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PHENOTYPIC VARIATION OF GLUTATHIONE PEROXIDASE ACTIVITY IN DIFFERENT GENOTYPES OF CHICKEN AND ITS CORRELATION WITH SOME PRODUCTION TRAITS

Ph. D. Thesis

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1. SCIENTIFIC BACKGROUND

Free radicals are produced continuously in animals both in physiological conditions and in pathological processes. Unless the presence of an efficient protective barrier, these reactive oxygen species induce processes, which end up in dysfunctions and cellular damage *(Fang, 2002)*.

Antioxidants play an important role in maintaining the health, productivity and reproductive characteristics of the animals. In general, an integrated antioxidant system has been described in avian tissues *(Surai, 1999a; 2002);* and it has been suggested that the first line of cellular antioxidant defense is based on the activity of three enzymes: superoxide dismutase (SOD), glutathione peroxidase (GSHPx) and catalase. In this respect GSHPx has received only limited attention in relation to poultry production. However, during recent years the importance of this enzyme in the antioxidant protection of tissues has become increasingly appreciated.

Glutathione peroxidases are substantially more efficient on a molar basis than other antioxidant enzymes *(Michiels et al., 1994)*. At least five isoforms of glutathione peroxidases have been reported; therefore it is called more like an enzyme family than a single enzyme. They are present in almost every cell of animals and the different isoforms are different in many properties, including their localization, subunit structure, primary structure and enzymatic nature *(Arthur, 2000)*.

There are several factors abrogating the activity of glutathione peroxidase. Some of these are internal, individual factors, resulting significant difference in the enzyme activity of different organs, different age groups and sex. Endocrine regulation can also control the enzyme activity.

Chick embryo tissues are characterised by high concentration of polyunsaturated fatty acids (*Noble and Cocchi, 1990*) and are very sensitive to lipid peroxidation therefore defence from lipid peroxidation is a crucial task for the embryo. The antioxidant system of the chick embryo consists of a combination of small molecular weight metabolites (*Gaál et al., 1995*) and antioxidant enzymes (*Wilson et al., 1992*). Antioxidant enzymes are the major cell defence against acute oxygen toxicity (*Harris, 1992*), the expression of their activity is regulated in tissue-specific fashion at the gene level. Information concerning antioxidant enzymes in the chick embryos is limited (*Gaál et al., 1995; Surai, 2002*).

A genetic variation in GSHPx activity has been suspected previously in chicken, goose, rabbit, pig, sheep and goat. Genetic influences have previously been described as

important factors in selenium deficiency in chicken; resulting in some strains or individuals being more susceptible to selenium deficiency than others (*LaVronga and Combs, 1982*).

There are some observations about the correlation of GSHPx activity and production traits, body weight, weight gain, growth rate and wool production. Also, there are some investigations concerning to the GSHPx activity as a possible selection criteria in rabbit breeding as slight negative phenotypic correlation was found between carcass traits and enzyme activity of erythrocytes in rabbits (*Virág et al., 1996*).

Several studies have suggested that activity of many enzymes in animal tissues are affected by age and sex. Sex differences may be the result of differences in distribution of selenium in male and female, or by the well-known metabolic differences between the two sexes *(Finley and Kincaid, 1991)*. According to the free radical ageing theory, ageing can be considered as a process of irreversible changes associated with an accumulation or integration of free radicals induced by damages in the cell *(Harman, 1956)*.

The existence of genetic variation in the concentration of GSHPx activity in blood, liver and red blood cell (RBC) of different animals suggests that GSHPx activity is genetically regulated. The study presented in the thesis an attempt was made to assess the relative importance of these factors by comparing GSHPx activity of different chicken breeds and crosses to obtain some information on the possible genetic background of liver homogenate, erythrocyte haemolysate and blood plasma GSHPx enzyme activity in different genotypes of chicken, and its correlation with some production traits, age and sex at standardised conditions, which has not been reported before in detail in chicken.

2. RESEARCH OBJECTIVES

The objectives of the investigation were:

- 1. Measurement of the phenotypic variation of liver GSHPx enzyme activity in chicken embryos in different genotypes during the embrionic development at standardised conditions.
- 2. Measurement of the phenotypic variation of GSHPx enzyme activity of liver, red blood cells and blood plasma in different chicken genotypes and their crosses from day-old age up to the age of highest egg production at standardised conditions.
- **3.** Measurement of the effect of heterosis and reciprocal effect on the GSHPx enzyme activity of liver, red blood cells and blood plasma and on body weight.
- **4.** Measurement of the effect of age and sex on GSHPx enzyme activity of liver, red blood cells and blood plasma during embrionic development and from day-old age up to the age of highest egg production at standardised conditions.
- **5.** Estimate of the correlation among different production traits and GSHPx enzyme activity of liver, red blood cells and blood plasma.

3. MATERIALS AND METHODS

3.1. Animals

The breeds used in these experiments are Hungarian indigenous, Transylvanian Naked Neck, New Hampshire and Plymouth Rock White maintained in the Institute for Small Animal Research, Gödöllő, Hungary.

3. 2. Experimental conditions

Birds were kept under semi-extensive circumstances, which is usual in rearing this type of chickens. All animals were clinically healthy and kept in the same environment and given the same diets. Fertilised eggs were obtained from a commercial hatchery incubated at 37.8 °C and 60 % relative humidity in a forced-draught incubator with automatic egg turning.

3. 3. Experiment 1: Changes of the glutathione peroxidase activity in chicken embryo

Fertilised eggs from eight breeds: Plymouth Rock White (PRW), New Hampshire (NH), Hungarian White (HW), Hungarian Speckled (HS), Naked Neck Plymouth (NNP), Naked Neck New Hampshire (NNNH), Transylvanian Naked Neck White (TNNW), Transylvanian Naked Neck Black (TNNB).

At least 400 samples (10 eggs of each breed) were weighed and embryos were killed at 14th, 16th, 18th and 20th days of incubation. Liver was dissected and immediately frozen

(-20 °C) until analysed. From one day-old chicken blood and liver samples were taken.

3. 4. Experiment 2: Phenotypic variation of GSHPx activity in different breeds of different age groups, from one-day until the age of highest egg production

Blood samples were collected from six breeds: Plymouth Rock White (PRW), Naked Neck Plymouth (NNP), Naked Neck New Hampshire (NNNH), Hungarian Speckled (HS), Transylvanian Naked Neck White (TNNW), Hungarian White (HW).

At least 1080 blood samples (15 males and 15 females of each breed at each age except at day-old sex was not determined) were collected at one day, 4th, 8th and 12th weeks of age, at the age of sexual maturity (SM) laying the first egg of females and at the period of the highest egg production. Liver samples were taken from one-day old chickens only.

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3. 5. Experiment 3: Phenotypic variation in the activity of GSHPx in two chicken breeds and their crosses

In a preliminary experiment some breeds of the same age were tested for GSHPx activity and it was chosen the breed showed the highest enzyme activity (New Hampshire) and the lowest (Transylvanian Naked Neck Black) and made two crosses (New Hampshire sires crossed Transylvanian Naked Neck Black dames) and its reciprocal one (New Hampshire dames crossed Transylvanian Naked Neck Black sires).

At least 600 blood samples (15 males and 15 females of each breed at each age except at day-old, when the sex was not determined) were collected. Blood samples were taken at one-day, 4th, 8th and 12th weeks of age and at the age of sexual maturity (SM) laying the first egg of females, respectively. Liver samples were taken from one-day old chickens only.

3. 6. Production traits

Egg weight (EW) and body weight (BW) were measured in the same time with liver and blood samples. Egg production at the highest egg production period (HEP) was recorded for each genotype.

3. 7. Blood and liver samples

Blood samples were collected into tubes containing EDTA-Na₂ (0.2 mol/l) as anticoagulant. Freshly collected blood samples were centrifuged (15 min 2,500 rpm), plasma was removed and stored frozen (-20 °C) until analysed.

Erythrocytes was washed three times with two-fold volume of physiological saline (0.65 % w/v NaCl) then haemolysed with nine-fold of their volume of redistilled water and by freezing (-20 °C, 24 hours) and thawing (37 °C, 30 min).

Liver samples were homogenised freshly before analyses with nine-fold amount of physiological saline and the 10,000 g supernatant fraction was used for the determination of enzyme activity.

3.8. Biochemical methods

Glutathione peroxidase activity was measured using reduced glutathione and cumene hydroperoxide co-substrates *(Lawrence and Burk, 1976)* and the oxidation of reduced glutathione measured by the method of *Sedlak and Lindsay (1968)*. The enzyme activity was expressed in units reflecting the oxidation of reduced glutathione in nmoles per minute at 25 °C and was related to the protein content.

Protein content of blood plasma and erythrocyte haemolysate were determined using biuret method (*Weichselbaum*, 1946) while of liver homogenate using Folin phenol reagent (*Lowry et al.*, 1951).

Sex determination was made in embryonic from blood samples at 14th, 16th, 18th, 20th days of incubation and in day-old chicks using a RAPD-PCR protocol *(Hidas and Edvi, 2001)*.

3. 9. Statistical analysis

Means and SD of egg weight, body weight, liver, blood plasma and red blood cell GSHPx activity were subjected to analysis using three-ways ANOVA with breed, age and sex as main effects, using the GLM procedure of SPSS program *(SPSS for Windows, 1999)*.

Means and SD of body weight, blood plasma and red blood cell GSHPx activity in Experiment 1. were subjected to analysis using two-ways ANOVA with breed and sex as main effects, using the GLM procedure of SPSS program.

Liver homogenate GSHPx activity was analysed by one-way ANOVA with breed as a main effect using one-way ANOVA of SPSS program.

Means were compared for main effects and their interaction by Duncan's multiple range test *(Duncan, 1955)* when significant F values were obtained (P<0.05).

Heterosis effect was calculated as the difference between the means of crosses and midparents. Reciprocal effect is the difference between the crosses of two parental breeds in which their roles as male or female parents are reversed.

Correlation analyses were performed by using the CORR procedure from SPSS. Spearman correlation coefficients (r_s) were used.

4. **RESULTS**

4. 1. Experiment 1: Changes of the glutathione peroxidase activity in chicken embryo4. 1. 1. Phenotypic variation of GSHPx activity of chicken embryo liver

Regarding the breed effect, significant differences were found among the breeds showing the highest enzyme activity (1.78 U/g protein) in TNNW and the lowest (1.61) in PRW breed. TNNW breed showed the highest liver enzyme activity (1.78) and TNNB the lowest (1.42) for males. TNNB breed showed the highest liver homogenate enzyme activity (1.84) and PRW the lowest (1.59) for females. GSHPx activity was higher in females than in males in all breeds except PRW.

Sex had significant influence on liver GSHPx activity, females having higher enzyme activity (1.76) than males (1.63).

Concerning the effect of age, liver enzyme activity was significantly decreased with age.

Regarding breed and age interaction, there were significant differences in the GSHPx activity of liver among breeds in all age groups. These differences were not consequent in different age groups.

Age and sex interaction showed that females having higher activity than males in all age groups. However these differences were significant at 14th day of incubation only.

Breed, age and sex interaction was statistically significant. The differences between males and females in different age groups have a wide variation among breeds.

4. 1. 2. Phenotypic variation of GSHPx activity of RBC

Concerning breed effect, significant differences were found among the breeds showing the highest enzyme activity (9.69) in NH and the lowest (5.77) in NNNH breed. The same tendency was found in males. For females HW breed showed the highest RBC enzyme activity and NNNH the lowest.

The GSHPx activity were higher in males than in females in NNP, HS, NH and TNNB breeds and higher in females than in males in NNNH, HW, PRW and TNNW breeds.

Sex effect was not significant in the case of RBC GSHPx activity, however females had higher activity than males (8.42 *vs* 8.16).

4. 1. 3. Phenotypic variation of GSHPx activity of blood plasma

Concerning breed effect, significant differences were found among the breeds showing the highest enzyme activity (16.88) in NNP and the lowest (11.15) in PRW breed. The same tendency was found in males. Otherwise NNNH showed the highest blood plasma and PRW had the lowest enzyme activity in females.

Breed and sex interaction showed that males had higher blood plasma enzyme activity than females in NNP, PRW, NH and TNNW breeds, while females showed higher enzyme activity than males in NNNH, HW, HS and TNNB breeds.

Sex had no significant influence on blood plasma GSHPx activity, however, females showed higher activity than males (14.35 *vs* 14.23).

4. 1. 4. Phenotypic correlation between liver, RBC and blood plasma GSHPx activity and egg weight and body weight

Significant positive correlations were found between liver GSHPx activity at dayold with egg weight at 14th (0.71; P \leq 0.05), 18th (0.83; P \leq 0.05) and 20th (0.74; P \leq 0.05) days of incubation and for day-old body weight (0.79; P \leq 0.05). Also, positive correlations were found between red blood cell at day-old with egg weight at each stage of development and for day-old body weight, however these correlations were not significant.

Significant negative correlations were found between GSHPx activity in blood plasma and egg weight at 14th (-0.79; P \leq 0.05), 18th (-0.71; P \leq 0.05) and 20th (-0.71; P \leq 0.05) days of incubation and BW of day-old chicken (-0.67).

4. 1. 5. Phenotypic correlation between liver, RBC and blood plasma GSHPx activity

Significant negative correlation was found between liver enzyme activity at 14th day of incubation with liver (-0.76; P \leq 0.01) and RBC (-0.52; P \leq 0.05) enzyme activity day-old chicken and body weight (-0.33; P \leq 0.05), while significant positive correlation was found with blood plasma enzyme activity (0.76; P \leq 0.01).

4. 2. Experiment 2: Phenotypic variation of GSHPx activity in different breeds of different age groups, from day-old to the age of highest egg production

4. 2. 1. Phenotypic variation of GSHPx activity of liver homogenate

Significant differences were found among the breeds showing the highest enzyme activity in HW and the lowest in NNP breed (1.61 *vs* 1.21).

4. 2. 2. Phenotypic variation of GSHPx activity of RBC

Concerning breed effect, HW breed had the highest RBC GSHPx activity and NNP had the lowest (7.39 *vs* 5.66). The same tendency was found in females while, TNNW breed showed the highest RBC enzyme activity in males.

The GSHPx activity was higher in males than in females in all breeds except HW.

Age significantly influenced RBC enzyme activity. It was the lowest in day-old chickens, increased up to 4th weeks of age and then decreased until the period of highest egg production.

Sex had significant influence on RBC GSHPX activity, males having higher values than females (6.75 *vs* 6.37).

Regarding breed and age interaction, there were significant differences in the GSHPx activity of erythrocyte haemolysate among breeds in all age groups, but these differences were not consequent.

Age and sex interaction was also significant. Males showed higher activity at 4th and 12th weeks, at sexual maturation and at the age of highest egg production. Females showed the higher activity at 8th weeks of age.

Breed, age and sex interaction was statistically significant. The differences between males and females in different age groups have a wide variation among breeds.

4. 2. 3. Phenotypic variation of GSHPx activity of blood plasma

Concerning the breed effect, PRW breed had the highest enzyme activity and NNP had the lowest (7.27 *vs* 6.14). The same tendency was found in females, while HS showed the highest and NNP the lowest activity in males.

Breed and sex interaction was statistically significant. Males had higher blood plasma enzyme activity in NNP, HS, TNNW and HW breeds and females showed higher enzyme activity in PRW and NNNH breeds.

Age also influenced significantly the blood plasma enzyme activity. It decreased from hatching until the age of sexual maturation and there was a moderate increase at the age of highest egg production. Regardless of age and breed effects, sex had significant influence on blood plasma GSHPx activity. Males had higher activity than females (6.81 *vs* 6.60).

The results also showed that there are significant differences in blood plasma enzyme activity between breeds in all age groups, but the differences were not consequent in different age groups. Variation of blood plasma GSHPx activity showed mixed pattern of increase and decrease as an effect of ageing, but it was breed dependent.

Breed, age and sex interaction was also significant. The differences between males and females in different age groups showed a wide variation among breeds.

4. 2. 4. Phenotypic correlation between body weight and liver, RBC and blood plasma GSHPx activity

Negative correlations were found between GSHPx activity in the liver homogenate of newly-hatched chick liver and body weight at 4^{th} (-0.49), 8^{th} (-0.60) and 12^{th} weeks (-0.60) of age, at sexual maturity (-0.31) and at the age of highest egg production (-0.54).

Negative correlation was found between GSHPx activity of RBC haemolysate and body weight at 4th (-0.66), 8th (-0.94; P \leq 0.01) and 12th (-0.94; P \leq 0.01) weeks of age, at sexual maturity (-0.71) and at the age of highest egg production (-0.89; P \leq 0.05). Regardless of age, significant negative correlation was found between GSHPx activity of RBC and body weight (-0.48; P \leq 0.01).

Not significant negative correlation was found between GSHPx activity in blood plasma and body weight in all age groups except at four weeks of age when the correlation was positive. Regardless of age, highly significant negative correlation was found between GSHPx activity in blood plasma and body weight (-0.46; P \leq 0.01).

4. 2. 5. Phenotypic correlation between egg production and liver, RBC and blood plasma GSHPx activity

Negative correlations were found between GSHPx activity in liver and RBC with egg production and significant positive correlation was between GSHPx activity in blood plasma and egg production (0.83; $P \le 0.05$).

4. 2. 6. Phenotypic correlation between liver, RBC and blood plasma GSHPx activity

Significant negative correlation was found between liver enzyme activity at day-old age with blood plasma GSHPx activity 12 weeks (-0.50; P \leq 0.05) and at the age of highest egg production (0.55; P \leq 0.05). Otherwise positive correlation was found with RBC at 4th (0.40; P \leq 0.05) and 8th weeks (0.50; P \leq 0.05) of age.

Significant negative correlation was found between blood plasma and RBC GSHPx activity at day-old (0.20; P \leq 0.05) and 4 weeks (0.20; P \leq 0.05) of age. While, significant positive correlation were found at 8th (0.30; P \leq 0.01) and 12th weeks (0.30; P \leq 0.01) of age. Regardless of age effect, significant positive correlation was found between blood plasma and RBC GSHPx activity (0.20; P \leq 0.01).

4. 3. Experiment 3: Phenotypic variation in the GSHPx activity in two chicken breeds and their crosses of different ages from 1-day to the age of sexual maturation

4. 3. 1. Phenotypic variation of liver GSHPx activity

Significant differences in the GSHPx activity of liver were found between the two breeds and crosses. The NH breed had higher activity than TNNB (1.83 *vs.* 1.68). The N x T cross had higher activity than the reciprocal one (1.54 *vs* 1.27).

4. 3. 2. Phenotypic variation of GSHPx activity of RBC haemolysate

Regarding the breed effect, as was found in liver, NH had higher activity than TNNB breed (5.89 *vs.* 5.25). The N x T cross had higher activity than the reciprocal one (5.42 *vs.* 4.97). The same tendency was found in males and females.

Regarding the effect of age, age significantly influenced the RBC enzyme activity, it was lowest at four weeks and highest at eight weeks.

Sex had also significant influence on erythrocyte haemolysate GSHPx activity, males having higher enzyme activity than females (5.50 *vs.* 5.30).

Breed and age interaction showed that, there are significant differences in the GSHPx activity of erythrocyte haemolysate between the two breeds and crosses in all age groups. Those differences were not consequent in different age groups.

4. 3. 3. Phenotypic variation of GSHPx activity of blood plasma

Significant differences in the enzyme activity of blood plasma were found between the two breeds and crosses in all age groups. Regarding the breed effect, as was found in liver and RBC the NH breed had higher activity than TNNB (7.20 *vs.* 6.30). The N x T cross had higher activity than the reciprocal one (7.44 *vs.* 7.15). The same tendency was found in females but T x N cross had higher activity than N x T for males.

Enzyme activity significantly decreased with age from day-old until 12th weeks of age and started to increase at the age of sexual maturity.

Sex had significant influence on blood plasma GSHPx activity, males had significant higher enzyme activity than females (7.11 *vs.* 6.93).

4. 3. 5. Heterosis and reciprocal effects

Regardless the age effect, the heterosis effect for T x N cross had higher percent than N x T cross for RBC (-11% vs.-3%) and liver (-28% vs.-12%) and lower percent for blood plasma (-6% vs.-10%) enzyme activity. Heterosis as a percentage of the mid-parent values for RBC and blood plasma affected by age. Mean heterosis as a percentage of the mid-parent values of N x T and T x N crosses values for live body weight showed that the heterosis effect was higher for N x T than T x N cross at all ages except at 4 weeks. The heterosis effect for live body weight decrease with age for two crosses. Reciprocal differences have high values for all traits.

4. 3. 6. Phenotypic correlation between GSHPx activity in RBC haemolysate and blood plasma with body weight

The phenotypic correlations between body weight and RBC haemolysate GSHPx activity at different age of the various breeds had different values. Regarding the breed effect, positive correlations were found for NH (0.41; P \leq 0.01) and TNNB (0.10) while the same values of negative correlations were found for the two crosses (0.10). Concerning the age effect, not significant negative correlations were found between BW and RBC GSHPx activity at 4th, 8th and 12th weeks of age and positive correlation at sexual maturity. Regardless of breed and age effects, positive correlation was found between BW and RBC GSHPx activity.

The phenotypic correlations between body weight and blood plasma enzyme activity at different age of various breeds had different values. In the case of breed effect, negative correlations were found for all breeds (NH,-0.39; P \leq 0.01; TNNB, -0.18; N x T, -0.42; P \leq 0.01; T x N,-0.43 P \leq 0.01). Concerning the age effect, positive correlations were found between BW and blood plasma GSHPx activity at 4th (0.10) and 8th (0.33; P \leq 0.01) weeks of age and at sexual maturity (0.20), while negative correlation was found at 12th weeks of age (-0.11). The overall of all observations showed that, negative correlation was found between body weight and blood plasma enzyme activity (0.31; P \leq 0.01).

4. 3. 7. Phenotypic correlation between liver, RBC and blood plasma GSHPx activity

Significant positive correlation was found between blood plasma and RBC GSHPx activity at the age of sexual maturity (0.30; $P \le 0.01$).

5. CONCLUSIONS

The objective of this study was to identify sources of variation in GSHPx activity, with potential use as early predictors for indirect selection which may be associated with disease resistance and performance traits. GSHPx activity of different tissues may be candidates for use in indirect selection if they have high variation among and within breeds and are correlated to performance or disease resistance. The existence of genetic variation in the GSHPx activity in blood, liver and RBC of different animals suggests that GSHPx activity is genetically regulated.

Environment and diet was the same for all parent genotypes during the whole experiment. Also, eggs were incubated in uniform conditions concerning the Experiment 1. All genotypes were kept at the same environment and given the same diets during the whole period in Experiments 2. and 3. This suggests that the observed differences among breeds likely to be genetic ones.

There is a considerable variation in GSHPx activity of different breeds and this presumably reflects to the differences of the metabolism of a range of different compounds. However, there are few data available on this point. The usefulness of attempting to identify breed variation therefore rests primarily upon whether it provides evidence for genetic involvement. If further studies confirm genetic regulation of enzyme activity, it could be used as selection criteria. The high values of the reciprocal effect on the enzyme activity suggests the possibility of sex-linked and maternal effects on GSHPx activity, but further research is needed to prove this hypothesis.

Our data clearly indicate that, Hungarian breeds (Hungarian White and Hungarian Speckled) have higher enzyme activity in liver and red blood cells than Transylvanian Naked Neck breeds and Plymoth Rock White. Also, New Hampshire breed have the highest liver, red blood cells and blood plasma enzyme activity than all other breeds used in the experiments. The significant differences within breeds also provided evidences of genetic regulation of the enzyme activity, which give an opportunity to make selection within breeds.

Few previous work has been done on the correlation between production traits and GSHPx activity. It is concluded that, the correlations depends on the species and tissue. Also, present results show that, the correlations are influenced by breed, age and tissues. Most of these data are reported for the first time.

6. NEW SCIENTIFIC RESULTS

- 1. Describe the phenotypic variation of GSHPx enzyme activity of liver in the embryos of different chicken genotypes during embryonic development at standardised conditions.
- 2. Describe the phenotypic variation of GSHPx enzyme activity of liver, RBC and blood plasma in different genotypes and their crosses of chickens from day-old age up to the age of the highest egg production at standardised conditions.
- **3.** Calculate the effect of heterosis and reciprocal effect on the GSHPx enzyme activity of liver, RBC and blood plasma and body weight.
- **4.** The effect of age and sex on GSHPx enzyme activity of liver, RBC and blood plasma during development of chick-embryo and from day-old up to the age of the highest egg production at standardised conditions was measured.
- **5.** Estimate the correlation among different production traits and GSHPx enzyme activity of liver, RBC and blood plasma.

6. SUGGESTIONS FOR FURTHER RESEARCH

Concerning the above mentioned results several further studies or new research projects can be initiated.

The existence of genetic variation in the GSHPx activities in different chicken breeds suggests that, GSHPx activity is genetically regulated which indicate that GSHPx activity of different tissues may be candidates for use in selection, the correlations between the enzyme activities and production traits which obtained in this study especially the correlations between the enzyme activities at day-old with adult body weight and egg production suggest that, this selection could be improve performance and disease resistance.

These data suggest also that selective breeding of chicken for new strains differing in sensitivity to nutritional selenium deficiency and high tolerance to oxidative stress might be possible. Such strains would be valuable tools in studies of biochemical basis of mode of nutritional and physiological action of selenium.

Estimation of heritability of GSHPx activity in different tissues could be valuable tool to study the inheritance of GSHPx activity.

Estimation of genetic correlations between GSHPx activity and production traits also important to know whether this correlations are of phenotypic or genotypic origin.

Artificial challange of that enzyme system can give further information concerning the real defence against oxidative stress by possibly various level of enzyme induction at different genetic background.

8. PUBLICATIONS RELATED TO THE SUBJECT OF DISSERTATION

Articles published in scientific periodicals:

- Gihan Shaaban, Mézes, M. and Hidas, A. (2003): Phenotypic variation of glutathione peroxidase activity in different genotypes of different age groups of chicken and its correlation with some production traits. Europ. Poult. Sci. (Arch. Geflügelk). 67 (2), 1-8.
- Gihan Shaaban, Mézes, M. and Hidas, A. (2003): Phenotypic variation in the activities of glutathione peroxidase and their correlation with some production traits in two chicken breeds and their crosses. Europ. Poult. Sci. (Arch. Geflügelk). (Accepted for publication).
- **3.** Mézes M.- Erdélyi M.- **Gihan Shaaban** (2003): Genetics of the glutathione peroxidase enzyme. Acta Biologica Szegediensis. (Accepted for publication).

Papers and abstracts in conference proceedings:

- Gihan Shaaban, Mézes, M. and Hidas, A. (2001): Phenotypic variation of glutathione peroxidase activity in different genotypes of different age groups of chicken. Proc. 2nd Poult. Genetics Symposium, Gödöllő, pp. 110-111.
- Gihan Shaaban, Mézes, M. and Hidas, A. (2002): Phenotypic variation in the activity of glutathione peroxidase and their correlation with some production traits in two chicken breeds and their crosses. Proc. 11th Europ. Poult. Conference, Bremen, pp. 98. (Abstr.)
- Gihan Shaaban, Mézes, M. and Hidas, A. (2002): Phenotypic variation of glutathione peroxidase activity in different genotypes of chicken and its correlation with production traits. Proc. 53nd Annual Meeting of EAAP, Cairo, Vol. 8. pp. 13. (Abstr.)

- Gihan Shaaban, Mézes, M., Balogh K. and Hidas, A. (2003): Effect of breed and sex on glutathione peroxidase activity in chicken embryo and its correlation with some production traits. V. Magyar Genetikai Kongresszus, Siófok. pp. 116. (Abstr.)
- 5. Gihan Shaaban, Mézes, M. and Hidas, A. (2003): Phenotypic variation in the activity of glutathione peroxidase in blood plasma and red blood cells in four breeds and two crosses of chickens and their correlation with body weight. V. Magyar Genetikai Kongresszus. Siófok. pp. 114. (Abstr.)

Conference presentations:

Mézes M., Erdélyi M. and **Gihan Shaaban** (2002): A glutation peroxidáz genetikája. Szabadgyök Kutatás 2002. konferencia, Szeged.