

On a possibility of predicting porcine meat quality from blood biochemical tests

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Summary

Two experimental groups of Polish Large White pigs were tested : the animals of the first group (I) consisting of 56 pigs (29 gilts and 27 hogs) were slaughtered when weighing 101 kg, and those in the other (II) group (58 gilts) were slaughtered when weighing 87 kg. Chemical analyses involving determinations of alanine aminotransferase (ALAT) and asparagine aminotransferase (AspAT) activities as well as P-RNA^{10°} (P-RNA - phosphorus of RNA) leuco- and lymphocytes were carried out in the 4-, 6-, and 7-month-old pigs of group I, and in the 4- and 6-month-old ones of group II. Blood serum Cu and Mg contents were determined ad above in group II and in the 4-month-old pigs in group I.

The objective of the work presented was to find a relationship between the blood biochemical parameters studied and porcine meat quality indices for various weights at slaughter (101 and 87 kg).

The following conclusions were drawn :

1. Of the blood biochemical parameters and meat quality indices tested, it is only the meat *rigor mortis* that is significantly influenced by sex, a highly significant difference in favour of hogs being found.

2. From the pig breeder's point of view, the most valuable blood biochemical parameters are : blood serum AspAT, Cu, and Mg, and peripheral blood P-RNA/10° leucocytes, all of them showing a statistically significant correlation with meat quality indices as early as in the 4-month-old pigs.

3. A phenotypic correlation does not suffice to state with certainty that one character in a definite way influences another ; therefore — in order to assess the relationships involved more definitely — it is necessary to have a more abundant study material as well as to calculate genetic correlations between the blood biochemical parameters and meat quality indices.

1. - Introduction

Pig breeding activities are focused mainly on increasing the meat yield, with a due consideration being at the same time given to retaining a good quality of meat produced. However, a decrease in meat quality accompanying the increase in quan-

titative yield indices is being observed by the breeders. An opinion has recently gained a wide acceptance that more fleshy pigs which grow faster and utilise their food more efficiently produce meat of a poorer quality (ENDER & PFEIFFER, 1974; DUNIEC *et al.*, 1975).

Therefore a need arises to look for new, possibly simple methods facilitating an intravital qualitative and quantitative assessment of meat. There is a body of data pointing towards a relation existing between pig fleshiness and meat utility indices on the one hand, and blood biochemical parameters on the other, the examples of the latter being provided by asparaginate and alanine aminotransferase (AspAT) and (ALAT) respectively activities (SUSKOV, 1971), P-RNA content in blood (PETRENKO, 1969), P-RNA content in blood leuco- and lymphocytes (KOĆWIN, 1974).

The work presented was aimed at seeking a connection between certain blood biochemical parameters (AsPAT, ALAT in blood serum P-RNA in leuco- and lymphocytes of blood, Cu and Mg contents in blood) as determined in various age groups and quality indices of porcine meat at various weights.

2. - Material and methods

The materials studied comprised porcine peripheral blood leucocytes, lymphocytes, and serum as well as carcasses.

Two experimental groups of Polish Large White (wbp) pigs were studied. One group (I), consisting of 56 randomly selected individuals (29 gilts and 27 hogs) of uniform age (± 3 days) was supplied by the Experimental Breeding Farm (EBF) at Kolbacz; the animals were slaughtered when weighing 101 ± 5.3 kg.

The other group (II), supplied by the Pig Slaughter Quality Control Station (PSQCS) at Melno, consisted of 58 individuals (all females) slaughtered when weighing 87 kg.

The experimental animals were kept under the same conditions in terms of location and diet (individual feeding):

- group I: from 26.5 to 101 kg body weight;
- group II: from 30 to 87 kg body weight.

Blood samples were taken from the anterior vena cava in the morning (before feeding) at the age of 4, 6 and 7 months, and at 4 and 6 months in groups I and II, respectively.

Chemical analyses involving determinations of enzymatic activities (AspAT and ALAT) in blood serum of P-RNA concentration per 10^9 leucocytes and lymphocytes were performed at age of 4, 6 and 7 months in group I, and at 4 and 6 months in group II, while serum Cu and Mg contents were determined twice (at 4 and 6 mo.) and once (at 4 mo.) in groups II and I, respectively.

All the analyses were made in triplicate.

The AspAT and ALAT activities were determined using the technique by REITMAN & FRANKEL (1956) and expressed in units required by the technique.

Leucocytes were isolated from blood using fractional sedimentation (WALTER, 1970), whereas a steelon gauze column was applied to isolation of lymphocytes (WALTER, 1970); numbers of leucocytes obtained per 1 mm³ were converted to numbers per a blood sample volume taken.

The procedures associated with isolating the P-RNA containing fraction of cell homogenate were performed according to SCHMIDT & TANNHAUSER (1945). Leucocyte and lymphocyte ribonucleic acids were determined spectrophotometrically according to TSANEV & MARKOV (1960). The amount of P-RNA per 10⁹ cells was calculated from the formulae given by these authors as described by WALTER (1970).

Blood serum Cu and Mg contents were determined using absorption spectrophotometry on a Pye Unicam SP 1900 spectrophotometer, following the manufacturer's instructions. The results were expressed in µg/100 ml serum (Cu) and mg p. 100 (Mg).

The following parameters were used for the meat quality assessment after slaughter : pH after 45 min., pH after 24 hours, *rigor mortis* and colour.

pH was measured with a combined electrode in the *longissimus dorsi* muscle.

Ham *rigor mortis* was determined using an rigorometer apparatus, according to VOS and SYBESMA (1971).

The *longissimus dorsi* muscle colour for group I was determined on a Specol spectrophotometer furnished with an Rd/O reflectance attachment at 680 nm, following OCKERMAN & CAHIL (1969). For group II meat colour was measured, 24 hours after slaughter, on a Göfo apparatus.

Statistical significance of differences between sexes with respect to the characters studied, i.e., AspAT and ALAT activities, serum Cu and Mg contents, P-RNA/10⁹ leuco- and lymphocytes in peripheral blood, as well as meat quality indices (pH, *rigor mortis*, and colour) was assessed from the formulae given by MUDRA (1958). Coefficients of correlation between the blood biochemical indices, determined for various ages in each group, and the meat quality ones were calculated according to procedures described by SNEDECOR (1956).

3. - Results and discussion

The group of biochemical parameters under consideration consisted of amino-transferase enzymes in blood serum, ribonucleic acids in peripheral blood leuco- and lymphocytes, all of them participating in protein biosynthesis, and Cu and Mg in blood serum. According to DAVIDSON (1972), Cu does take part in protein biosynthesis, however the mechanism of its activity is being, though, poorly known; on the other hand, Mg in the presence of an appropriate starter and influenced by a polymerase (nucleotidyltransferase) takes an active part in nucleic acids biosynthesis during triphosphate polymerisation to DNA and RNA.

TABLE 1

*Mean values of 87 kg pig meat quality indices
and blood biochemical parameters (group II)*

*Valeurs moyennes des indices pour des porcs de 87 kg
et paramètres biochimiques sanguins (groupe II)*

Item	n	\bar{x}	S
pH after 45 min.	58	6 338	0 391
Meat colour (Göfo)	58	63 655	4 348
AspAT activity :			
— in 4-mo.-old pigs	58	16 224	6 374
— in 6-mo.-old pigs	58	9 328	3 882
AlAT activity :			
— in 4-mo.-old pigs	58	10 310	4 227
— in 6-mo.-old pigs	58	9 569	4 668
P-RNA/10 ⁹ leucocytes :			
— in 4-mo.-old pigs	58	545 983	140 314
— in 6-mo.-old pigs	58	447 379	101 126
P-RNA/10 ⁹ lymphocytes :			
— in 4-mo.-old pigs	58	622 966	203 402
— in 6-mo.-old pigs	58	487 754	160 562
Cu ($\mu\text{g}/100$ ml) :			
— in 4-mo.-old pigs	58	223 386	40 118
— in 6-mo.-old pigs	58	238 105	46 605
Mg (mg %) :			
— in 4-mo.-old pigs	58	2 989	0 451
— in 6-mo.-old pigs	58	2 782	0 388

n : Number of individuals tested.

\bar{x} : Arithmetic mean.

S : Standard deviation.

TABLE 2

*Mean values of 101 kg pig meat quality indices
and blood biochemical parameters (group I)*

*Valeurs moyennes des indices pour des porcs de 101 kg
et paramètres biochimiques sanguins (groupe I)*

Item	n	\bar{x}	S
pH after 45 min.	56	6 795	0 167
pH after 24 hrs	56	5 700	0 265
Meat texture	56	7 482	2 288
Meat colour	56	16 277	1 841
AspAT activity :			
— in 4-mo.-old pigs	53	8 075	3 050
— in 6-mo.-old pigs	55	57 266	23 698
— in 7-mo.-old pigs	56	56 143	26 410
AlAT activity :			
— in 4-mo.-old pigs	53	12 113	3 412
— in 6-mo.-old pigs	55	18 127	5 703
— in 7-mo.-old pigs	56	14 054	6 887
P-RNA/10 ⁹ leucocytes :			
— in 4-mo.-old pigs	54	389 778	137 308
— in 6-mo.-old pigs	56	486 143	105 715
— in 7-mo.-old pigs	56	454 929	109 756
P-RNA/10 ⁹ lymphocytes :			
— in 4-mo.-old pigs	56	658 411	240 365
— in 6-mo.-old pigs	56	515 589	147 227
— in 7-mo.-old pigs	56	520 268	139 943
Cu ($\mu\text{g}/100 \text{ ml}$) :			
— in 4-mo.-old pigs	55	232 127	46 471
Mg (mg %) :			
— in 4-mo.-old pigs	55	2 386	0 198

n : Number of individuals tested.

\bar{x} : Arithmetic mean.

S : Standard deviation.

The relatively high variability shown by the aminotransferases studied (tables 1 and 2) was also observed by SUSKOV (1971) who found high variabilities of serum AspAT and ALAT in pigs of 40-100 kg body weight, and by DEREVINSKIJ (1970) who - when analysing activities of these enzymes in blood serum of various pig breeds showed a high breed-dependent variability in both ALAT and AspAT activities. A high (exceeding 30 p. 100) variability of this parameter was observed in other domestic animals as well : poultry (KOLATAJ, 1966) and cattle (GUSZKIEWICZ, 1972). The case of coefficients of variation calculated for the peripheral blood leuco- and lymphocytes P-RNA contents in various age groups (tables 1 and 2) is slight different. Against the background of the literature data this parameter exhibits a relatively low variability (21.7-36.5 p. 100). At the same time, a marked decline in the coefficients of variation for the above indices is observed with age of the experimental animals. A decreased variability is observed in the 7-month-old pigs (ribonucleic acid contents in porcine blood leuco- and lymphocytes level off ; KOĆWIN, 1974, 1976). Similar, although slightly higher coefficients of variation were reported by ZIELINSKA (1973) for ribonucleic acids in cattle blood (c.v. of 41.5-44.6 p. 100), GLEN (1967) for ribonucleic acids in human blood (32 p. 100), and KOĆWIN (1974, 1976) for RNA in leuco- and lymphocytes of 4-, 6-, and 8-month-old pigs (about 45 p. 100).

TABLE 3

Levels of significance for differences between mean values of blood biochemical parameters and meat quality indices in males and females of 101 kg pigs

Taux de signification concernant les différences entre les valeurs moyennes des paramètres biochimiques sanguins et les indices de qualité de la viande chez les mâles et les femelles de 101 kg

Item	Age (months)	Sd	d
AspAT activity	4	0.842	0.673
	6	6.420	— 5.241
	7	7.121	2.350
ALAT activity	4	0.941	— 0.846
	6	1.548	— 1.071
	7	1.846	1.606
P-RNA/10 ⁹ leucocytes	4	37.410	36.660
	6	27.603	— 53.078
	7	29.622	1.078
P-RNA/10 ⁹ lymphocytes	4	64.651	39.485
	6	39.650	— 19.174
	7	37.769	2.595
Cu (µg/100 ml)	4	12.511	— 14.493
Mg (mg %)	4	0.052	— 0.093
Meat pH after 45 min.		0.045	0.032
Meat pH after 24 hrs		0.070	0.093
Meat texture		0.515	2.505**
Meat colour		0.488	— 0.699

d : Difference between means (♀ - ♂).

** : Highly significant difference.

Sd : Empirical value calculated according to a formula given by MUDRA, 1958.

The observed spread of the P-RNA content values results presumably from the varying stage of blood cells maturity (DAVIDSON, 1972) and from altered leucocyte types circulating in blood (MURRAY, 1961; HARRIS, 1961).

When determining the level of significance for differences between mean values of the blood biochemical parameters in the 4-, 6-, and 7-month-old pigs, no effect of sex on the indices studied was found (table 3). This finding is corroborated by other papers, both with reference to the blood serum AspAT and ALAT (DEREVINSKIJ, 1970; KOĆWIN & PIECH, 1978) and to the peripheral blood leuco- and lymphocytes P-RNA (KOĆWIN, 1974, 1976).

TABLE 4

*Coefficients of correlation between blood biochemical parameters
and meat quality indices in group I (101 kg pigs)*

*Coefficients de corrélation entre les paramètres biochimiques sanguins et les indices
de qualité de la viande dans le groupe I (porcs de 101 kg)*

Item	n	Age (months)	pH after 45 min.	pH after 24 hrs	Meat rigor mortis	Meat colour
AspAT activity	53	4	0.051	0.275*	-0.278*	-0.283*
	55	6	0.110	-0.019	-0.207	-0.083
	56	7	-0.093	-0.101	0.030	-0.186
ALAT activity	53	4	-0.177	-0.084	-0.244*	-0.085
	55	6	0.090	0.014	-0.086	0.065
	56	7	0.086	0.071	-0.020	-0.093
P-RNA/10 ⁹ leucocytes	54	4	0.175	0.286*	0.142	-0.178
	56	6	0.111	0.064	-0.227	-0.050
	56	7	0.228	0.065	0.122	-0.006
P-RNA/10 ⁹ lymphocytes	56	4	0.114	0.134	-0.141	-0.099
	56	6	0.163	0.181	-0.118	-0.083
	56	7	0.054	-0.074	-0.106	0.029
Cu (µg/100 ml)	55	4	0.007	0.124	-0.069	0.030
Mg (mg %)	55	4	-0.057	-0.060	-0.079	0.084

n : Number of individuals.

* : Statistically significant coefficient.

Contrary to the general consensus as to a clear superiority of gilts when the quantity characters of meat produced are concerned, there are various opinions with respect to an effect of sex on meat quality. Some papers show no such effect to exist (MCGLOUGHLIN & MCGLOUGHLIN, 1975), while other authors reveal clearly-marked, statistically significant differences documented for pH and colour of meat of gilts and hogs, in favour of the latter (DUNIEC *et al.*, 1975).

The present studies failed to reveal any effect of sex upon pH and colour of meat. On the other hand, highly significant differences were found between ham meat *rigor mortis* of gilts and hogs (table 3), the hogs examined showing more favourable values of this parameter.

The analyses of the interrelationship between the blood biochemical characteristics and meat quality indices (tables 4 and 5) showed the serum AspAT and ALAT activities as well as P-RNA/10⁹ leucocytes, determined in the 4-mo.-old to be significantly correlated with pH after 24 hours, meat colour, and ham *rigor mortis* for those animals reaching 101 kg when slaughtered (group I). The values of correlation coefficients obtained, positive for the correlation with pH and negative for those with meat colour and *rigor mortis*, were relatively low.

TABLE 5

Coefficients of correlation between blood biochemical parameters and meat pH colour in group II (87 kg pigs)

Coefficients de corrélation entre les paramètres biochimiques sanguins, le pH et la couleur de la viande dans le groupe II (porcs de 87 kg)

Item	n	Age (months)	pH after 45 min.	Meat colour
AspAT activity	58	4	0.015	— 0.028
	58	6	— 0.023	0.115
ALAT activity	58	4	— 0.181	— 0.183
	58	6	— 0.095	0.043
P-RNA/10 ⁹ leucocytes	58	4	0.086	— 0.133
	58	6	0.304*	0.177
P-RNA/10 ⁹ lymphocytes	58	4	0.074	— 0.051
	58	6	0.194	0.250*
Cu (µg/100 ml)	58	4	0.240*	0.102
	58	6	0.178	0.102
Mg (mg %)	58	4	0.180	0.330*
	58	6	— 0.079	— 0.155

n : Number of individuals.

* : Statistically significant coefficient.

Of the blood biochemical parameters discussed, the AspAT activity proved most valuable as an index interrelated with all the quality indices tested. The ALAT activity, when assessed in the 4-mo.-old pigs, was found to be significantly correlated with ham *rigor mortis* only ($r = -0.244$, $p > 0.05$) while the P-RNA/10⁹ leucocytes showed a significant correlation with the *longissimus dorsi* muscle pH ($r = +0.286$, $p > 0.05$).

The correlation coefficients obtained imply an increase in meat pH, colour intensity, and improvement of *rigor mortis* to accompany any increase in the blood biochemical parameters studied.

The PSQCS batch of animals showed statistically significant positive correlations between P-RNA in leuco- and lymphocytes and pH after 45 min, and meat colour in the 6-mo.-olds, as well as between the Cu and Mg contents and meat pH and colour in the 4-mo.-olds (Table 5).

The trends exhibited by the relationships between the biochemical and meat quality indices differed in the two groups of animals examined, which might have perhaps resulted from different conditions of living and slaughter and from different weights at slaughter (JANICKI, 1970).

Another question is the effect of various breeding stations providing animals for the studies on meat quality indices. As opposed to the EBF pigs, the PSQCS animals were bred in pigsties situated within the area covered by controlling activities of the Station.

So far there have been a few papers only dealing with the problem of possible relationships between the physiological characters discussed and what here thus precluding a more extensive comparison of the present results with those reported by other authors.

Owing to that reason, the comparison must be restricted only to the results of attempts to interrelate some enzyme activities and macroelements contents in blood serum and meat quality indices, mainly the after-slaughter pH.

In their paper concerning relations between the contents of K, Na, Ca, and Mg, and the CPK and GOT activities in blood serum, and meat utility and pH, SIDOR & KOVAC (1972) presented statistically significant correlations between the parameters they compared.

The significant correlations obtained in the present work may indicate towards a relevant question of improving porcine meat quality without decreasing an optimal meat yield. It seems, however, that a more detailed assessment of the correlations considered (based on a more ample material and genetical relationships) would provide a more definite answer to the problem. A phenotypic relationship is not enough to claim a defined effect of one character upon another; the correlation coefficients obtained in this study are thus representative only of the population for which they have been evaluated.

4. - Conclusions

The following conclusions can be drawn from the results presented :

1. Highly significant differences with respect to hind ham *rigor mortis* were found between pig sexes in favour of hogs.

2. No effect of sex on the blood biochemical parameters (AspAT and ALAT activities, P-RNA/10⁹ leuco- and lymphocytes, Cu and Mg contents in blood serum) and meat pH and colour was found.

3. Significant coefficients of correlation were found to exist in the 101 kg pigs between the AspAT and ALAT activities, P-RNA/ 10^9 leucocytes, as determined in the 4-mo.-old pigs and pH 24 hrs after slaughter, *rigor mortis*, and colour of meat. The correlation coefficients obtained imply an increase in meat pH, colour intensity, and improvement of *rigor mortis* to accompany any increase in the blood biochemical parameters studied.

4. The P-RNA/ 10^9 leuco- and lymphocytes determined in the 6-mo.-old pigs are significantly correlated with pH after 45 min. ($r = + 0.304^x$) and with meat colour ($r = + 0.250^x$).

5. Significant coefficients of correlation were found to exist in the 87 kg pigs between the serum Cu content in the 4-mo.-old animals and meat pH ($r = + 0.240^x$), and between the serum Mg content and meat colour ($r = 0.330^x$).

6. A phenotypic correlation is not sufficient to conclude on a defined effect of one character upon another; therefore, a more detailed assessment of those correlations calls for a more abundant study material and an investigation into genetic relationships between the blood biochemical parameters studied and meat quality indices.

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Résumé

Indices biochimiques sanguins et caractéristiques de la qualité de la viande de porc

Cette étude a porté sur deux groupes expérimentaux de porcs de race *Large White Polonais* : un premier groupe de 56 animaux (29 truies et 27 mâles castrés) abattus au poids vif de 101 kg, un deuxième groupe composé de 58 truies abattues au poids de 87 kg. L'estimation des activités alanine aminotransférase (ALAT) et asparagine aminotransférase (AspAT) dans le sérum sanguin, et du taux de phosphore du RNA (P.RNA) dans les leucocytes était effectuée à trois reprises, aux âges de 4, 6 et 7 mois, dans le premier groupe, et à deux reprises aux âges de 4 et 6 mois, dans le deuxième groupe.

Le cuivre et le magnésium dans le sérum sanguin ont été déterminés aux âges de 4 mois dans le premier groupe, et 4 et 6 mois dans le deuxième groupe.

Le but de ce travail était de rechercher un rapport entre des caractères biochimiques du sang à différents âges et des caractéristiques de qualité de la viande de Porcs abattus à deux poids différents (87 et 101 kg).

Les résultats obtenus permettent de tirer les conclusions suivantes :

1) la seule différence sexuelle observée portait sur l'état de *rigor* du jambon, avec un avantage en faveur des porcs mâles castrés ;

2) les caractères sanguins qui se sont révélés les plus intéressants sont l'activité AspAT et les taux de Cu et Mg dans le sérum, et le taux de P.RNA dans les leucocytes, qui dès l'âge de 4 mois montrent des relations significatives avec les caractéristiques de qualité de la viande ;

3) une relation phénotypique n'autorise pas à affirmer qu'un caractère en influence un autre d'une façon définie. Des études sur un matériel animal plus important et le calcul des corrélations génétiques entre les indices biochimiques sanguins et les caractères de qualité de la viande sont donc nécessaires pour établir de façon plus certaine les relations rapportées ici.

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