The Effect of Coenzyme Q_{10} and Lipoic Acid Added to the Feed of Hens on Physical Characteristics of Eggs

Dušan TERČIČ [1] (✉)
Barbara KOTNIK [1]
Gregor GORJANC [1]
Petra JAZBEC KRIŽMAN [2]
Antonija HOLCMAN [1]

Summary

This study was designed to investigate whether inclusions of coenzyme Q10, alpha lipoic acid and their combination into diets of hens improve egg quality characteristics. Forty-eight, 33 weeks old Lohmann Brown hens were assigned randomly to four groups of 12 hens each and fed either a basal diet or basal diet supplemented with 2 g/kg coenzyme Q10, 0.4 g/kg alpha lipoic acid and 2 g/kg coenzyme Q10 plus 0.4 g/kg alpha lipoic acid. The diets were fed for 12 weeks. Eggs were weekly examined for interior or exterior quality characteristics. There were no effects of dietary treatments on egg shape index. Coenzyme Q10 supplementation resulted in a reduction in egg shell colour (darker shells) and yolk colour (paler yolks) and higher incidence of blood and meat spots, which reduce the internal quality of the egg. Alpha lipoic acid had no effect on egg weight, egg shell colour, egg shell density, egg shell weight, egg shell thickness, yolk colour, incidence of blood and meat spots but increased shell strength, albumen height and Haugh units values were noted. Egg shell strength for hens supplemented with alpha lipoic acid was greater than for control hens. The results of the experiment indicated that alpha lipoic acid supplementation to the diet of layers may be of practical value due to the increased egg shell strength and better albumen characteristics without any adverse effect on other egg quality traits.

Key words

hens, coenzyme Q10, alpha lipoic acid, egg quality

[1] University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Groblje 3, 1230 Domžale, Slovenia
✉ e-mail: dusan.tercic@bf.uni-lj.si
[2] National Institute of Chemistry, Hajdrihova 19, 1001 Ljubljana, Slovenia

Received: May 15, 2011 | Accepted: June 25, 2011

Aim

Coenzyme Q10 (CoQ10), also known as ubiquinone, CoQ and vitamin Q10 is a lipid soluble, vitamin-like, endogenously synthesized molecule that has several cell functions (Frei et al., 1990). Relatively high concentrations of CoQ10 are found in the mitochondria of cells where it has a critical role in energy production (Ernster et al., 1995). Because dysfunctional energy metabolism has been cited as a contributing factor for a number of conditions, CoQ10 has been indicated in the treatment of cardiac, neurologic, oncologic, and immunologic disorders (Bonakdar and Guarneri, 2005). Additionally, CoQ10 has acquired increasing attention with regard to its function in the reduced form (ubiquinol) as an antioxidant (Crane, 2001). Alpha lipoic acid (LA) and its reduced form, dihydrolipoic acid, are also powerful antioxidants. LA scavenges hydroxyl radicals, hypochlorous acid, peroxynitrite, and singlet oxygen. Dihydrolipoic acid also scavenges superoxide and peroxyl radicals and can regenerate thioredoxin, vitamin C, and glutathione, which in turn can recycle vitamin E (Packer et al., 2001). Therefore CoQ10 and LA have applications as pharmaceutical and dietary supplements and as cosmetic ingredients. On the other hand, in chickens, only a few studies have been performed, mainly on broilers. This study was designed to investigate whether supplementation with CoQ10 and/or LA effects the physical characteristics of table eggs.

Material and methods

Forty-eight Lohmann Brown layers were obtained from a commercial farm at 33 weeks (wk) of age and housed individually in wire laying cages under a photoperiod of 14 h light : 10 h darkness. From 16 to 17 wk of age, the birds were fed a commercial layer diet, which was formulated to meet or exceed National Research Council (1994) nutrient requirements for laying hens. All birds were allocated to one of the four dietary treatments, each comprised of twelve adjacently caged hens fed individually. The hens were fed the basal diet (control group) or the basal diet supplemented with 2g/kg CoQ10 (group 1), 0.4 g/kg LA (group 2) and 2g/kg CoQ10 plus 0.4 g/kg LA (group 3). All data were collected per cage. All hens were adapted to the new environment two weeks before being placed on experiment. The experimental phase consisted of one period of 12 wk and lasted from 35 to 47 wk of age. Lohmann Brown hens were given access ad libitum to 125 g of feed per hen per day. Drinking water was freely available. Egg characteristics were measured on a weekly basis by saving produced eggs from one day production. External and internal egg quality traits including egg weight (EW), egg shell colour (ESC), egg shell weight (ESW), albumen height (AH), Haugh units (HU) and yolk colour (YC) were measured by an egg multitester instrument (QCM-System, TSS, York, UK). The incidence of blood and meat spots (BMS) on the eggs was determined by a single controller that was blinded to treatments. Each egg that contained visible blood or meat spots were recorded. In addition, egg shell strength (ESS) was quantified through the measurement of maximum fracture loads using a 3345 Single Column Testing Machine (Instron, High Wycombe, UK), with pressure applied across the width of the shell. Egg shell thickness (EST) was measured in these eggs by using a mechanical micrometer. The egg shape index (ESI) was calculated by the formula ESI = (ESL/ELL)×100, where ESL is the short length of an egg, and ELL is the long vertical length of an egg. The surface area (SA) of the egg was calculated using a formula $SA(cm^2)=4.6\times(EW)^{0.66}$ and the shell density (ESD) was calculated as the weight of the dry shell divided by the surface area. All data were analysed using the statistics software of R statistical program and the following additional packages: Multcomp (Hothorn et al., 2008), Ime4 (Bates and Maechler, 2010) and Zelig (Imai et al., 2008). Tukey's test was used to compare treatment and main effect means, as appropriate. A significance level of $P<0.05$ was used for all comparisons.

Results and discussion

Coenzyme Q10's and lipoic acid's wide-ranging cellular properties implicate them for the potential treatment of numerous conditions that may improve with mitochondrial and antioxidant support. Geng et al. (2004) and Nakamura et al. (1996) studied effects of CoQ10 supplementation on growth performance and ascites in broilers. They showed that dietary CoQ10 supplementation was beneficial in reducing the ascites mortality in broilers. However, to our knowledge, no systematic empirical research exists addressing the question of how administration of two popular antioxidant agents, CoQ10 and LA affects table egg quality. For the egg industry worldwide, the production of eggs which are of good egg shell quality and good internal quality is critical to the economic viability of the industry. Neither LA nor CoQ10 supplementation did not have a significant effect on ESI (Table 1). Hens fed diets containing CoQ10 had significantly ($P<0.05$) heavier eggs, lower shell weight, density and thickness compared to LA supplementation, whereas no significant differences in these traits were found when both treatments were compared with control group. The control diet had significantly greater ESC than the CoQ10 and CoQ10 plus LA ($P < 0.05$) with a ESC of 37.0 % (Table 1). The minimum force required to cause failure of the shell was recorded. Eggs from treatment with LA had significantly higher ESS, whereas CoQ10 had no effect. The amount and thickness of the egg shell have been found to be related to egg shell strength, but the later is determined not just by the amount of shell that is present, but also by the quality of construction of the shell (Roberts, 2004). The current study suggests that addition of LA does not significantly influence the amount of eggshell material deposited during shell formation but LA can improve egg shell strength.

The interior of the hen's egg consists of the yolk and the white or albumen. Albumen height and Haugh Units measure the viscosity of the thick albumen. A higher Haugh unit score indicates a better egg quality. A number of nutritional factors have been reported to affect albumen quality, although Williams (1992) concluded that albumen quality is not greatly influenced by bird nutrition. Nevertheless, albumen height and Haugh units increased with LA supplementation and with combination CoQ10 plus LA (Table 2). The CoQ10 dietary supplementation did not affect AH and HU. A good quality egg should be free from internal blemishes such as blood and meat spots. Number of blood and meat spots was higher in CoQ10 group in comparison with control group. Jeffrey and Walker (1950) found a strong positive correlation between darkness of shell colour and % of coloured meat spots. Our results agree with the findings of Jeffrey and

Table 1. Effect of CoQ10 and LA supplementation on external egg characteristics

External egg characteristics	Control group	LA	CoQ10	CoQ10+LA
ESI (%)	77.8 ^{a} (77.1; 78.6)	77.3 ^{a} (76.6; 78.1)	77.7 ^{a} (77.0; 78.5)	77.6 ^{a} (76.8; 78.3)
EW (g)	59.6 ^{ab} (58.0; 61.2)	58.8 ^{a} (57.2; 60.5)	60.2 ^{b} (58.6; 61.8)	59.3 ^{ab} (57.7; 61.0)
ESC (%)	37.0 ^{a} (35.5; 38.4)	35.7 ^{ac} (34.2; 37.2)	33.6 ^{b} (32.2;35.0)	34.2 ^{bc} (32.8; 35.7)
ESW (g)	5.8 ^{ab} (5.7; 5.9)	5.9 ^{a} (5.8; 6.0)	5.7 ^{b} (5.6; 5.8)	5.7 ^{b} (5.6; 5.8)
ESD (mg/g)	80.8 ^{ab} (79.5; 82.0)	82.2 ^{a} (80.9; 83.5)	79.9 ^{b} (78.6; 81.1)	79.8 ^{b} (78.6; 81.0)
EST (mm)	0.389 ^{ab} (0.383; 0.394)	0.392 ^{a} (0.387; 0.398)	0.384 ^{b} (0.379; 0.390)	0.383 ^{b} (0.378; 0.388)
ESS 1 (N)	39.2 ^{a} (37.9; 40.5)	41.6 ^{b} (40.4; 43.0)	40.6 ^{ab} (39.4; 41.8)	40.2 ^{ab} (38.9; 41.4)
ESS 2 (N)	38.0 ^{a} (36.9; 39.0)	39.9 ^{b} (38.8; 40.9)	39.8 ^{ab} (38.8; 40.8)	39.7 ^{b} (38.7; 40.7)

Abbreviations: ESI=egg shape index; EW=egg weight; ESC=egg shell colour; ESW=egg shell weight; ESD=egg shell density, EST=egg shell thickness; ESS1=egg shell strength; ESS2=egg shell strength corrected on the same egg shell thickness; $^{a.b.c}$ Means within rows with the same superscript letters are not significantly different (P≤0.05); Means in brackets represent confidence interval of the mean

Table 2. Effect of CoQ10 and LA supplementation on internal egg characteristics

Internal egg characteristics	Control group	LA	CoQ10	CoQ10+LA
AH (mm)	7.2 ^{a} (6.7; 7.6)	7.6 ^{b} (7.2; 8.0)	7.4 ^{ab} (7.0; 7.9)	7.6 ^{b} (7.1; 8.0)
HU	83.8 ^{a} (81.1; 86.4)	86.5 ^{b} (83.8; 89.2)	85.3 ^{ab} (82.7; 87.9)	86.2 ^{b} (83.5; 88.8)
YC (Roche)	12.0 ^{a} (11.9; 12.2)	11.9 ^{ab} (11.8; 12.0)	11.8 ^{b} (11.7; 11.9)	11.8 ^{b} (11.7; 11.9)
BMS	28.6 ^{a} (21.2; 37.0)	36.3 ^{ab} (27.7; 45.6)	46.3 ^{b} (38.0; 54.9)	38.0 ^{ab} (29.8; 46.7)

Abbreviations: AH=albumen height; HU=Haugh units; YC=yolk colour; BMC=blood and meat spots; $^{a.b.c}$ Means within rows with the same superscript letters are not significantly different (P≤0.05); Means in brackets represent confidence interval of the mean

Walker (1950) since there was a consistent relationship between egg shell colour and incidence of blood clots. Yolk colour preference varies considerably depending on the part of the world (Roberts, 2004). Yolk color became significantly lighter with CoQ10 and CoQ10 plus LA content (Table 2).

Conclusions

In this study, the effects of supplementation of CoQ10, LA and their combination on egg quality parameters were investigated, and their effectiveness was compared. Supplemental CoQ10 had effects on shell colour, yolk colour and on number of blood nad meat spots. In comparison with control group it had no effects on other egg quality parameters. Compared to controls, supplemental LA significantly improved egg shell strength, albumen height and Haugh units. Since current problems with internal quality often involve a very low viscosity of the thick albumen and poor egg shell strength supplementation of LA may extend the profitability of a layer flock.

References

Bates D. and Maechler M. (2010). Linear mixed-effects models using S4 classes. R package version 0.999375-33. http://CRAN.R-project.org/package=lme4

Bonakdar R.A., Guarneri E. (2005). Coenzyme Q10. Am Fam Physician 72: 1065-1070.

Crane F.L. (2001). Biochemical functions of coenzyme Q10. J Am Coll Nutrition 20: 591-598.

Ernster L., Dallner G. (1995). Biochemical, physiological and medical aspects of ubiquinone function. Biochim Biophys Acta 1271: 195–204.

Frei B., Kim M.C., Ames B.N. (1990). Ubiquinol-10 is an effective lipid-soluble antioxidant at physiological concentrations. Proc Natl Acad Sci 87: 4879–4883.

Geng A. L., Guo Y. M., Yang Y. (2004). Reduction of ascites mortality in broilers by coenzyme Q10. Poultry Sci 83: 1587–1593.

Hothorn T., Bretz F., Westfall P. (2008). Simultaneous inference in general parametric models. Biometrical J 50: 346-363.

Imai K., King G., Olivia L. (2008). Toward a common framework for statistical analysis and development. J Comput Graph Stat 17: 892-913.

Jeffrey F. P., Walker C. E. (1950). The relationship between egg shell color and incidence of colored meat spots. Poultry Sci 29: 244-247.

Nakamura K., Noguchi K., Aoyama, T., Nakajlma T., Tanimura N. (1996). Protective effect of ubiquinone (coenzyme Q9) on ascites in broiler chickens. Br Poult Sci 37: 189–195.

National Research Council. 1994. Nutrient Requirements of Poultry. 9th rev. ed. National Academy Press, Washington, DC

Packer L., Kraemer K., Rimbach G. (2001). Molecular aspects of lipoic acid in the prevention of diabetes complications. Nutrition. 17: 888-895.

Roberts J.R. Factors affecting egg internal quality and egg shell quality in laying hens. (2004). J Poult Sci 41: 161-177.

Williams K. C. (1992). Some factors affecting albumen quality with particular reference to Haugh unit score. World Poultry Sci J 48: 5-16.

acs76_37