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THE EFFECT OF DDGS INCLUSION LEVEL ON BROILER AND TURKEY PERFORMANCE AND MEAT QUALITY PARAMETERS

Thesis of Ph.D. dissertation

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1. INTRODUCTION, THE PRECEDENCE OF THE STUDY

1.1. Introduction

From the 1950s there was interest about the use of by-products from cereal ethanol industry. In these ages the beverage alcohol industry was the primary source of DDGS, however from the 1980s the bio-ethanol industry took over the production. DDGS was a highly preferenced feedstuff, which can be easily use in the feeding of ruminants and it was preferably to consume by the animals.

From the early ’50s till present besides ruminants, investigations were conducted with pig and poultry as well to evaluate the maximum inclusion rate of DDGS which not affect negatively the performance traits. Beyond these changes some meat quality parameters were also monitored considering the high PUFA content of DDGS which may reduce the texture of lard and muscle.

In the USA from the middle ’90s bio-ethanol industry and thus the DDGS production raised fastly. From that period the use of DDGS was not just an option but a necessary issue. There was a huge amount of the by-product available in the market therefore the purchase was easy so DDGS can be use to replace corn or soybean meal.

In spite of the 50 years investigations about DDGS as feed ingredient, still not clear all aspects of its application to the performance traits and meat quality parameters, especially in poultry species. Therefore the main purpose of my investigations were to evaluate the reasonable and widely usable amount of DDGS can be incorporated into broiler chicken and turkey diets.

My research focused on evaluation of the effect of different amount of DDGS included in the diet of broiler chicken and turkey without negative effects on performance traits. Moreover my aim was to investigate the effect of DDGS inclusion on breast meat quality and lipidperoxidation parameters of broiler chicken and turkey.

1.2. Objectives

- Aim of my research was to evaluate the inclusion level of DDGS in broiler feed that does not affect the performance.
- Additionally I've studied the increasing level of DDGS on meat quality and lipidperoxidation parameters in chicken breast meat fillet.
- Objective of my research was to evaluate the inclusion level of DDGS in turkey feed that does not affect the performance.
- At last I've studied the increasing level of DDGS on meat quality and lipidperoxidation parameters in turkey breast meat fillet.

2. MATERIALS AND METHODS

2.1. Sample collection

2.1.1. Feed sampling

Feed sampling was carried out from every kind of batch (starter, grower, finisher diet broiler and turkey as well) in order to analyse the composition.

2.1.2. Blood and tissue sampling

Blood samples were taken from the jugular veins *(aa. carotis ext. et int., v. jugularis)* during bleeding and collected in anticoagulant-containing tubes (0,2 mol/L EDTA-Na2 0,05 ml/ml blood) and native blood collection tubes gain blood serum.

Post mortem tissue samples (liver, breast meat) were collected in the course of dissection. Samples were stored at -18°C until biochemical analysis.

Broiler breast meat fillet were collected from *musculus pectoralis major and minor (m. pectoralis superficialis).* Turkey breast meat fillet were collected from *musculus pectoralis minor.*

Tissue samples were homogenized in phosphate buffer saline (1:9). Native homogenizates were used for malondialdehyde concentration determination, while further biochemical analysis was performed from the 10.000g supernatant of the homogenizates (Mézes, 1999).

2.2. Evaluation of the production parameters

Body weight and feed consumption were measured weekly in broilers and twice a month in turkey. Daily gain was calculated from body weigh data and feed conversion ratio was calculated from weigh gain and feed consumption.

2.3. Feed analysis

Weendei, starch, sugar, fatty acid, amino acid, toxin (DON) analyses were carried out to determine the content of DDGS and diets used in the experiments.

2.4. Biochemistry

Thiobarbituric acid reactive agents (malondialdehyde) were measured in the plasma, red blood cell (RBC) haemolysate and tissue homogenizates with colorimetry according to the protocol of Placer et al. (1966), modified by Matkovics et al. (1988).
Reduced glutathione concentrations of the plasma, RBC haemolysate and tissue homogenizates werre determined on the basis of complex formation of free non protein SH_groups with 5,5'dithiobis-2-nitrobenzoic acid (Sedlak and Lindsay, 1968).
Glutathione peroxidase activity was measured in the plasma, RBC haemolysate and tissue homogenizates using the endpoint direct assay of Matkovics et al. (1988).
Enzyme activity data were correlated to protein concentration determined by Biuret reaction for the plasma and RBChaemolysate and Folin phenol reagent for tissue homogenizates (Lowry et al., 1951).

2.5. Meat quality parameters

2.5.1 pH
pH was measured at 45 min and 24 hours after slaughter by portable pH meter with electrodes (pH-STAR, Firma Matthäus, Németország).

2.5.2 Color

Meat color (CIELab L*,a*,b*) was measured in freshly cut piece of breast fillet by Minolta Chromameter (Minolta CR-330, Minolta Co).

2.5.3 Shear force and cooking loss

Frozen samples were thawed on 4 °C for 24 h. Melting samples were weighted and roasted till 72°C nuclear temperature (TESTO 926, TESTO AG., Németország) in a contact grill oven (Cucina HD 2430, Philips, Németország), then weighted again. Samples cooled to room temperature for 1.5 hours. Two pieces (each 8x8 square prismatic cores) were cut out from the breast meat and the crust were removed. Then 5-5 cut were carried out by the Warner-Bratzler blade (60° angle, 1 mm thick, 250 mm/minute) for the measurements (TA.XT Plus texture analyser, Stable Micro System, Nagy-Britannia). Shear force value were calculated by the Texture Exponent 32 softver, based on the force/time (kg/s) diagram.

2.5.4 Drip loss

Drip loss was measured from one slice breast meat by the modified Honikel method (Honikel, 1987). During controlled condition (+4 ^{o}C, 96 h.) the water left only gravitationally. The amount of the loss was presented as the percentage of the original sample weight (Lesiak et al., 1995).

2.5.5 Content analysis

Breast meat content (fat, protein, ash and dry material) was determined. Chicken breast meat samples were taken during the slaughter and turkey breast meat samples were taken following the cutting 24 hours after slaughter, and kept on -70°C till the analysis.

2.6. Statistical evaluation

Statistical evaluation of the data has been carried out using SPSS 16.0 software. I've used variance analysis (ANOVA) for comparing the results. Tukey, or Tamhane test was used for comparing the means, based on the result of the previous homogeneity analysis. Correlation analysis was used to prove the correlation of given parameters. Statistical evaluation of the data

has been carried out using SPSS 16.0 software. Diagrams were created by using Microsoft Office 2003 Excel.

2.7.Experimental arrangement

Experiments with broiler chicken were kept in the Szent István University, Department of Animal Nutrition facility, in Gödöllő. Experiments with turkey were kept in the facility of Galli-Farm Kft., in Kerekegyháza.

1. *experiment: Effect of different inclusion level of DDGS on Ross 308 broiler performance and meat quality parameters*

Items/group	**0**	**10**	**15**	**20**
Genotype	ROSS 308			
Number	50	50	50	50
DDGS inclusion level of starter diet (%)	0	10	15	20
DDGS inclusion level of finisher diet (%)	0	10	15	20
Initial day	1	1	1	1
Final day	42	42	42	42
Housing and rearing conditions	deep litter, *ad libitum* feed and water			

2. *experiment: Effect of different inclusion level of DDGS on Ross 308 broiler performance and meat quality parameters*

Items/group	**0**	**15**	**20**	**25**
Genotype	ROSS 308			
Number	50	50	50	50
DDGS inclusion level of starter diet (%)	0	15	15	15
DDGS inclusion level of finisher diet (%)	0	15	20	25
Initial day	1	1	1	1
Final day	42	42	42	42
Housing and rearing conditions	deep litter, *ad libitum* feed and water			

3. experiment: Effect of 10 % DDGS on B.U.T. Big 6 turkey performance and meat quality parameters

Items/group	**0**	**10**
Genotype	B.U.T. Big 6	
Number	140	140
DDGS inclusion level of grower 1-2 diet (%)	0	10
DDGS inclusion level of finisher 1-2 diet (%)	0	10
Initial day	43	43
Final day	136	136
Housing and rearing conditions	deep litter, *ad libitum* feed and water	

4. experiment: Effect of 15 % DDGS on B.U.T. Big 6 turkey performance and meat quality parameters

Items/group	**0**	**15**
Genotype	B.U.T. Big 6	
Number	70	70
DDGS inclusion level of grower 1-2 diet (%)	0	15
DDGS inclusion level of finisher 1-2 diet (%)	0	15
Initial day	35	35
Final day	140	140
Housing and rearing conditions	deep litter, *ad libitum* feed and water	

3. RESULTS

3.1. Effect of different inclusion level of DDGS on Ross 308 broiler performance and meat quality parameters - 1. experiment

There were no significant difference in body weight among the groups nor the 21. days or the 42. days. Feed consumption was the same in every stages as in the Ross 308 manual shows. FCR were a bit higher than in the Ross 308 manual. There were no significant difference in grill, breast and thigh weight among the groups. 24 hours after slaughter pH results were in the normal range, however there were no difference among the groups.
According to the CIELab color parameters yellowness (b*) of the breast were significantly higher in group fed 20% DDGS.
Shear force values of the breast were significantly lower in 20% DDGS group than in the 0-10-15% DDGS groups.
Dry material, fat, protein and ash content of the breast meat was significantly affected by the DDGS inclusion. Although there were no obvious trend in the direction of the changes.
Blood plasma MDA content were significantly affected by the diet. 20% DDGS fed group had higher MDA in blood plasma than the other tested groups.
In RBC haemolysate the reduced glutathione content were significantly different in group fed 15% DDGS. In liver homogenizates the reduced glutathione content were significantly lower in 0% DDGS groups than in the other groups.
There were no significant differences in the results that not mentioned.

3.2. Effect of different inclusion level of DDGS on Ross 308 broiler performance and meat quality parameters - 2. experiment

There were significant difference in body weight among the groups at the 42. days. 0% DDGS group had higher live weight than other tested groups.
According to the body weight controll group had significantly higher grill weight than 15-20-25% DDGS fed groups. Breast and thigh weight in 0-15% DDGS groups were statistically higher compared to the 20-25% DDGS groups.

Shear force values of the breast were significantly higher in 0% DDGS group than in the 15-20-25% DDGS groups.
Cooking loss were significantly higher in 0% DDGS group than in the 15-20-25% DDGS groups.
Dry material content of the breast meat was statistically lower in 20% DDGS groups than in the other groups. Fat content of the breast meat was significantly higher in controll group than in 15-20-25% DDGS groups.
In a few fatty acid content there were significant difference among gropus. However MUFA content were lower and PUFA content were higher in groups fed 15-20-25% DDGS included diet.
In RBC haemolysate reduced glutathione content were higher in 20-25% DDGS groups likewise in the 1. experiment. In liver homogenizates reduced glutathione content dose dependent changes occurred. The DDGS inclusion increased the reduced glutathione content increased.
In plasma glutathione peroxidase activity were significantly higher in controll and 15% DDGS groups than in 20-25% DDGS included diet fed groups. In liver homogenizates the glutathione peroxidase activity were significantly higher in the 15-20-25% DDGS groups than in the controll group. There were no significant differences in the results that not mentioned.
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3.3. Effect of 10 % DDGS on B.U.T. Big 6 turkey performance and meat quality parameters – 3. experiment

In the beginning and in the end of the experiment there were no significant difference in body weight. Unlike from day 72 to day105 the DDGS group had significantly higher body weight than the controll group.
There were significant difference in grill, breast and thigh weight between the groups.
Shear force and cooking loss of the group that fed DDGS included diet had significantly higher values than in the controll group.
Dry matter content of the breast meat in 10% DDGS group was statistically higher than int he 0% DDGS group. There were no significant differences in the results that not mentioned.

3.4. Effect of 15 % DDGS on B.U.T. Big 6 turkey performance and meat quality parameters – 4. experiment

During the experiment there were no significant difference in body weight. Excepting the day 126 when DDGS group had significantly higher body weight than the controll group.
Grill, breast and drumstick weight were not affected by the DDGS inclusion diet. However the thigh weight in the DDGS group was significantly higher than in controll group.
Shear force of the group that fed DDGS included diet had significantly higher values than in the controll group. But the cooking loss was significantly lower in the 15% DDGS group.
Protein content of the breast meat was statistically higher in the group that fed DDGS included diet.
Among the experimented fatty acid contents of the breast meat there were only two cases when statistically proofed difference were occurred (linoleic and eicosatrienoic acid). SAT content was significantly and MUFA mathematically higher in controll group. Although PUFA content was significantly higher in 15% DDGS group according to the higher linoleic acid content in the breast.
MDA content in plasma, RBC haemolysate and liver homogenizate were significantly higher in group that fed DDGS included diet.
Reduced glutathione content of the plasma and RBC haemolysate were statistically lower in 15% DDGS group than in 0% DDGS group. However in the liver homogenizate the content of reduced glutathione was higher in 15% DDGS group than in 0% DDGS group.
Glutathione peroxidase activity in plasma and RBC haemolysate were lower in 15% DDGS group than in 0% DDGS group. However in the liver homogenizate the glutathione peroxidase activity was higher in 15% DDGS group than in 0% DDGS group.
MDA content in breast meat at 45 min. after incubation was significantly lower in DDGS group than in controll group.

3.5. New scientific results

1. I demonstrated that 15% DDGS inclusion in the diet increase the protein content of the chicken breast meat compared to the 10-20-25% DDGS inclusion level.

2. I concluded that 15% DDGS inclusion in the grower-finisher diet (from 6. weeks of age) do not affect the production and meat quality parameters in turkey hens. Moreover I found that diet containing 15% DDGS increase the protein content of the turkey breast meat.

3. I proofed that 15-20-25% DDGS inclusion level in the broiler diet increase the PUFA content of the chicken breast meat.

4. I demonstrated that chicken and turkey diet that contain15% DDGS do not reduce the oxidative stability of the breast meat.

5. I concluded that 15% DDGS inclusion in the broiler and turkey diet do not affect substantially the intensity of lipidperoxidation in the studied tissues as well as its effect on the antioxidant capacity in regard to the investigated glutathione redox system that efficiently tolerated the oxidative stress factors principally in the liver.

4. CONCLUSIONS AND DISCUSSION

4.1.Changes of the production parameters in broiler chicken

I concluded from the result that DDGS influence the body weight in broiler chickens. 15% DDGS inclusion level in the broiler diet does not effect negatively the live weight however the higher inclusion levels significantly reduce the body weight.

According to the feed consumption and FCR result higher than15% DDGS inclusion level in the diet had a negative impact on these parameters. I concluded that diet containing various level of DDGS does not affect the vitality.

4.2.Changes of the meat quality parameters in broiler chicken

I demonstrated that consumption of DDGS containing diet influence some meat quality parameters. Protein content of the breast meat had the highes result in case of 15% DDGS containing diet. Water holding capacity increased as the DDGS inclusion level increased up to 25%. According to the breast meat color results DDGS included diet increased the redness (a*) and yellowness (b*) of the breast meat.

4.3.Changes in lipidperoxidation and glutathione redox system in broiler chicken

Various level of DDGS inclusion (0-25%) does not affect principally the malondialdehide content in the tested tissues such as plasma, RBC haemolysate, liver homogenizate and breast meat. Reduced glutathione content increased in RBC haemolysate and liver homogenizate as the DDGS inclusion level increased. Dose dependent decreasing occurred in glutathione peroxidase activity in plasma but increasing in the liver homogenizate according to the higher PUFA content of the DDGS.
I demonstrated that increasing level of DDGS in the diet does not effect increasing malondialdehyde content in the breast meat.

4.4.Changes of the production parameters in turkey

I concluded from the result that DDGS influence the body weight in turkey hens. Or 10 either 15% DDGS inclusion level in the turkey grower-finisher diet effect positively the live weight.
According to the feed consumption and FCR result up to 15% DDGS inclusion level in the diet does not affect negatively these parameters. I concluded that diet containing various level of DDGS does not affect the vitality.

4.5.Changes of the meat quality parameters in turkey

I demonstrated that consumption of DDGS containing diet influence some meat quality parameters. Water holding capacity decreased as the DDGS inclusion level reached the 10% but increased as the DDGS inclusion level increased up to 15%. According to the breast meat color results DDGS included diet increased the redness (a*) and yellowness (b*) of the breast meat. Consumption of the DDGS included diet mathematically but not statistically increased the unsaturated fatty acids content in breast meat that may influence the lipidperoxidation in the meat.

4.6.Changes in lipidperoxidation and glutathione redox system in turkey

15% DDGS inclusion affect the malondialdehide content in the tested tissues such as plasma, RBC haemolysate, liver homogenizate. Reduced glutathione content decreased in plasma and RBC haemolysate but increased in liver homogenizate as the DDGS inclusion level increased. Different amino acid and energy content of the diets can cause variance in this parameter that occurred in the liver but not in the periphery. I demonstrated similar tendency in glutathione peroxidase activity that may be caused by the different co-substrate content. in plasma but increasing in the liver homogenizate according to the higher PUFA content of the DDGS.
I demonstrated that 15% of DDGS in the diet does not affect principally the malondialdehyde content in the breast meat.

4.7.Recommendation for DDGS inclusion level of broiler chicken and turkey diet

I concluded that reasonable amount is not more than 15% DDGS inclusion level in broiler diet during the whole rearing stages (from 1 day to 42 day). In case of turkey I concluded that 15% DDGS inclusion in the grower-finisher diet (from 6 weeks to 20 weeks) may be acceptable without any adverse effect on production and meat quality parameters.

5. PUBLICATIONS ON THE SUBJECT OF THE THESIS

5.1.Scientific articles about the topic of the thesis

Scientific articles published in journals with impact factor:

Heincinger M., K. Balogh, H. Fébel, M. Erdélyi, M. Mézes (2011): Effect of diets with diferent inclusion levels of distillers dried grain with solubles combined with lysine and methionine supplementation on the lipid peroxidation and glutathione status os chickens. Acta Veterinaria Hungarica 59 (2) 195-204.

Heincinger M., K. Balogh, M. Mézes, H. Fébel (2012): Effects of Distillers Dried Grain with Soluble (DDGS) on Meat Quality, Lipid Peroxide and Some of Antioxidant Status Parameters of Fattening Turkey. Journal of Poultry Science 49: 268-272.

Scientific articles published in other supervised journals:

Weber M., Balogh K., **Heincinger M**., Borbély A., Ábrahám Cs., Forgó G., Mézes M. (2008): E-vitamin kiegészítés hatása a pulykák termelési eredményeire és a hús porhanyósságára, eltarthatóságára. A Baromfi XI. évf. 1.

Articles published in full text form in conference materials:

Heincinger M., M. Mézes (2009): Effect of different DDGS inclusion levels on chicken breast quality. XXI International Poultry Symposium PB WPSA, Jelenia Góra, Poland, 2009.

Heincinger M., M. Mézes (2009): Productivity and meat quality aspect of feeding DDGS to broilers. IV. International Scientific PhD. Students Conference Nitra, 2009.

Articles published as an abstract in conference materials:

Borbély A., Weber M., Balogh K., Ábrahám Cs., **Heincinger M**., Mézes M. (2008): E-vitamin adagolás hatása pulyka mellhús minőségére. XIV. Ifjúsági Tudományos Fórum, április 3. Keszthely

Heincinger M., Mézes M. (2009): Különböző mennyiségben etetett DDGS hatása brojler csirkék és pulykák teljesítményére. Állattenyésztés-tudományi Doktori Iskola V. fórum, április 15. Gödöllő.

Heincinger M., Mézes M. (2009): Különböző mennyiségben etetett DDGS hatása brojler csirkék teljesítményére. XV. Ifjúsági Tudományos Fórum, április 16. Keszthely

Balogh K. , M. Weber, **M. Heincinger**, J. Seenger, M. Mézes (2011): Lipid peroxide and gluthation redox status of liver, spleen, and kidney in different genotypes of pigs Fatty Pig Science and Utilisation International Conference, Herceghalom, 2011.

5.2.Scientific articles about other than the thesis

Scientific articles published in other supervised journals:

Heincinger M.., Seenger J., Ábrahám Cs., Radnóczi L. (2007): Genotype effect on the palatability of the pork loin. Bulletin of the Szent István University 15-22.

Heincinger M.., Ábrahám Cs., Weber M., Balogh K., Kiss Z., Mézes M. (2007): A vágottárú minőségének javítása hízósertések takarmányának E-, illetve C-vitamin kiegészítésével. A Hús 2007/4.

Heincinger M.., Weber M., Balogh K., Seenger J., Ábrahám Cs., Mézes M. (2008): Egyes hazai sertésfajták és hibridek húsminőségi paramétereinek összehasonlítása. A sertés 2008/1. 34-38.

Articles published in full text form in conference materials:

Heincinger M.., Weber M., Seenger J., Balogh K., Ábrahám Cs., Mézes M. (2008): Magyarországon széles körben alkalmazott sertés fajták és hibridek összehasonlítása a karaj nyíróerő értéke és sütési vesztesége alapján. 1.Gödöllői Állattenyésztési Tudományos Napok, Gödöllő, 2008.

Superviesd articles published as an abstract in conference materials:
Heincinger M., Seenger J., Ábrahám Cs., Mézes M. (2007): A genotípus hatásának vizsgálata a sertéskaraj porhanyósságára. XIII. Ifjúsági Tudományos Fórum, március 22. Keszthely.

Heincinger M., Weber M., Seenger J., Balogh K., Ábrahám Cs., Mézes M. (2008): Magyarországon széles körben alkalmazott sertés fajták és hibridek összehasonlítása a karaj nyíróerő értéke és sütési vesztesége alapján. I. Gödöllői Állattenyésztési Napok, április 11-12, Gödöllő.

Seenger J., H. Fébel, Cs. Ábrahám, M. Weber, K. Balogh, M. Horvainé Szabó, M. **Heincinger, M**. Mézes (2011): Performance test results of Swallow Bellied Mangalitza compared to modern genotypes. Fatty Pig Science and Utilisation International Conference, Herceghalom, 2011.