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The Activity of Aldolase, Aspartate Aminotransferase and the Level of Glucose in the Blood Plasma of Chickens of Various Breeds and Crossbreds

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Summary. Studies on the activity of aldolase, aspartate aminotransferase and on the level of glucose in the blood serum of chickens from various breeds and crossbreds have shown that:

, 1. Breed and sex had a significant influence on the level of glucose and the activity of aldolase and aspartate aminotransferase.

2. The highest level of glucose was observed in both sexes of White Rock chickens; the lowest in Greenleg hens and Leghorn cocks.

3. The highest activity of aldolase was observed in White Rock cocks and Plymouth Rock hens; the lowest in Greenleg hens and Leghorn cocks.

4. The highest activity of aspartate aminotransferase was observed in White Rock chickens; the lowest in Leghorns.

5. As regards the traits investigated, crossbreds, in comparison to the parental breeds, were characterised in a majority of cases by values intermediate or only slightly different. Cases of homosis and heterosis in the level of the physiological indicators examined were also observed.

Key words: Chicken-serum enzymes – Serum glucose-Crossbreds-Physiological Heterosis

Introduction

Examining mechanisms of heredity of physiological traits in domestic animals is an interesting field of investigation in contemporary genetics. Obtaining an adequate set of information in this field would render it possible to introduce physiological selection tests, and thus would improve the results of breeding work and enable us to elucidate the occurrence of heterosis.

The productivity and vitality of animals are conditioned, to a considerable degree, by genetical factors which control the metabolic direction and rates at the level of the cell. Adequate sets of genes determine, under specified conditions, the processes of physiological regulation and initiate the metabolic pathways determined genetically in organisms. As a result there appears the possibility of significant differences occurring in the metabolic rate and in the level of active substances in various breeds and types.

It is assumed that enzymes count among such systems and are, to a considerable degree, dependent on genetical factors.

The present work aims at observing the activity of chosen enzymes in various breeds and crossbreeds of chickens.

As is clear from the literature, the metabolic processes are much more intensive in the organisms of young, growing animals (Guszkiewicz 1974; Steć 1974; Władymirow 1972). One can expect, therefore, that the physiological observations conducted on such animals will yield clearer results.

Material and methods

The observations were conducted in Spring, on 3-months old Leghorn (Lg), Greenleg (Gl), White Rock (WR) and Plymouth Rock (Pt) chickens, on two-directional crossbreds of the Leghorn and Greenleg, Leghorn and Plymouth Rock, Greenleg and White Rock chickens and on the ♂ Plymouth Rock × ♀ White Rock crossbreds. The chickens came from the Michrów Experimental Farm belonging to the Polish Academy of Sciences, Institute of Genetics and Animal Breeding, and were maintained in normal chicken-houses with adequate ventilation and lighting. There were 12 chickens to 1 m^2; the temperature oscillating around 18°C.

The chickens were fed according to the standards accepted for their age and utility types.

In the period preceeding, as well as during the experiment itself, no infectious illnesses were observed on the farm.

A total of 481 birds were examined in experimental groups (presented in Table 1).

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After 12 hours of fasting, (over-night), the chickens were weighed and blood was drawn from the wing vein into a syringe containing heparine. Directly afterwards, the blood was centrifuged 20 minutes at 3500 revol./min and the samples of plasma were frozen at a temperature of – 30°C. The analyses were completed 10 days later after the samples had been thawed at room temperature. The following determinations were conducted: activity of aldolase (4.1.2.13), activity of aspartate aminotransferase (2.6.1.1) and the level of glucose.

The activity of aldolase was determined according to the method by Sibley and Lehinger, as modified by Bruns and Puls (Krawczyński and Osiński 1967).

The activity of aspartate aminotransferase was determined according to the method by Reitman and Frankel (Krawczyński and Osiński1967).

The results are presented in units specific for the given method. The level of glucose was determined by the orto-toluidyne method and the results presented in mg% (Krawczyński and Osiński 1967). The measurements of the colour extinctions of compounds created were completed on a spectrophotometer 'Specol'.

The results obtained were subjected to a statistical analysis. For each observation, the following analyses of variance were calculated: one-directional (breed); two-directional (breed and sex).

A detailed comparison of the mean values obtained was conducted using the Student's t-test which determined the smallest confirmed differences.

Table 1. Mean values of body weight (grams) ± standard error of the mean

Group of birds		Number	Body weight
Leghorn	♀	36	858.00 ± 19.44
	♂	20	1066.50 ± 32.98
Greenleg	♀	30	840.33 ± 22.22
	♂	25	1019.23 ± 34.89
White Rock	♀	23	1007.21 ± 21.32
	♂	19	1300.52 ± 30.95
Plymouth Rock	♀	8	1070.00 ± 51.51
	♂	4	1435.00 ± 25.13
Lg X Gl	♀	22	927.72 ± 28.64
	♂	19	1053.94 ± 41.03
Gl X Lg	♀	20	902.00 ± 32.76
	♂	17	1052.35 ± 49.44
Lg X Pl	♀	33	921.96 ± 18.70
	♂	17	1216.76 ± 66.78
Pt X Lg	♀	29	939.82 ± 24.87
	♂	30	1111.25 ± 34.17
Pt X WR	♀	29	1088.10 ± 26.08
	♂	33	1369.24 ± 33.90
Gl X WR	♀	35	977.71 ± 31.24
	♂	28	1263.21 ± 35.84
WR X Gl	♂	12	839.16 ± 34.58

Results and Discussion

The results obtained with regards to the traits examined are collected in Table 2.

Glucose

Among the cocks, the highest level of glucose was observed in the White Rock breed (211.18); the lowest in

Table 2. Mean values of aldolase and aspartate aminotransferase activity and level of glucose of examined birds ± standard error of the mean

Group of birds		Number	Glukose mg%	Aldolase I.U.	AspAT Reitman's-Frankel Units
Leghorn	♀	36	188.07 ± 2.58	9.63 ± 0.34	47.37 ± 2.55
	♂	20	184.00 ± 3.52	9.43 ± 0.39	48.65 ± 4.17
Greenleg	♀	30	185.75 ± 3.19	9.29 ± 0.34	51.93 ± 2.62
	♂	25	188.46 ± 4.85	10.17 ± 0.37	53.88 ± 2.80
White Rock	♀	23	202.82 ± 3.43	11.51 ± 0.42	60.82 ± 3.37
	♂	19	211.18 ± 4.36	12.29 ± 0.53	60.73 ± 4.07
Plymouth Rock	♀	8	200.62 ± 7.64	11.74 ± 1.51	53.50 ± 6.77
	♂	4	203.75 ± 8.18	11.74 ± 0.73	50.00 ± 9.19
Lg X Gl	♀	22	191.13 ± 4.58	10.51 ± 0.55	53.59 ± 2.92
	♂	19	194.73 ± 5.12	10.98 ± 0.55	48.63 ± 4.43
Gl X Lg	♀	20	184.75 ± 5.04	9.49 ± 0.54	47.75 ± 2.85
	♂	17	197.20 ± 5.30	10.07 ± 0.62	61.88 ± 5.17
Lg X Pt	♀	33	196.21 ± 2.73	10.46 ± 0.44	57.75 ± 2.70
	♂	17	199.85 ± 3.58	10.12 ± 0.58	47.64 ± 4.31
Pt X Lg	♀	29	192.75 ± 3.12	9.96 ± 0.50	53.27 ± 3.42
	♂	30	194.87 ± 3.30	9.76 ± 0.46	58.30 ± 3.80
Pt X WR	♀	29	211.81 ± 5.76	10.96 ± 0.48	50.34 ± 3.66
	♂	33	195.60 ± 4.72	10.32 ± 0.39	65.15 ± 2.84
Gl X WR	♀	35	204.35 ± 4.32	9.55 ± 0.48	61.00 ± 2.74
	♂	28	201.78 ± 4.84	9.79 ± 0.47	54.03 ± 3.27
WR X Gl	♀	12	198.33 ± 6.51	10.69 ± 0.77	48.16 ± 3.45

the Leghorn breed (184.00). Among the hens also the highest level was observed in the White Rock birds (202.82) but the lowest was now found for the Greenleg breed (185.75). Among the crossbred cocks the highest level of glucose was observed in the Greenleg × White Rock crossbred birds (201.78) while the Plymouth Rock × Leghorn and Leghorn × Greenleg crossbreds demonstrated the lowest values (194.87, 194.73, respectively). The Plymouth Rock × White Rock crossbred hens showed the highest level of glucose (211.81) while the group of Greenleg × Leghorn crossbred hens – the lowest (184.75).

The level of glucose in the Leghorn × Greenleg, Plymouth Rock × White Rock and Greenleg × White Rock corssbred hens exceeded that of the parental breeds while the two-directional crossbreds of the Leghorn and Plymouth Rock and White Rock × Greenleg birds demonstrated a glucose level intermediate between that of the parental breeds.

The two-directional Leghorn and Plymouth Rock and Greenleg × White Rock cocks crossbreds demonstrated a medium level of glucose in relation to the parental groups; the Leghorn and Greenleg crossbred cocks demonstrated a higher level of glucose than the parental breeds. In the Plymouth Rock × White Rock crossbred a lower level than that of the parental breeds was observed.

An analysis of variance confirmed the significance of differences between breeds and crossbreds, and also between sexes. A detailed analysis (Student's t-test) of the mean values demonstrated that Leghorn and Greenleg chickens of both sexes differ from the White Rock breed. In the group of Leghorn and Plymouth Rock crossbreds only the cocks differed with regards to the level of glucose from the Leghorn cocks. The Plymouth Rock × White Rock cocks demonstrated a significant difference only in relation to the White Rock breed. Also, the Greenleg × White Rock crossbreds of both sexes differed from the Greenleg cocks and hens.

Glucose is a metabolite extremely susceptible to the conditions in which the investigated animals are maintained. Arising from Twiest and Smith (1970) and Smith (1972) are observations that the concentration of glucose in the blood of hens kept for 12 hours in darkness decreases. It also changed according to the duration of the light, on changing the light period and on the time of fasting. According to this author, the level of glucose in the blood changes concurrently with the changes in the body temperature: for instance hypothermia can cause decreases of glucose in the blood of up to 40%. Warming the bird to a normal temperature restores the normal level of this carbohydrate. In turn, inducing a fever increases the glucose level by about 10% when compared with the norm.

Hazelwood and Lorenz (1959), examining the results of prolonged fasting of adult birds, observed that the level of glucose first decreased during the 24-36 hours after the beginning of fasting and then increased gradually until it reached a maximum on the 6th day of the experiment. Similar observations were conducted by Nir et al. (1973) on 4-month old chickens and geese; it was ascertained that after two days of fasting, the level of glucose decreased in chickens from 274 to 230 mg% and in geese from 237 to 183 mg%. Despite further fasting, this level increased, reaching the initial values.

The cited works indicate that the level of glucose in the blood is a trait dependent to a considerable degree on environmental conditions and, as it is suggested by Smith (1972), experiments taking these indicators into consideration ought to be conducted under very strictly standardised conditions.

Interesting results were obtained by Kirłow (1968) who observed the glucose level in Cornish and Russian White chickens and in their crossbreds. He showed that the differences between breeds decreased from hatching to the tenth day of life, and that during this period the crossbreds were characterised by lower levels.

According to the investigations conducted by Witmar and Lane (1960), the level of glucose in the blood of chicken embryos in the same stages of development but of different breeds showed significant differences. In an earlier work, Majewska and Kołataj (1973), examining the activity of aldolase and the level of glucose in the blood of 12-month old Leghorns, Greenlegs, Plymouth Rock and White Rock hens, observed a higher level of glucose in Plymouth Rock and White Rock birds and suggested genetical control of this trait. The levels of glucose obtained for White Rock (223.Omg%), Plymouth Rock (198.0 mg%) and Greenleg (178.1 mg%) chickens were similar to those obtained in the present work in which there was observed a lower level of this metabolite in Leghorn and Greenleg birds, i.e., in birds with a lower body weight, and a high level in White Rock birds. The crossbreds, with the one exception of the Plymouth Rock × White Rock cocks, demonstrated values similar to those obtained for the parental breeds. A similar occurrence of a lower concentration of glucose in crossbreds as compared with the parental breeds, was observed by Steć (1974) during investigations on cattle crossbreds. The results of the present investigations seem to suggest the possibility of a genetical control of the level of glucose in the blood principally on the basis of a comparison between the heavy and the light breeds.

Aldolase

The results presented in Table 2 indicate, that the highest activity of this enzyme was observed in White Rock

(12.29) cocks; it was also high in Plymouth Rock (11.74) cocks; in the Leghorn breed it was the lowest (9.43).

Among the hens a high activity of aldolase was recorded for the Plymouth Rock and White Rock breeds, (11.74, 11.51, respectively), while the Greenleg hens demonstrated a low activity of this enzyme (9.29). Among the crossbred cocks the highest activity of the enzyme was observed in the Leghorn × Greenleg (10.98) group; the lowest in the Greenleg × White Rock and the Plymouth Rock × Leghorn groups (9.75 and 9.76, respectively). In the case of crossbred hens the highest activity of aldolase was shown by Plymouth Rock × White Rock (10.96) birds; the lowest by Greenleg × Leghorn birds (9.49). The crossbred hens from the Greenleg × Leghorn groups and from two-directional Leghorn and Plymouth Rock and Greenleg and White Rock crossbreds were characterised by values intermediate between those of the parental breeds. The Leghorn × Greenleg crossbred hens demonstrated higher values of this enzyme than the parental breeds while the Plymouth Rock × White Rock hens demonstrated a lower activity.

Among the cocks, analogically as in the groups of hens, the Leghorn × Greenleg crossbreds demonstrated higher values of aldolase than the parental breeds and the two-directional Leghorn and Plymouth Rock crossbreds showed intermediate values. The Plymouth Rock × White Rock crossbred cocks, as in the hens, demonstrated low values compared to the parental breeds. The same can be said the Greenleg × White Rock crossbred.

The analysis of variance confirmed the significant influence of breed and sex on this trait.

Significant differences in the activity of aldolase were ascertained between both sexes of the Leghorn and White Rock chicken, between the Greenleg and White Rock chicken and also between the Leghorn and Plymouth Rock and Greenleg and Plymouth Rock hens.

Comparing the crossbreds with the chickens of the parental breeds it was ascertained that there existed differences between the Leghorn × Greenleg crossbred cocks and the Leghorn cocks and between the Plymouth Rock × White Rock crossbred cocks and the White Rock cocks. Also, the Greenleg × White Rock crossbred cocks and hens differed significantly from both sexes of White Rock chickens.

The results of comparative studies on the activity of this enzyme in the liver of various groups of vertebrates, conducted by Heinz and Weiner (1969) are interesting. These authors observed the activity of aldolase in fish, amphibians, reptiles, birds and mammals and found that it reaches the highest values in liver homogenates of fish, followed by birds. Among birds, the highest activity of aldolase was observed in pigeons, then ducks and chickens. Also interesting are the observations made by Martin et al. (1966), who determined the activity of chosen enzymes in the brain of the Japanese quail and described its value, when compared to the remaining ones, as medium – 8.61 units. In the work by Majewska and Kołataj (1973), it was ascertained, similar to the present work, that there was a low activity of aldolase in the blood plasma of Leghorn and Greenleg chickens (8.47 and 10.05) and a high activity in the blood of heavy chicken breeds – White Rock (11.27) and Plymouth Rock (12.84). As regards the activity of the investigated enzyme, significant differences occurred between the Leghorn and Greenleg, Plymouth Rocks and White Rocks, and also between the Greenleg and Plymouth Rocks.

The results seem to indicate that the activity of aldolase in the blood plasma of chickens of various breeds is a

Table 3. Influence of breed and sex on the examined traits Test F-Fisher-Snedecor (E-emp)

	Glucose	Aldolase	AspAT
Breed	4.77[a]	4.09[a]	2.24[b]
Sex	95.55[a/b]	184.75[a]	32.38[a]
Breed × Sex	1.44	0.49	2.18[b]

[a] highly significant /p = 0,01/
[b] significant /p = 0,05/

Table 4. Statistically significant differences between examined groups of birds

Examined groups	Glucose		Aldolase		AspAT	
	♂	♀	♂	♀	♂	♀
Lg – Gl						
Lg – WR	x	x	x	x	x	x
Lg – Pt				x		
Gl – WR	x	x	x	x		x
Gl – Pt				x		
Pt – WR						
Lg – Lg × Gl			x			
Lg – Gl × Lg					x	
Gl – Lg × Gl						
Gl – Gl × Lg						
Lg × Gl – Gl × Lg					x	x
Lg – Lg × Pt	x					x
Lg – Pt × Lg						
Pt – Lg × Pt						
Pt – Pt × Lg						
Lg × Pt × Lg						
Pt – Pt × WR						
WR – Pt × WR	x		x			x
Gl - Gl × WR	x	x				x
Gl – WR × Gl						
WR – Gl × WR			x	x		
WR – WR × Gl						x
Gl × WR – WR × Gl						x

x = significant differences (p = 0,05)

characteristic trait. A lower activity of this enzyme, observed in certain groups of crossbreds, was also recorded by Dembowski (1976) and Guszkiewicz (1974) in experiments conducted on rabbits and cattle.

Aspartate Aminotransferase (AspAT)

The highest activity of this enzyme among the pure-bred birds was observed in White Rock chickens of both sexes, (♀ 60.82, ♂ 60.73) and the lowest in Leghorns of both sexes (♀ 47.37 ♂ 48.65). Among the crossbred hens the Greenleg × White Rock group demonstrated the highest enzyme activity (61.00) and the Greenleg × Leghorn group – the lowest (47.75). In turn, among the crossbred cocks the highest activity of this enzyme was demonstrated by the Leghorn × Plymouth Rock birds (47.64). Comparing the crossbred birds with the parental breeds, one can notice a considerable increase in the enzyme activity in the group of Greenleg × Leghorn and Plymouth Rock × Leghorn crossbred cocks. The activity of AspAT in those groups considerably exceeded the activity observed in the parental breeds. In the groups of Leghorn × Greenleg and Leghorn × Plymouth Rock crossbred cocks i.e., an opposite direction of crossbreeding, the activity of AspAT decreased and was almost the same as in the purebred Leghorn cocks. The crossbred hens in the Plymouth Rock × White Rock group demonstrated a lower activity than the parental breeds; the group of Greenleg × White Rock crossbred hens was characterised by a medium value of this trait and one very similar to that observed in the purebred White Rock hens. The opposite direction of crossbreeding gave values below the mean for the parental breeds.

The analysis of variance demonstrated that breed and sex have a significant influence on this trait and also indicated the existence of a breed and sex interaction. Detailed examinations with the t-test testified that significant differences between sexes occurred in the following groups: Greenleg × Leghorn, Greenleg × White Rock, Leghorn × Plymouth Rock. A highly significant difference occurred in the Plymouth Rock × White Rock group.

Using the method of the smallest confirmed difference, it was ascertained that the following experimental groups differed with regards to the activity of the enzyme discussed: Leghorn cocks and hens from the White Rock birds and Greenleg hens from White Rock hens. Among the groups of crossbreds, the Greenleg × Leghorn cocks differed from the Leghorn cocks and the hens and cocks of two-directional crossbreds of the Leghorn and Greenleg breeds. In the group of Leghorn × Plymouth Rock crossbreds only the hens differed from the Leghorn hens. The hens of the Plymouth Rock × White Rock crossbreds differed from the White Rock hens. Also, the differences between the hens of two-directional Greenleg and White Rock crossbreds were confirmed. The results obtained in the present experiment seem to confirm the assumption that the activity of aspartate aminotransferase can be a characteristic of the given breed. This would be in agreement with the conclusions drawn by Chakrabarty and Deb (1968) from investigations conducted on Leghorn, New Hampshire and Rhode Island Red hens which indicated clear differences between breeds in the activity of this enzyme. Władymirow (1972), observing the activity of this enzyme in the liver and breast muscles of meat-type chickens obtained from mating the Biała Ruska, Jubilejnaja and Czerwona Białoogoniasta hens with Sussex and Red Cornish cocks, ascertained a higher, but age-decreasing, activity of AspAT on the crossbreds, as compared with the parental breeds. This was noticeable in all periods of rearing up to 3 months of life. According to this author, the changes in the activity of aminotransferases in the growing tissues and principally in the liver, indicate the existence of a direct connection between the intensity of transamination and the growth rate.

A higher enzyme activity would make it possible to assume that more intensive transamination processes create conditions which render possible an increased synthesis of the organism's protein and, in effect, a greater body weight.

Numerous works concentrate on seeking the biochemical criterions of selection and choice for mating. The introduction of indicators of this type was proposed by Rako (1961) and Williams (1960), among others, but up to now there are few observations from which one could draw unequivocal conclusions.

One of the more interesting studies is the investigation conducted by Doronina and Antipow (1973) on the progeny of Adler Silver hens obtained from mating birds both characterised by a high AspAT activity, from mating hens with a high to cocks with a low AspAT activity or both hens and cocks from mating with a low AspAT activity. It was shown that the progeny of birds with a high activity demonstrated the greatest body weight at 75 days of age, the highest daily weight gains and the highest dressing percentage, with the lowest intake of food per 1 kg of body weight gain.

Opposite traits were demonstrated by the progeny of parents characterised by a low AspAT activity.

Interesting observations were made by Awrutina et al. (1969), who ascertained a lower activity of such enzymes as polypeptydases, aminotransferases, amylaze and lipaze in the Leghorn and White Plymouth Rock crossbred as compared with purebred birds, especially in those cases when the crossbreds grew quicker. In chickens demonstrating a poorer feed conversion, the activity of lipaze and amylaze was higher.

A similar phenomenon, a lower enzyme activity in crossbreds, was observed in the present work. Perhaps one ought to agree with Kołątaj (1973) who considers that the higher biological capability of crossbreds lies in more precise and economic management of the metabolic products already on the level of the cell: the crossbred birds obtain an adequate level of the metabolite with a lower energy expenditure.

It seems that a complex treatment of the problem, a widening of the investigations to other enzymes, observations of the levels of hormones and various specific metabolites, studies of the rate of tissue breathing and connecting those observations with performance traits in various breeds and crossbreds of domestic animals would render it possible to find a wider basis for interpretation of the phenomenon of heterosis in a physiological aspect. The explanation of this phenomenon would be of indisputable importance to breeding practice.

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