

Effects of age and live weight on fat 5 α -androstenone levels in young boars fed two planes of nutrition

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Summary. The aim of the present experiment was to determine whether age, live weight, or a combination of both, was the most important factor influencing fat 5 α -androstenone levels in male pigs. Three groups of 50 boars each were fed either on a liberal plane of nutrition (CTRL group) or were restricted (SW and SA groups). Fat 5 α -androstenone was measured three times in each pig (on biopsies at two different times and at slaughter) at either the same live weight (SW) or at the same age (SA) as CTRL boars. In addition, the genital tract was dissected at slaughter.

SW boars (aged 169 days) exhibited higher fat 5 α -androstenone levels than CTRL boars (aged 139 days) when the first biopsy was taken at 80 kg of live weight (1.2 vs 0.8 $\mu\text{g/g}$; $P < 0.05$). By the time of the second biopsy (100 kg of live weight) and at slaughter (125 kg) there was no significant difference between the SW and CTRL groups, although the SW were 43-55 days older than the CTRL. At all three measurement times, fat 5 α -androstenone was lower in SA than in CTRL boars which were 21-36 kg heavier (0.5 vs 0.8 $\mu\text{g/g}$ at 139 days; 0.9 vs 1.3 $\mu\text{g/g}$ at 160 days; 1.2 vs 2.0 $\mu\text{g/g}$ at 185 days; $P < 0.001$).

Partial correlations between fat 5 α -androstenone and age were significant at the first biopsy, whereas partial correlations with live weight were significant at all three times of measurement. In SA boars weighing 90 kg there was a significant correlation between fat 5 α -androstenone and all the developmental traits of the genital tract. In SW and CTRL pigs weighing 125 kg, fat 5 α -androstenone was significantly correlated with accessory sex gland development but not with testis or epididymis weight.

From the present data it is concluded that both age and live weight had a significant effect on fat 5 α -androstenone levels in young, light boars. In older, heavier boars, age had no effect *per se* but live weight still had a significant influence on 5 α -androstenone concentrations. In boars weighing 90 kg, fat 5 α -androstenone level depended on sexual maturity. When the animals were sexually mature at 125 kg of live weight, 5 α -androstenone level depended on the individual's potentiality for steroid production, which is probably under genetic control.

Introduction.

The testicular steroid, 5 α -androstenone (5 α -androst-16-ene-3-one), is one of the main compounds causing boar taint (Bonneau, 1982a). The rate of 5 α -androstenone and other steroids synthesis is regulated by pituitary LH (Carlström *et al.*,

1975 ; Claus and Alsing, 1976). A dramatic increase in testosterone (Meusy-Dessolle, 1975 ; Colenbrander *et al.*, 1978 ; Flor Cruz and Lapwood, 1978), DHA (Tan and Raeside, 1980), estrogens (Claus and Hoffmann, 1980) and 5α -androst-
stenone (Claus, 1975 ; Andresen, 1976 ; Malmfors *et al.*, 1978 ; Bonneau and Desmoulin, 1980 ; Willeke *et al.*, 1980) production is observed around puberty. Sexual development, and therefore 5α -androst-
stenone production, is dependent on animal age and live weight. However, the respective influence of each factor is not known.

A first experiment was conducted (Bonneau, 1982b) to study this question by comparing boars fed two planes of nutrition in which fat 5α -androst-
stenone levels were determined either at similar live weights and different ages or at similar ages and different live weights. However, the results were not conclusive because growth rate differences between the groups were not sufficient to induce significant differences in fat 5α -androst-
stenone levels.

The present study was conducted according to a similar experimental design but with a higher degree of restriction on a larger number of pigs exhibiting improved growth performance.

Materials and methods.

1) *Animals and experimental design.* — A total of 150 Large White boars from 50 litters, aged 64.7 ± 0.3 days (mean \pm SEM) and weighing 26.3 ± 0.2 kg, were given one of three treatments on a within-litter basis. The boars given treatment 1 were fed a diet containing 3 090 kcal DE/kg, 17.3 % crude protein and 0.83 % lysine on a liberal scale of feeding based on animal live weight (from 1.40 kg of feed per day at 25-30 kg of live weight up to 3.20 kg at 105 kg or more of live weight). Pigs given treatments 2 and 3 were offered 70 % of the same diet at similar live weights.

The boars were housed in groups of 5 each and fed collectively. They could see, hear, smell and have nose-to-nose contact with females of similar age housed in adjacent pens. The boars given treatment 1, considered as the control (CTRL), were slaughtered at about 125 kg of live weight. Those given treatment 2 (SW) were slaughtered at the same live weight, whereas the animals given treatment 3 (SA) were slaughtered at the same age as the controls.

The experiment was repeated four times according to the same experimental design : in autumn 1982 (experiment 1), spring and autumn 1983 (experiments 2 and 3) and spring 1984 (experiment 4) (30, 45, 45 and 30 boars, respectively).

2) *Fat 5α -androst-
stenone measurements.* — The backfat of every boar was sampled at slaughter in the neck area in all four experiments. In addition, in experiments 1 and 2, backfat biopsies were performed in the same area at around 80 and 100 kg of live weight in the CTRL boars, at similar live weights in SW pigs and at similar ages in SA pigs.

Fat 5α -androst-
stenone levels were measured by radioimmunoassay after extraction with solvents, as previously described (Claus, 1974 ; Uzu and Bonneau, 1980). The results were expressed in μg of 5α -androst-
stenone/g of ether extract.

The mean ages and live weights of the boars, at the times 5 α -androsthenone was measured, are shown in table 1.

TABLE 1
Age and live weight of the boars at the time of fat 5 α -androsthenone measurements.

Time of 5 α -androsthenone measurement	Treatment		
	1 CTRL	2 SW	3 SA
First biopsy (1-2)			
age (d)	138.8 \pm 1.4	168.7 \pm 2.7	138.5 \pm 1.4
live weight (kg)	80.8 \pm 0.6	79.8 \pm 0.4	59.5 \pm 1.4
Second biopsy (1-2)			
age (d)	159.9 \pm 1.5	202.9 \pm 3.3	160.0 \pm 1.6
live weight (kg)	101.4 \pm 0.5	100.3 \pm 0.3	73.2 \pm 1.9
Slaughter (1-2)			
age (d)	184.8 \pm 2.1	237.1 \pm 3.8	184.7 \pm 2.1
live weight (kg)	125.6 \pm 0.7	125.2 \pm 0.3	90.1 \pm 2.6
Slaughter (1-4)			
age (d)	183.7 \pm 1.6	241.5 \pm 2.6	183.2 \pm 1.7
live weight (kg)	126.2 \pm 0.4	125.0 \pm 0.2	90.7 \pm 1.6

Means \pm s.e.m.

(1-2) Experiments 1 and 2 (69 pigs).

(1-4) Experiments 1, 2, 3 and 4 (141 pigs).

3) *Measurements at slaughter.* — The genital tract was dissected ; the testes, epididymis, seminal vesicles + prostate and bulbourethral glands were weighed and the length of the latter glands measured. The right side of each carcass was cut, and the percentages of total muscle and fat were estimated using the multiple regression equations described by Desmoulin *et al.* (1976). The results on genital tract development and carcass composition are presented elsewhere (Prunier *et al.*, 1987). Only the relationships between these traits and fat 5 α -androsthenone levels have been considered here.

4) *Statistical analysis.* — The distribution of fat 5 α -androsthenone levels were skewed, so the data on these were converted to natural logarithms and almost normal distributions were obtained. Variance analysis was used to test the effects of experiments and treatments. When relevant, the effects of time of measurement and animal within treatment were also tested (fig. 1). Multiple comparison of the means was achieved using the Scheffe test.

Results.

1) *Feed consumption and growth performance* (table 2).

The overall levels of restriction actually achieved were 24, 27 and 29 % for the periods — 26-60 kg, 60-90 kg and 90 kg — slaughter respectively. Average

daily gains were lower in restricted than in CTRL boars and did not differ significantly between SW and SA animals.

TABLE 2
Feed consumption and growth performances.

Live-weight period	Treatment		
	1 CTRL	2 SW	3 SA
26-60 kg			
Feed consumption (kg/d)	1.81	1.37	1.36
Daily gain (g/d)	694 ± 13 ^a	476 ± 10 ^b	475 ± 13 ^b
60-90 kg			
Feed consumption (kg/d)	2.69	2.00	1.95
Daily gain (g/d)	941 ± 17 ^a	626 ± 13 ^b	634 ± 15 ^b
90 kg-slaughter			
Feed consumption (kg/d)	3.06	2.16	
Daily gain (g/d)	961 ± 23 ^a	616 ± 17 ^b	

Feed consumption : boars were fed collectively. Therefore statistical analysis of individual results was not possible.

Daily gain : Means ± s.e.m. Within rows, treatment means followed by different superscript letters were significantly different ($P < 0.05$).

2) Fat 5α -androstenone levels (fig. 1).

There was no significant effect of season (experiments 1 + 2 vs 2 + 4) on fat 5α -androstenone level. At the time of first biopsy (around 80 kg of live

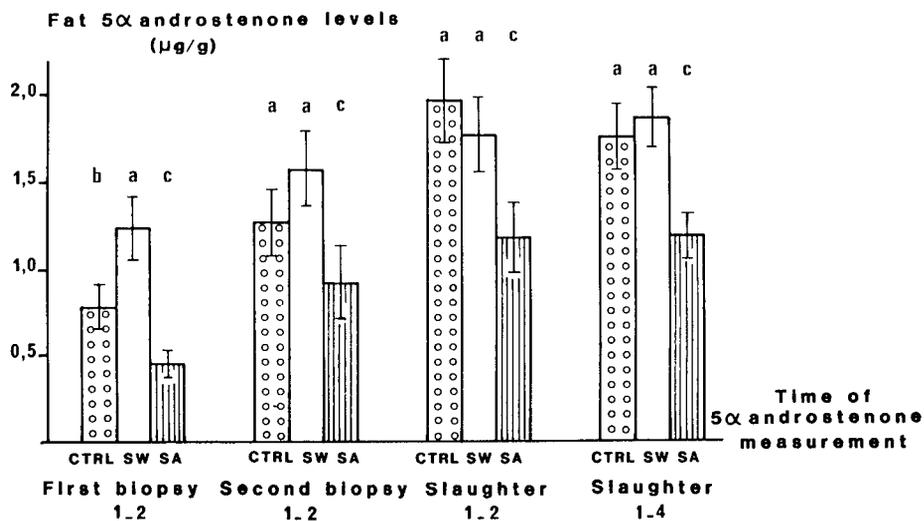


FIG. 1. — Fat 5α -androstenone levels (means + s.e.m.).

(1-2) Experiments 1 and 2 (69 pigs).

(1-4) Experiments 1, 2, 3 and 4 (141 pigs).

Significance of differences : a-b : $P < 0.05$; a-c : $P < 0.001$; b-c : $P < 0.001$.

weight), fat 5 α -androstenone was significantly higher in SW boars, aged 169 days, than in CTRL boars which were 30 days younger. At higher live weights there was no significant difference between SW and CTRL boars, although SW animals were 43 and 52-55 days older than CTRL ones at 100 and 125 kg, respectively.

At all three times of measurement, fat 5 α -androstenone levels were significantly lower in SA than in CTRL boars.

3) Correlations between fat 5 α -androstenone levels and other traits.

Age and live weight (table 3). — Fat 5 α -androstenone level was significantly correlated with animal live weight. The correlation of fat 5 α -androstenone with age was higher at the first biopsy than at subsequent measurements. At all the three times studied, fat 5 α -androstenone was more closely related with live weight than with age.

TABLE 3

Coefficients of correlation between fat 5 α -androstenone level and age or live-weight.

Time of 5 α -androstenone measurement	Total correlation with		Partial correlation(S) with	
	Age	Live-weight	Age. LW	LW. age
First biopsy (1-2)	0.32**	0.38**	0.28*	0.28*
Second biopsy (1-2)	0.11 NS	0.32**	0.05 NS	0.29*
Slaughter (1-2)	0.22 ⁺	0.44***	0.05 NS	0.43***
Slaughter (1-4)	0.26**	0.32***	0.14 NS	0.24*

(S) Partial correlation of fat 5 α -androstenone with :

— age, common effect of live weight being eliminated (age.LW),

— live-weight, common effect of age being eliminated (LW.age).

(1-2) Experiments 1 and 2 (69 pigs).

(1-4) Experiments 1, 2, 3 and 4 (141 pigs).

Significance of the coefficients of correlation : NS - Non significant ; ⁺ P < 0.10 ; * P < 0.05 ; ** P < 0.01 ; *** P < 0.001.

TABLE 4

Coefficients of correlation between fat 5 α -androstenone levels and genital tract development traits.

Genital tract development traits	Treatment		
	CTRL	SW	SA
Weight of :			
— testes	0.19 NS	— 0.04 NS	0.50***
— epididymis	0.13 NS	0.06 NS	0.50***
— seminal vesicles	0.44**	0.31*	0.53***
— bulbourethral glands	0.71***	0.56***	0.72***
Length of bulbourethral glands	0.63***	0.61***	0.66***

Significance of the coefficients of correlation : NS Non significant ; * P < 0.05 ; ** P < 0.01 ; *** P < 0.001.

After the common effect of age was eliminated, partial correlations between fat 5α -androstenone and live weight were slightly lower than the total correlations, but still significant. Partial correlations with age (the common effect of live weight eliminated) was only significant at the first biopsy.

Growth rate and carcass composition. — The coefficients of correlation between fat 5α -androstenone levels and average daily gain, percentage of muscle or of fat in the carcass were very low ($-0.21 < r < +0.18$).

Genital tract development (table 4). — In CTRL and SW boars slaughtered at 125 kg of live weight, fat 5α -androstenone levels were correlated with the development of the seminal vesicles and bulbourethral glands but not with the weight of the testes or epididymis. In SA boars slaughtered at 70 kg, there was a significant relationship between 5α -androstenone and all the developmental traits of the genital tract. The relationships between 5α -androstenone level and the weight of the testes in SA boars or of the bulbourethral glands in all boars are shown in figures 2 and 3.

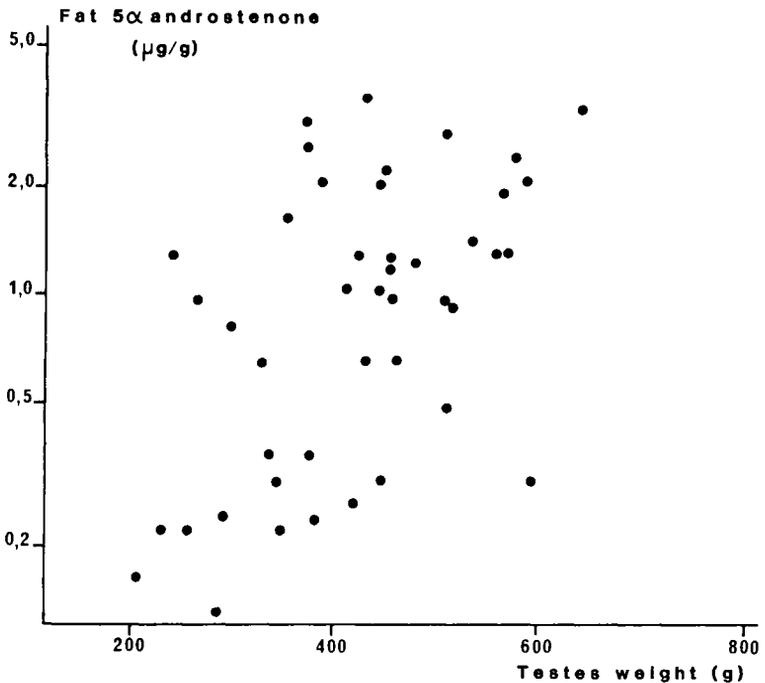


FIG. 2. — Distribution of fat 5α -androstenone level against testes weight in SA boars.

Discussion.

1) *The effect of age and live weight on 5α -androstenone levels.* — At 80 kg of live weight, SW boars exhibited higher 5α -androstenone levels than CTRL

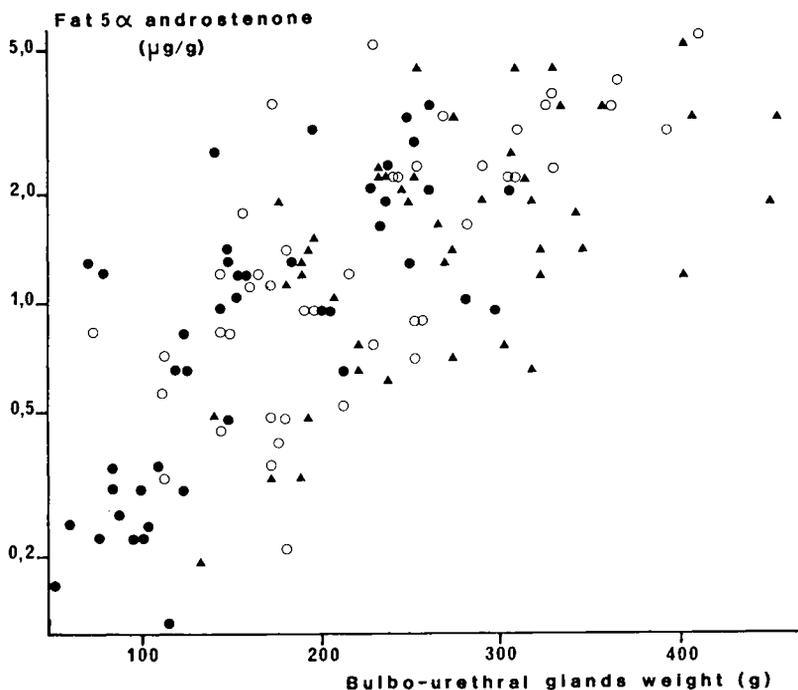


FIG. 3. — Distribution of fat 5 α -androstenone level against bulbo-urethral glands weight in overall population.

(○) CTRL boars ; (▲) SW boars ; (●) SA boars.

boars which were 30 days younger. The influence of age in young, light animals (139-169 days and 60-80 kg at first biopsy) was also demonstrated by the significant relationship between fat 5 α -androstenone and age. That influence is an actual effect of age since partial correlation between 5 α -androstenone levels and age, after elimination of live weight effect, was significant.

This effect of age was no longer observed in older, heavier boars (160-239 days and 73-126 kg at second biopsy and at slaughter). Indeed, there was no significant difference between SW and CTRL boars, although the former were 43 to 55 days older than the latter. Moreover, partial correlations of fat 5 α -androstenone with age, after elimination of the live weight effect, were not significant. These findings are consistent with the results of Mosenthin *et al.* (1984) who found no difference in 5 α -androstenone levels at 100 kg between groups of 12 and 6 boars aged 171 and 205 days, respectively.

For boars of similar ages, fat 5 α -androstenone levels were higher in CTRL than in SA boars which were 21, 28 and 36 kg lighter at 139, 160 and 185 days of age, respectively. Such a difference is an actual effect of live weight since partial correlations of fat 5 α -androstenone levels with live weight, after elimination of age effect, were significant at all three times of measurement.

Thus, the present data demonstrate that both age and live weight have an effect on fat 5 α -androstenone levels in young, light boars aged about 140-

170 days and weighing 60-80 kg. Later on, age has no significant influence, whereas live weight still has an effect on 5α -androstenone levels. Such findings have practical implications. If boars are killed at light commercial weight, a reduced growth performance induced by excessive feed restriction will increase fat 5α -androstenone levels at slaughter. On the other hand, if they are slaughtered at heavier commercial weights of 100 kg or more, there is no adverse influence of feed restriction on fat androstenone levels at slaughter.

2) *Relationship between fat 5α -androstenone levels and genital tract development.* — The existence of close relationships between fat 5α -androstenone levels and seminal vesicle or bulbourethral gland development has been previously reported (Forland *et al.*, 1980 ; Uzu and Bonneau, 1980 ; Bonneau and Russeil, 1985).

The SA boars weighing 90 kg were not sexually mature at slaughter, as demonstrated by their lower genital tract development compared to SW or CTRL boars (Prunier *et al.*, 1987). In such pigs, the positive relationship between 5α -androstenone level and testis or epididymis weight is thus the result of between-animal variability in sexual maturity.

SW and CTRL boars weighing 126 kg were sexually mature at slaughter. In such boars, 5α -androstenone level was not related to sexual maturity since there was no significant correlation with testis or epididymis weight, and fat 5α -androstenone level depended on between-animal variability in the potentiality for steroid production, as shown by the significant correlations with seminal vesicle or bulbourethral gland development. Indeed, both glands are well-known target organs for androgens and estrogens in male pigs (Joshi and Raeside, 1973 ; Morat *et al.*, 1980 ; Booth, 1980, 1983 ; Lauwers *et al.*, 1981).

Conclusion.

The results of the present experiment demonstrate that both age and body weight influence fat 5α -androstenone levels in young, light boars. In older, heavier boars, the influence of body weight is greater than the effect of age. However, most fat 5α -androstenone variability is not dependent on developmental traits. Further studies are needed to investigate the genetic factors controlling both sexual development and the potentiality for steroid production.

*Reçu en septembre 1986.
Accepté en décembre 1986.*

Acknowledgements. — The author wishes to thank A. Prunier, M. Etienne and J. Noblet for their help in preparing the manuscript. He is also indebted to Dr Claus (Universität Hohenheim, FRG), Dr Hafferl (Institute of Organic Chemistry Synthex, Palo Alto, U.S.A.) and Dr Hewitt (Organon Laboratories, Newhouse, U.K.) who generously provided the antiserum and the tritiated and unlabelled 5α -androstenone, respectively.

Résumé. *Influences respectives de l'âge et du poids sur la teneur en 5 α -androsténone du tissu adipeux de jeunes verrats nourris selon deux plans d'alimentation.*

Le but de cette expérience est de déterminer lequel des deux critères âge ou poids des animaux est le facteur déterminant de la teneur en 5 α -androsténone du tissu adipeux des porcs mâles entiers. Trois groupes de 50 verrats sont nourris selon un plan d'alimentation libéral (CTRL) ou restreint de 30 % (SW et SA). La teneur en 5 α -androsténone du tissu adipeux est mesurée à trois reprises pour chaque animal, 2 fois sur une biopsie puis à l'abattage, soit au même poids (SW) soit au même âge (SA) que les porcs témoins (CTRL).

Les verrats SW (âgés de 169 jours) présentent des teneurs en 5 α -androsténone plus élevées que celles des CTRL (âgés de 139 jours) au moment de la première biopsie, à 80 kg de poids vif (1,2 contre 0,8 $\mu\text{g/g}$; $P < 0,05$). Au moment de la deuxième biopsie (100 kg de poids vif) ou à l'abattage (125 kg), il n'y a aucune différence significative entre les groupes SW et CTRL, bien que les porcs SW soit plus âgés que les CTRL de 43 à 55 jours. Au trois moments de mesure, la teneur en 5 α -androsténone est plus faible dans le groupe SA que dans le groupe CTRL où les verrats sont plus lourds de 21 à 36 kg (0,5 contre 0,8 $\mu\text{g/g}$ à 139 jours ; 0,9 contre 1,3 $\mu\text{g/g}$ à 160 jours ; 1,2 contre 2,0 $\mu\text{g/g}$ à 185 jours ; $P < 0,001$).

Les coefficients de corrélation partielle entre la teneur en 5 α -androsténone et l'âge sont significatifs au moment de la première biopsie alors que les corrélations partielles avec le poids vif sont significatives aux trois temps de mesure. Chez les verrats SA (pesant 90 kg) il existe une corrélation significative entre la teneur en 5 α -androsténone et l'ensemble des critères de développement de l'appareil génital. Chez les verrats SW et CTRL (pesant 125 kg) la teneur en 5 α -androsténone est significativement corrélée avec le développement des glandes annexes mais pas avec le poids des testicules ou des épидидymes.

En conclusion, chez les verrats jeunes et légers, les deux critères âge et poids ont une influence significative sur la teneur en 5 α -androsténone. Dans le cas des porcs plus lourds et plus âgés l'âge n'a plus aucun effet propre alors que le poids vif conserve une influence significative sur les concentrations en 5 α -androsténone. Chez des verrats aux alentours de 90 kg de poids vif, la teneur en 5 α -androsténone du tissu adipeux dépend du degré de maturité sexuelle des animaux. Par contre, lorsque les animaux ont atteint leur pleine maturité sexuelle, vers 125 kg de poids vif, les concentrations en 5 α -androsténone dépendent des potentialités individuelles de production de stéroïdes, qui sont probablement sous contrôle génétique.

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