on meat quality. Meat quality can also be improved by a more classical approach of selection as indicated by the strong heritabilities obtained in a heavy commercial line for different breast meat indicators.

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