Ann. Génét. Sél. anim., 1982, **14** (1), 43-48

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

T. PRZYTULSKI, M. KOĆWIN-PODSIADLY and A. KLEMKE

Institute of Animal Breeding and Technology of Animal Production, Academy of Agriculture, 71-460 Szczecin, Judyma 6 Poland

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 :

$$R — O — PO_3H_2 + H_2O \rightarrow R — OH + H_3PO_4$$

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 *Göttingen 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 occured 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).

TABLE 1

Frequencies of serum Akp genotypes and alleles.

Fréquences des génotypes et des allèles Akp.

	Genotypes	Observed		Expected	Chi² (3 d.f.)
		No.	%		
N = 1 165	AB	79	6.8	72.7	9.24*
	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						F	Differences
	AB n = 18		BB n = 252		BC n = 18			
	$\bar{x}$	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 (Akp^A, Akp^B and Akp^C) 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 Mc 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.

Received for publication in January 1982.

Acknowledgments

We would like to thank Dr L. OLLIVIER *(Station de Génétique quantitative et appliquée, I.N.R.A., Centre national de Recherches zootechniques, France)* for valuable discussion, and the constructive criticism of this manuscript.

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*.

References

AGERGAARD N., 1976. Plasma alkaline phosphatase activity and growth in pigs. *Å rsberetn. Inst. Sterilitetsforsk.*, **19**, 40-50.

AGERGAARD N., KATHOLM J., 1977. The activity and the isoenzymes composition of plasma alkaline phosphatase as indicator of weight gain in calves. *Å rsberetn. Inst. Sterilitetsforsk.*, **20**, 115-129.

BAKER L., 1967. After SAISON, 1968.

BASSEY O.A., LOWRY O.H., BROCK M., 1946. After instruction of Alkaline Phosphatase Test. *J. biol. Chem.*, **164**, 321.

COMAR C.L., BRONNER F., 1961. Mineral metabolism. An advanced treatise. *Acad. Press*, New York and London.

DINKLAGE H., 1968. The alkaline phosphatase in the pig. XIth Europ. Conf. Anim. Blood Grps Biochem. Polymorph., Warsaw, 329-330.

GAHNE B., 1963. Genetic variation of phosphatase in cattle. *Nature*, **199**, 305-306.

GAHNE B., 1967. Inherited high phosphatase activity in cattle serum. *Hereditas*, **57**, 83-99.

KATHOLM J., 1978. Plasma alkaline phosphatase isoenzymes in cattle. *Årsberetn. Inst. Sterilitetsforsk.*, **21**, 17-30.

KIEREK-JASZCZUK D., ZURKOWSKI M., SKLADANOWSKA-KRZYZANOWSKA E., TOMASZEWSKA-GUSZKIEWICZ K., 1978. The genetic polymorphism of blood serum alkaline phosphatase of pigs. XVIth Inter. Conf. Anim. blood Grps Biochem. Polymorph., Leningrad.

KIEREK-JASZCZUK D., ZURKOWSKI M., SKLADANOWSKA-KRZYZANOWSKA E., TOMASZEWSKA-GUSZKIEWICZ K., 1979. Serum alkaline phosphatase in pigs. *Anim. Blood Grps Biochem. Genet.*, **10**, 15-18.

MCCUAIG L.W., MOTZOK I., 1974. Interactions of Ca, P, Zn and alkaline phosphatase in the chick. II - Effect of dietary Ca level. *Can. J. Physiol. Pharmacol.*, **52**, 90-95.

MCCUAIG L.W., MATZOK I., 1974 a. Interactions of Ca, P, Zn and alkaline phosphatase, NaCl and theophylline. *Comp. Biochem. Physiol.*, **48**, 663-674.

PRZYTULSKI T., PORZECZKOWSKA D., 1980. Genetic markers of resistance to leptospirosis in pigs of *Large White* Polish breed. *Acta Vet., Brno*, **49**, 237-244.

RASMUSEN B.A., 1965. *Genetics*, **51**, 767. After SAISON, 1968.

SAISON R., 1968. Serum and red enzyme systems in pigs. XIth Europ. Conf. Anim. Blood Grps Biochem. Polymorph., Warsaw, 321-328.

SMITHIES O., 1955. Zone electrophoresis in starch gel : group variation in the serum of normal human adults. *Biochem. J.*, **61**, 629-641.

STANKIEWICZ A., 1978. Zinc-containing enzymes (in polish). *Post. Biochem.*, **24**, 461-479.

TAMAKI Y., WATANABE S., YAMADA Y., 1975. The genetic role of isozyme types in plasma alkaline phosphatase activity in the young chicken. *Anim. Blood Grps Biochem. Genet.*, **6**, 185-193.

TAMAKI Y., ABE T., WATANABE S., 1976. The contribution of isozymes to alkaline phosphatase activity in chicken plasma. *Anim. Blood Grps Biochem. Genet.*, **7**, 225-230.

WALAWSKI K., KACZMARCZYK E., KOLMAN G., GLOGOWSKA B., 1977. Relationship between polymorphism and alkaline phosphatase activity in cattle. *Genet. pol.*, **18**, 261-265.

WIDDOWSON R.W., 1967. After SAISON, 1968.

WILCOX F.H., 1966. A recessively inherited electrophoretic variant of alkaline phosphatase in chicken serum. *Genetics*, **53**, 799-805.

ZAGULSKA A., 1976. Electrophoteric polymorphism of alkaline phosphatase in pigs of the *Zlotnicka Pstra* breed. VIth Meet. Pol. Genet. Assoc. (in polish).