Relationship between serum alkaline phosphatase genetic polymorphism and activity of the enzyme in Large White pigs

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Summary

In a population of 1,165 Large White pigs, three different serum alkaline phosphatase (Akp) types (AB 6.78 p. 100, BB 83.60 p. 100 and BC 9.62 p. 100) were found. The Akp activity of the AB type was significantly (P < 0.01) higher in comparison to the BB and BC types and the BB type had lower activity than the BC type (P < 0.05). The Zn level of the AB type was higher than those of BB and BC types (P < 0.05). The correlation between activity of Akp and Zn level in serum was highly significant (+ 0.535). The Ca level of the BC type was higher than those of the BB (P < 0.05) and AB (P < 0.01) types. On the basis of these results it is concluded that serum Akp activity and Zn and Ca levels are genetically controlled through the Akp genotype.

I. - Introduction

Alkaline phosphatase (EC 3.1.3.1.) is the enzyme which catalyses the hydrolysis of orthophosphoric monoesters. The basic reaction of alkaline phosphatase (Akp) is as follows:

\[ \text{R} - \text{O} - \text{PO}_4\text{H}_2 + \text{H}_2\text{O} \rightarrow \text{R} - \text{OH} + \text{H}_3\text{PO}_4 \]

The activating ions are Zn\(^{2+}\), Mg\(^{2+}\) and Ca\(^{2+}\) (COMAR & BRONNE, 1961; STANKIEWICZ, 1978).

DINKLAGE (1968) described polymorphism of serum Akp in pigs of German Improved Landrace and Gottingen Miniature breeds. Akp is controlled by five alleles Akp\(^A\), Akp\(^B\), Akp\(^C\), Akp\(^D\) and Akp\(^E\). Akp heterogeneity has been also analyzed by Saison (1968), Zagulska (1976) and Kierek-Jaszczuk et al. (1978).

RASMUSEN (1963) reported no variation in the sera of pigs of the Duroc, Landrace and Yorkshire breeds. Other workers have also failed to find polymorphism in pig sera (BAKER, 1967; WIDDOWSON, 1967).

The aim of our investigations was to determine the serum Akp polymorphism in Large White pigs as well as its relationship with Akp activity and mineral levels.
Material and methods

Serum samples from 1,165 animals were tested. Fractions of blood serum Akp were determined by the method of starch gel electrophoresis according to Smithies (1955) in the buffer system of Gahne (1963).

The relationship between types and activity of Akp was carried out on 288 pigs. The Large White pigs were taken from one farm and included 288 daughters and sons of 11 boars and 42 sows. Blood samples were taken from the anterior vena cava one time at the age of 5 months.

Activity of Akp was measured by the Alkaline Phosphatase-Test (Fermognost, East Germany). This method is based on the method described by Bessey et al. (1946). Levels of mineral (Zn, Ca, Mg) in the serum were assayed by the atomic absorption spectrophotometry (SP 1900, Pye Unicam).

The results were statistically analyzed by the analysis of variance (F-test) and correlation coefficients.

II. - Results

In the population of 1,165 head of pigs studied three different Akp types AB, BB and BC were observed as shown in table 1. The frequency of BB type was very high (83.60 p. 100) and the Akp AB and BC types occurred at a lower frequencies of 6.78 and 9.62 p. 100, respectively. In the present study the inheritance type of Akp was not analyzed. Comparison of the observed and the expected distribution of Akp phenotypes in the population studied shows that the population deviates significantly from equilibrium (P < 0.05, table 1).

| Genotypes | Observed | Expected | Chi² (3 d.f.) |
|------------|----------|----------|--------------|
|            | No.      | %        |              |              |
| AB ....... | 79       | 6.8      | 72.7         |              |
| BB ....... | 974      | 83.6     | 981.8        |              |
| BC ....... | 112      | 9.6      | 102.7        |              |
| AA ....... | 0        | 0        | 1.3          |              |
| CC ....... | 0        | 0        | 2.7          |              |
| AC ....... | 0        | 0        | 3.8          |              |

Gene frequencies: A = 0.034, B = 0.918, C = 0.048 (fréquences géniques).

* Significant at 0.05 level (significatif au seuil de 5 p. 100).
### Table 2

Relationship between Akp genotype and Akp activity and Zn, Ca, Mg levels.

Relation entre le génotype Akp et l'activité Akp, et les niveaux de Zn, Ca, Mg.

| Akp genotype | AB n = 18 | BB n = 252 | BC n = 18 | F
|--------------|-----------|------------|-----------|---
|              | $\bar{x}$ | $s$ | $\bar{x}$ | $s$ | $\bar{x}$ | $s$ |     |
| Akp activity (U/1) . | 59.11 | 11.40 | 46.92 | 13.51 | 57.00 | 12.81 | 5.36** | AB > BB**, AB > BC*, BC > BB** |
| Zn μg/100 ml . . . . | 214.00 | 27.27 | 168.68 | 38.53 | 180.00 | 40.78 | 4.50* | AB > BB, BC* |
| Mg mg/100 ml . . . . | 2.20 | 0.25 | 2.12 | 0.24 | 2.23 | 0.02 | 1.01 NS |
| Ca mg/100 ml . . . . | 9.50 | 1.00 | 9.70 | 0.83 | 10.62 | 0.72 | 8.89** | BC > AB**, BC > BB* |

The correlation coefficient between Akp activity and Zn level = + 0.535 ** (corrélation Akp - Zn);
Akp activity and Ca level = + 0.108 NS (corrélation Akp - Ca);
Akp activity and Mg level = + 0.195 NS (corrélation Akp - Mg).

NS : Not significant (non significatif).
* : Significant at 0.05 level (significatif au seuil de 5 p. 100).
** : Significant at 0.01 level (significatif au seuil de 1 p. 100).
$\bar{x}$ : Mean (moyenne).
s : Within genotype standard deviation (écart-type intra-génotype).
The distribution of the levels of activity for types is shown in table 2. The *Akp* activity of the AB type was significantly (*P* < 0.01 and *P* < 0.05) higher in comparison to the *Akp* BB and BC types. *Akp* BC animals had higher (*P* < 0.05) activity than *Akp* BB animals.

As seen in table 2, there was a significant association of *Akp* activity with the Zn level in serum of pigs. The Zn level of AB type was higher than those of BB and BC types (*P* < 0.05). The Zn level between BB and BC types was not significant (*P* > 0.05). The correlation coefficient between activity of *Akp* and Zn level was high (+0.535) and highly significant (*P* < 0.01) (table 2).

The calculated level of the Ca of *Large White* pigs varied between 9.50 and 10.62 mg/100 ml of serum. There seems to be a relationship between the level of Ca and *Akp* types of pigs. The results pertaining to this relationship are presented in table 2. The Ca level of the BC type was very high. The differences obtained between the Ca level of types BC and types AB and BB are highly significant and significant (*P* < 0.01 and *P* < 0.05). The difference between AB and BB types was not significant (*P* > 0.05). The correlation coefficient between activity of *Akp* and Ca level (+0.105) was not significant (table 2).

Relationship between types of *Akp* and Mg level was not significant (*P* > 0.05) neither the correlation coefficient between *Akp* activity and Mg level (table 2).

### III. - Discussion

The A and C fractions of *Akp* occur in association with the B fraction. Therefore in the population studied the AA, CC and AC types did not occur. In the present study the inheritance type of *Akp* was not analyzed.

The genetic control of pig serum *Akp* was reported by KIEREK-JASZCZUK *et al.* (1979). They stated that it was controlled by three alleles (*Akpa*, *Akpb* and *Akpc*) in Zlotnicka Pstra breed.

In the study presented here, significant relationships were found between types and activity of *Akp* as well as Zn and Ca levels. On the basis of this work it is concluded that *Akp* activity as well as level of Zn and Ca in serum are genetically controlled through the *Akp* genotype. However, the variances explained by this locus, for the four quantitative traits considered in table 2, represent rather small fractions (around 10 p. 100) of the within-genotype variances.

It may be legitimate to suggest that the activity of *Akp* is connected with growth and development (AGERGAARD, 1976) or natural resistance to disease of pigs (PRZYTULSKI & PORZECZKOWSKA, 1980).

Similar results for the association between types and *Akp* activity were obtained by GAHNE (1967), WALAWSKI *et al.* (1977), AGERGAARD & KATHOLM (1977), KATHOLM (1978) for cattle serum *Akp* and by WILCOX (1966), TAMAKI *et al.* (1975) and TAMAKI *et al.* (1976) for chicken.

In the population studied the pigs of the BC type had higher level of Ca in serum than those of the BB and AB types. This indicates a unique function of the *Akp* C
fraction in metabolism of Ca compared to the other fractions. Interactions of Ca, P, Zn and Akp in the chick have been analyzed by Me CUAIG & MOTZOK (1974, 1974 a) and they found that the duodenal Akp may regulate the metabolism of Ca and Zn via effects on the movements of inorganic phosphate.

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Résumé

Relation entre le polymorphisme génétique pour la phosphatase alcaline sérique et l'activité de cette enzyme chez des porcs Large White

Dans le sérum de 1 165 porcs Large White trois types de phosphatase alcaline (Akp) ont été trouvés : AB 6,78 p. 100, BB 83,60 p. 100 et BC 9,62 p. 100. L'activité Akp du type AB est significativement (P < 0,01) supérieure à celles des types BB et BC et le type BB a une activité inférieure à celle du type BC (P < 0,05). Le niveau de Zn du type AB est supérieur à ceux des types BB et BC (P < 0,05). La corrélation entre l'activité Akp et le niveau de Zn dans le sérum (+ 0,535) est hautement significative. Le niveau de Ca du type BC est supérieur à ceux du type BB (P < 0,05) et du type AB (P < 0,01). Sur la base de ces résultats il est conclu que l'activité Akp et les niveaux de Zn et de Ca sont génétiquement contrôlés par le génotype pour Akp.

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