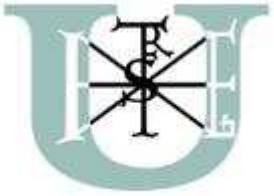

**SZENT ISTVÁN UNIVERSITY**

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

# ANTIOXIDATIVE CAPACITY OF EGG IN JAPANESE QUAIL

**Thesis of the Doctoral (PhD) Dissertation**

**Lengyel László**

**Gödöllő**

**2010**

**Doctoral School**

**Name:** **ANIMAL HUSBANDRY SCIENCE DOCTORAL SCHOOL**

**Discipline**: **Animal Husbandry Science**

**Leader**: **Dr. Miklós Mézes**

University Professor, Doctor of the Hungarian Science Academy

Szent István University, Faculty of Agriculture and Environmental Sciences, Animal Sciences Institute, Department of Animal Nutrition

**Supervisor**: **Dr. Zsuzsanna Kiss**

Associate Professor

Szent István University, Faculty of Agriculture and Environmental Sciences, Animal Sciences Institute, Department of Animal Physiology and Animal Health

_____ _____

Confirmation of Leader Confirmation of Supervisor

# 1. SCIENTIFIC BACKGROUND

Oxygen is a prerequisite for the development of life on Earth. Its presence is essential for aerobe organisms. In some cases, however, it represents a threat to living organisms, since reactive oxygen particles released from oxygen can damage the structure and function of cells and tissue. Oxidative stress is the cause of many diseases. Processes induced by free radicals can be monitored in animal breeding and husbandry as well.

Antioxidants are substances that protect the organism from the negative effect of free radicals and other oxidizing matters formed as the result of oxidation processes. An organism's antioxidant capacity depends on the amount of available anti-oxidative compounds, and on the level of oxidative stress it is being exposed to.

The natural antioxidants of low molecular weight – carotenoids, vitamins A, E and C, selenium – play a significant role in maintaining reproductive biology and production processes. In the embryonic development of chicken it can be found that there is a difference in the concentration of various types of antioxidants in individual organs. During animal breeding the organism is exposed to a number of environmental stress that result in the creation of intra and extracellular free radicals of oxygen origin. The main function of anti-oxidative compounds is the removal of these free radicals, that is, maintaining the amount on the "physiological level" that will, besides its other effects, "help" the immune system as well.

Egg, in its natural form, contains a number of nutrients in organic bound that are essential even in human nutrition. Its nutrient, vitamin and mineral content are highly influenced by feeding and assets of husbandry technology used. Using these methodologies egg can be enriched with supplements that are essential in human nutrition as well (Se, E-vitamin, C-vitamin, ß-carotene). Still, we consume these in small amount or in an uneasily utilizable form. Egg can not only be regarded as a propagation formula, a functional food, but also as food that may be recommended for potentially therapeutic goals. When egg is enriched with antioxidant compounds (eg. Se, E and C vitamins, ß-carotene) using feed supplements, the organism's anti-oxidative system is strengthened, and the durability of this highly oxidative food of animal origin with a high content of unsaturated fat is prolonged as well.

## 2. OBJECTIVES

The core objective of our experiment was the analysis of Japanese quail egg with increased antioxidant content. According to our goals, four separate experiments have been carried out and analyzed.

- Increasing the concentration level of selenium, vitamin E and ß-carotene in Japanese quail egg;
- What concentration and composition of antioxidant supplements give the most effective storing capacity of the analyzed substances;
- What are the effects of the increased level of antioxidants in eggs on hatching ability;
- What is the extent to which antioxidant compounds from eggs with increased level of antioxidants – as from natural matrix – are utilized in mammals (mice).

During the experiments, another aim was to determine the effect that antioxidant compounds of different concentration and compound have on the antioxidant capacity of egg.

The experiments were carried out using blood and egg sampling and laboratory analysis to get the answer to our hypotheses.

Namely:

- The level of concentration build-up of compounds of antioxidant properties mixed into food synthetically in the Japanese quail bloodplasma and egg.
- Which and of what concentration level do the antioxidant compounds mixed into food build-up in the blood, egg and organs of Japanese quail, all compared to the amount of antioxidant compounds put into food.
- When can the optimal physiological result be obtained in case of all antioxidant compounds used in our analysis: if all antioxidant compounds are added simultaneously, or in case of various combinations of antioxidant compounds mixed into food.
- Our studies have also covered the analysis of the effect egg yolk treated with antioxidant compounds has on haching capability and on hatched birds' vitality.
- How are antioxidants utilized in the organism of rodents after they were given food enriched with antioxidants?

- Are the laboratory measuring equipments, the methods suggested by the international literature suitable to measure the effect of the analyzed compounds, do they provide reliability and possibility to replicate our experiments.

## 3. MATERIALS AND METHODS

We chose Japanese quail (*Coturnix coturnix japonica*) for the experiments due to the fact that it proved to be an excellent model animal in studies carried out on breeding and nutrition of gallinaceous birds.

During the study, the Japanese quail were kept in closed-caged conditions, were fed with commercially available household feed for hen. During the study, the supplements were mixed into this feed. All experimental groups used this feed and drinking water *ad-libitum*. Only tap water was given to the animals, without any supplements and drugs. The study was free from impact caused by varying environmental conditions due to the fact that all animals were kept under natural light, and same climate conditions. The experimental groups were placed separately, in appropriate distance from one another so that the food of separate groups could not get mixed with that of another group. The cage had a sloping grid floor so that the egg could leave the cage immediately after it was layed. The possibility of consuming eggs besides that used as part of the experiment was therefore minimized. Eggs were collected on a daily bases, and depending on the experiment, were kept in cold, dry place, in some cases in a refridgerator until the laboratory experiments.

The study was carried out in four experimental phases. All experiments dealt with analysis of the optimal amount, composition and utilization of antioxidant compounds mixed into poultry feed, using different aspects.

Antioxidant feed supplements used in the study:

| Name of the active substance | Product name | Active substance content |
|---|---|---|
| Selenomethionine | SelPlex ™ (Alltech) | 1000 mg/kg Selenium |
| Vitamin E | Lutavit E 50 S (BASF) | 50% DL-α-tocopherol acetate |
| ß-carotene | Lucarotin 10% feed (BASF) | 10% β-carotene |
| Vitamin C | L-aszkorbinsav (Reanal) - ascorbic acid | 99,7% L-ascorbic acid |

## 1st experiment

Experiment title: measuring the antioxidative capacity of egg and blood plasma (experimental analysis in Japanese quaint)

8-week old Japanese quaints were put into 5 experimental groups in this experiment.

The amount of antioxidant supplements added to the experimental feed.

| Group number | Selenium (mg/kg of feed) | Vitamin E (mg/kg of feed) | Vitamin C (mg/kg of feed) | ß-carotene (mg/kg of feed) |
|---|---|---|---|---|
| 1 | 0,8* | 0 | 0 | 0 |
| 2 | 0,8* | 500 | 0 | 0 |
| 3 | 0,8* | 0 | 0 | 33,3 |
| 4 | 0,8* | 0 | 500 | 0 |
| 5 | 0,8* | 500 | 500 | 33,3 |
| Control | 0 | 0 | 0 | 0 |

* The 0,8 mg/kg selenium added to the complete feed used in this study exceeds the limit of 0,5 mg/kg level of selenomethionine in feed as set by EC Regulation (1750/2006/EC).

## Sampling, Test Parameters

For the experiment, 8-week old Japanese quaints were put into hen cages in the following sex ratio: 1 cock – 3 hens. The Japanese quaints were given commercially available hen feed (Bábolnai Takarmányipari Kft., Bábolna) before the start of the experiment. Following the sampling on day 0 (self-control), the same feed was enriched with selenium, vitamin E, vitamin C, and ß-carotene.

During the first phase the feed of the experimental group was enriched with supplements according to active ingredient content. The animals consumed the feed enriched with antioxidant compounds *ad libitum* for 3 weeks.

Blood sampling (one sample per animal) was done before the start of the experiment (day 0) and on the closing day (day 21). The samples were gathered in heparine tubes, blood plasma and bloodcells were separated by centrifugation, and the selenium, α-tocopherol, retinol and ß-carotene content of the blood plasma was measured.

During the experiment eggs were collected daily and were stored in groups, under same conditions. Similar to the blood plasma, the selenium, α-tocopherol, retinol, and ß-carotene content of egg yolks, as well as the antioxidant capacity of egg yolks using FRAP (Ferric Reducing Antioxidant Power) was measured.

## 2nd experiment

Experiment title: The effect of different amounts and varying composition of antioxidant supplements in japanese quaint

The goals of the experiment are summarized below:

- To what extent do antioxidant compounds added to animal feed in other than the required amount affect the concentration of these supplements in the blood plasma, and its presence in the egg.
- What amount and composition of the above mentioned antioxidant compounds results in the highest antioxidant capacity of egg.
- Do the composed feed supplements help or hinder the storing of individual antioxidants.

The experimental groups were given feed with different amounts of selenium, vitamin E, vitamin C and ß-carotene content. We measured the extent to which the consumed amount affects the antioxidant content of blood plasma and egg. Additionally, the level to which the decrease of any of the supplement consumed affects the antioxidant deponation in blood and egg. Antioxidant compounds were left out one by one from the feed given to

the experimental group with the aim of measuring the effect it has on the deposition of the other antioxidant compounds.

The amount of antioxidant supplements added to the experimental feed

| Group number | Selenium (mg/kg of feed) | Vitamin E (mg/kg of feed) | Vitamin C (mg/kg of feed) | ß-carotene (mg/kg of feed) |
|---|---|---|---|---|
| Control | 0 | 0 | 0 | 0 |
| 1 | 0,8* | 500 | 500 | 35 |
| 2 | 0,8* | 100 | 100 | 6,6 |
| 3 | 0,8* | 0 | 100 | 6,6 |
| 4 | 0,8* | 100 | 100 | 0 |
| 5 | 0 | 100 | 100 | 6,6 |
| 6 | 0,8* | 100 | 0 | 6,6 |

* The 0,8 mg/kg selenium added to the complete feed used in this study exceeds the limit of 0,5 mg/kg level of selenomethionine in feed as set by EC Regulation (1750/2006/EC).

In the second experiment 8-week old Japanese quaints were put into hen cages in the following sex ratio: 1 cock – 3 hens. The control feed given to the Japanese quaints was a commercially available hen feed (Bábolnai Takarmányipari Kft., Bábolna), while the experimental groups received feed of same nutrient value enriched with selenium, vitamin E, vitamin C and ß-carotene.

The animals consumed the control and the antioxidant compound enriched feed *ad libitum* for 3 weeks.

Blood sampling (one sample per animal) was done before the start of the experiment (day 0) and on the closing day (day 21). The samples were gathered in heparine tubes, blood plasma and bloodcells were separated by centrifugation, and the selenium, α-tocopherol, retinol and ß-carotene content of the blood plasma was measured.

During the experiment eggs were collected daily and were stored in groups, under same conditions. Similar to the blood plasma, the selenium, α-tocopherol, retinol, and ß-carotene content of egg yolks, as well as the antioxidant capacity of egg yolks using FRAP (Ferric Reducing Antioxidant Power) was measured.

**3rd experiment**

Experiment title: Effect of antioxidant food supplement on the hatching ability and vitality of Japanese quaints.

Our third experiment aimed at analysing the extent to which food supplement added in the form of organic bond selenium, alpha tocopherol, and beta carotene influence the hatching ability of eggs, and the vitality of hatched chicken. The concentration change of oil-soluble antioxidant compounds in the liver of these chickens was also measured.

*Experimental animals and experimental layout*

The Japanese quaints were divided into two groups, kept in cages under natural light, with *ad libitum* water and food consumption. For each treatment, groups of 5 with a 3:1 (♀:♂) sex ratio were analyzed. One group received commercially available layer hen food, while the other received the same with added antioxidant compounds.

The amount of antioxidant supplements added to the experimental food

| Group number | Selenium (mg/kg of food) | Vitamin E (mg/kg of food) | ß-carotene (mg/kg of food) |
|---|---|---|---|
| Treated | 0,8* | 500 | 35 |
| Control | 0 | 0 | 0 |

* The 0,8 mg/kg selenium added to the complete feed used in this study exceeds the limit of 0,5 mg/kg level of selenomethionine in feed as set by EC Regulation (1750/2006/EC).

The Japanese quaints received food mixture *ad libitum* for 3 weeks. During the last week eggs were collected for hatching. 40-40 pieces of these eggs were randomly selected for analysis. During the experiment, blood samples were taken weekly from laying hens. During the first week after hatching 5 Japanese quaints per day/group were bled and their liver removed for analysis. The body weight of newly hatched chicken was measured daily for 4 days.

*Analyitical methods*

The retinoid, α-tocopherol and β-carotene concentration of blood plasma and egg yolk was measured using the HPLC method. The antioxidant capacity of egg yolk was measured using the FRAP methodology. The measurement of selenium was done using a flameless atomic absortion spectrophotometric method.

*Hatching technology*

After completing the egg collection, the eggs were left still for 3 days, and then 100 pieces of each group were placed in the incubator. The eggs were brooded using a *"Bábolna Egg Star EU-6-S"* type incubator. 8 hours prior to placing them into the incubator, the eggs were pre-heated to 25 $^{o}$C. the incubator was pre-heated as well, and the eggs were placed into a 37,5 $^{o}$C incubator. Incubation was done following the recommended parameters (Biesalski et al, 1986; Czibulyás és Kovács, 1976; Kiss, 1981). The newly hatched chickens were removed every 6 hours from the incubator which was the bases for calculating the hatching intensity. Also, the weight of the chickens was measured at this point, too. The hatched Japanese quaints were grouped separately for additional measurements.

## 4$^{th}$ experiment

Experiment title: Utilization of antioxidant micronutrients (ß carotene, vitamin E, Selenium) of natural and artificial origin.

The aim of the experiment was to measure the utilization of the analyzed antioxidant micronutrients (ß carotene, vitamin E, Selenium) from natural and chemical formula.

During the first phase of the experiment – as in the previous experiments – the food given to the Japanese quaints was enriched with antioxidant compounds way above the required amount (selenium 0,8 mg/kg of food, + vitamin E 500 mg/kg of food, ß-carotene 35 mg/kg of food), that resulted in eggs with increased content of antioxidants. In the second phase of the experiment the yolk of these eggs were given to mice.

Two Japanese quaint groups were formed at the beginning of the experiment. 5 layer hens were put into each group in cages with natural light. One group received commercially available layer hen food, the other group received the same with supplements described in table below.

The amount of antioxidant supplements added to the food

| Group number | Selenium (mg/kg of food) | Vitamin E (mg/kg of food) | ß-carotene (mg/kg of food) |
|---|---|---|---|
| 1 | 0 | 0 | 0 |
| 2 | 0,8* | 500 | 35 |

* The 0,8 mg/kg selenium added to the complete feed used in this study exceeds the limit of 0,5 mg/kg level of selenomethionine in feed as set by EC Regulation (1750/2006/EC).

During the first week of the experiment egg samples were taken, and their interior was measured.

Antioxidant compound content of control eggs:

Vitamin E: 0,09 mg/g

ß-carotene: 0,34 µg/g

Selenium: 90,3 µg/kg

Eggs with increased antioxidant content:

α-tocopherol: 0,39mg/kg

ß-carotene: 3,43mg/kg

Selenium: 392,6 µg/kg

The values of the control egg were substracted from the values of eggs with increased antioxidant content which gave us the difference. This difference was added to the control egg yolks in synthetic form. The eggs were boiled and the hard boiled yolks were given to mice. The synthetic supplements were added to these boiled yolks.

3 groups of 13-17g Balb-C (Charles River) mice were formed (10 mice per group), which were fed according to the followings:

Mice groups:

1. fed with egg yolks of increased antioxidant content;

2. fed with egg yolks of control eggs enriched with synthetic supplements;

3. fed with egg yolks of control eggs.

The amount of synthetic supplements:

E-vit.: 0,3 mg/kg food

ß-carotene: 3,09 mg/kg food

Se: 300 µg/kg food

The mice consumed only egg yolks during the experiment *ad libitum* , without any additional food.

The mice were fed for 14 days, and following the extermination samples of liver and brain were taken, and the effect of antioxidant compounds given through incorporation into the egg yolk and in the form of synthetic supplements on the brain and liver were compare.d

Using a FRAP method the iron reduction capability of the brain, and using the HPLC method, the retinol, and the alpha tocopherol content was measured. Using the liver, via the HPLC method we measured the retinil palmitate, retinol, alpha tocopherol, and the beta carotene content. Using a flameless atomic adsorption spectrophotometric method the selenium content was measured. During the experiment for the purpose of proving the usability of the FRAP method, the MDA content of eggs was determined by means of tiobarbitur acid.

## Applied biochemical methods

### HPLC methods used during the course of the analyses

During our experiments we used high performance liquid chromatography (HPLC) methods for retinoid and carotinoid analyses (Kerti and Bárdos, 1999).

The measurements were carried out in the premises of the Animal Physiology and Animal Health Department of the Faculty of Agriculture and Environmental Sciences of Szent Istvan University.

### Defining FRAP (Ferric Reducing Antioxidant Power) for (plasma and tissue samples)

Our experiments were carried out using the methodology developed by Benzie and Strain (1996) and further modified by the same authors (Benzie és Strain 1999).

### Methodology for Selenium analyses in complete blood and tissue samples

Se content was measured using an electrochemically induced flameless atomic adsorption spectrometer (UNICAM 939 QZ GFAA spectrometer) with Zeeman background correction. The used methodology is developed by the central laboratory of the Szent Istvan University (SM 501/0837. Reg. nr. 3:1996).

### Measuring the malondialdehyde content:

In the 4th experiment, for measuring the oxidative stability of egg yolk in TBARS (in nmol MDA/g egg yolk) the Dorman et al (1995) developed methodology was used.

### Statistical methodologies:

The significant effect of experimental treatments was determined by a single-factor analysis of variance.

## 4. EVALUATION OF THE RESULTS OF THE EXPERIMENTS

1. experiment:
   The results confirm that the test materials are stored in measurable quantities in both the blood plasma and egg yolks. Based on our results, it can be observed that co-administration of selenium and the tested antioxidant supplements resulted in synergic interaction in number of cases.
   The synergy effect of selenium and vitamin E can be observed by the result that shows increase in storing even in cases when only selenium and vitamin E are administered. From supplements used in the experiment selenium is the only one that helps increase the antioxidant capacity in all cases, added either separately or in combination with other compounds.
   During the experiments, even though the supplement was significantly higher (nearly 10x) than the physiological need no clinically manifested toxic reactions could be observed.

2. experiment:
   The selenium concentration stored in eggs proportionally followed the selenium concentration measured in the blood plasma of the experimental groups. The selenium concentration of blood plasma is significantly influenced by the relative and absolute amount of food supplements.
   High dose antioxidant supplement (1st group) significantly increased the beta carotene concentration of blood plasma.
   The high dose antioxidant mixture in eggs (1st group) significantly increased the α-tocopherol, ß-carotene and selenium concentration.
   Based on the findings of the experiment, it can be stated that the composition and the amount of individual antioxidants administered for a subchronic time is significant from the point of view of antioxidative effect when administered individually or simultaneously as well.
   In the experiment carried out on Japanese quaint the antioxidant supplement of different composition and doses in the case of blood plasma, did not show significant alterations in alpha tocopherol and retinol content, and the beta carotene content was increased only in the case of the first group when administered in high doses of antioxidant mixture. The selenium concentration of blood plasma on the other hand, shows significant increase in case of all experiments where food with

selenium content was administered. This is presumably the result of the extremely high concentration of selenium.
The concentration of alpha tocoferol, retinol, beta carotene and selenium in the egg was the highest when vitamin E, beta carotene, and selenium was added to the experimental food without adding vitamin C.
The used antioxidant supplements resulted in significant increase of antioxidant capacity in Japanese quail that were given feed enriched with selenium as measured using FRAP methodology for measuring Ferric Reduction capability.
Based on the results, it can be stated that antioxidant compounds used in our experiments show variations in the level of antioxidant capacity of blood plasma and egg yolk. They may significantly increase the antioxidant capacity of blood plasma, and are stored in egg yolk in high concentration. The amount of stored antioxidant compounds is proportional to the antioxidant content of food.

3. experiment
Based on our findings antioxidant supplement mixed into food given to Japanese quaint parents had its effect in the hatched chickens as well. The liver of the hatched chickens from the experimental group contained higher concentration of compounds that were given to their parents. More chicken hatched from the eggs of the treated group.

From the result, we can draw the conclusion that in species with vivid metabolism such as in the case of Japanese quail, the simultaneous use of antioxidant supplements in higher than usual dosage may be justified.

Our experiment confirmed that selenium, vitamin E, and beta carotene added to the food of Japanese quail layer hens significantly increased the concentration of these compounds both in blood plasma and in egg yolk. The favourable effect was found in the hatching ability as well.

4. experiment:
The results of the experiment show that the liver of the experimental mice had a higher concentration of selenium, alpha tocopherol, retinol, retinyl palmitate when receiving egg yolk with higher content of antioxidant as opposed to when given food with synthetic supplements.
The highest concentration of alpha tocopherol and retinol, and the FRAP value in the brain of the mice was higher when given antioxidant supplement incorporated naturally into egg yolk, as opposed to the

control group that received egg yolk enriched with synthetic supplements.
These findings show that mice can better utilize antioxidants from natural sources, in organic bound, that is, when consumed after being incorporated into egg yolk. These results, projected to human nutrition, show that there is a possibility to improve out organism's antioxidant content by consuming egg yolk naturaly enriched with antioxidant compounds.

## 5. NEW SCIENTIFIC RESULTS

- The FRAP methodology, originally developed for the purpose of measuring the Ferric Reduction ability of blood plasma, can be adapted and used for measuring the antioxidant capacity of egg, liver and brain tissues.
- Egg composition can be changed proportionally to the amount of organic bound antioxidants added to food. After supplementing the food with antioxidants a high amount of organic bound antioxidant is stored in egg, which can be freely consumed as functional food.
- The hatching ability of eggs with increased content of antioxidants and the vitality of hatched chicken were significantly improved.
- The high doses (0,8 mg/kg of food) of organic bound selenium consumed did not cause toxic effects in the Japanese quail organism.
- Both smaller concentration of selenium and alpha tocopherol (Se: 0,8 mg/kg of food, α-tocopherol: 100 mg/kg of food) and higher concentration (Se: 0,8 mg/kg of food, α-tocopherol: 500 mg/kg of food) have synergic effect.
- Antioxidant compounds incorporated into egg in natural matrix were better utilized in mice than antioxidants given in synthetic form.
- Fat soluble antioxidants (α-tocopherol, beta carotene, selenium) increase the antioxidant capacity of brain tissue in mice.

## PUBLICATIONS OF THE AUTHOR IN THE FIELD OF THE THESIS

**INTERNATIONAL CONFERENCES:**

- LENGYEL L., SZABÓ M., KISS ZS., BÁRDOS L. (2001): Utilization of antioxidants from natural and synthetic matrices. *Annual Symposium of the European Academy of Nutritional Sciences*, Budapest. In: *Táplálkozás–Allergia-Diéta*. 6. évf. 3-4. sz. 19. p.

- LENGYEL L., SZABÓ M., BÁRDOS L., KISS ZS. (2002): Természetes és mesterséges eredetű antioxidáns mikronutrielemek (ß-karotin, E-vitamin, szelén) hasznosulása. *Vajdasági Magyar Tudományos Társaság tanácskozása.* In: RIBÁR B. (szerk.) *Környezetkímélő mezőgazdasági és élelmiszeripari termelés a Vajdaságban.* Újvidék, 45–51. pp.

- LENGYEL L., SZABÓ M., BÁRDOS L., KISS ZS. (2002): Utilization of antioxidants in mice. *7th Internet World Congress for Biomedical Science,* Inabis, 2002. ápr. 14–20.

- SZABÓ M., BÁRDOS L., KISS ZS., LENGYEL L. (2002): Characterization of IgYdeposition into developing follicles of Japanese quail. *11th European Poultry Conference,* Bremen, 2002. szept. 6–10.

- SZABÓ M., LENGYEL L., BÁRDOS L. (2002): Characterization of IgY deposition into developing follicles of Japanese quails. *7th Internet World Congress for Biomedical Science*, 2002. april 14–20.

- LENGYEL L., SZABÓ M., KISS ZS., BÁRDOS L. (2003): Természetesebb életminőség; Az almaecet alkalmazása a fácánnevelés folyamán. *Vajdasági Magyar Tudományos Társaság*. In: *Fenntartható fejlődés időszerű kérdései a Vajdaságban*. Újvidék, 66–75. pp.

**DOMESTIC CONFERENCES:**

- LENGYEL L., BÁRDOS L., KISS ZS. (2000): A tojás és a vérplazma antioxidáns kapacitásának mérése. Modellkísérlet fürjekben. *Akadémiai beszámoló* – Állatorvosi Egyetem, Budapest 2000. dec., Állatélettani Szekció

- BÁRDOS L., SZABÓ M., LOSONCZY S., SZABÓ CS., LENGYEL L. és KISS ZS. (2001): Madár immunglobulinnal (IgY) kapcsolatos vizsgálatok. *Innováció, a tudomány és a gyakorlat egysége az ezredforduló agráriumában*. Gödöllő. 338–345. pp.

- KISS ZS., SZABÓ M., LENGYEL L. és BÁRDOS L. (2001): IgY alkalmazásának lehetősége a Salmonellozis elleni védekezésben. *Magyar Zoonózis Társaság Rudnai-Kemenes tudományos ülése*, Budapest, 2001. ápr. 23.

- LENGYEL L., SZABÓ M. (2001): Természetes antioxidáns anyagok tojásba történő depozíciója (Japánfürjekben végzett modellkísérlet) *VII. Ifjúsági Tudományos Fórum*, Keszthely, 2001. márc. 29.

- LENGYEL L., SZABÓ M., BÁRDOS L., KISS ZS. (2002): Antioxidáns tulajdonságú mikronutriensek (ß-karotin, E-vitamin, szelén) hasznosulása különböző mátrixokból. *Akadémiai beszámoló.* Állatorvosi Egyetem, Budapest, 2002. jan., Állatélettani Szekció

- LENGYEL L., SZABÓ M. (2002): Az antioxidáns kiegészítés hatása japán fürjek keltethetőségére és vitalitására. *VIII. Ifjúsági Tudományos Fórum*, Keszthely, 2002. márc. 28.

- RADICS J., LENGYEL L., BÁRDOS L. (2002): Esszenciális zsírsavakkal és antioxidánsokkal dúsított tojás előállítása. *A Magyar*

*Táplálkozástudományi Társaság XXVII. Vándorgyűlése*, Eger, 2002. nov. 7–9.

- LENGYEL L., SZABÓ M., BÁRDOS L., KISS ZS. (2004): Megnövelt antioxidáns anyag tartalmú tojás előállítása és annak hasznosulása egerekben. *„Szelén az élettelen és élő természetben”, kerekasztal konferencia,* SZIE – Gödöllő, Kisállattenyésztési és Takarmányozási Kutatóintézet, 2004. okt. 1.

**SCIENTIFIC PAPERS:**

- LENGYEL L., KISS ZS., BÁRDOS L. (2002): Előzetes kísérletek a tojás antioxidáns kapacitásának növelésére japánfürjben. *Állattenyésztés és Takarmányozás,* 51. 2. 165–174. pp.

- LENGYEL L., KISS ZS., BÁRDOS L. (2002): Tenyésztői gyakorlat: Vissza a természethez. *Vadászlap,* 11. évf. 12. szám 57–58. pp.

- LENGYEL L., SZABÓ M., BÁRDOS L., KISS ZS. (2002): Antioxidants against risk factors. Better utilization from biological matrix. Rizikové Faktory Potravového Retazca, *Zborník prác z 2. Medzinárodnej Vedeckej Konferencie,* SPU Nitra, 76–79. pp.

- KISS ZS., BÁRDOS L., SZABÓ CS., LENGYEL L. és SZABÓ M. (2003): Effect of ß-carotene supplementation on plasma and yolk IgY levels induced by NDV vaccination in japanese quail. *Int.J.Vitam.Nutr.Res*., 73 (4), 285–289. pp.

- LENGYEL L., KISS ZS., BÁRDOS L. (2003): Ajándék a természettől; Almaecettel a gyöngytyúknevelés sikeréért. *Őstermelő, Euro info centre hírlevél,* 10. 2003/1.

- LENGYEL L., KISS ZS., BÁRDOS L. (2003): Életerősebb gyöngytyúkok. *Agro Napló* 7. évf. 4.

- LENGYEL L., KISS ZS., BÁRDOS L. (2005): A tojótáp antioxidánskiegészítésének hatása japán fürjek keltethetőségére és vitalitására. *Magyar Állatorvosok Lapja*, 2005/11. 127. 661–667. pp.

**OTHER SCIENTIFIC PUBLICATIONS:**

- LENGYEL L., KISS ZS., BÁRDOS L. (2002): Életerősebb gyöngytyúkok. *Kistermelők Lapja*, 2002/12., 20–21. pp.

**SUPERVIZOR FOR DIPLOMA THESIS**

- Sverteczki Mónika: Antioxidáns-kapacitás mérése vér- és tojásmintákban – Témavezető: Dr. Kiss Zsuzsanna egyetemi docens és Lengyel László PhD hallgató

**SCIENTIFIC STUDENT ASSOCIATION CONFERENCE:**

- Sverteczki Mónika: Antioxidáns-kapacitás mérése különböző baromfitojásban – Témavezetők: Dr. Kiss Zsuzsanna egyetemi docens és Lengyel László Ph.D. hallgató, *XXVI. Országos Tudományos Diákköri Konferencia*, Agrártudományi Szekció, Állatélettan és Állategészségügy A tagozat. (Összefoglaló: 198–199. pp.) Kaposvár, 2003.