EFFECT OF LONG TERM EXPOSURE TO DIFFERENT DIETARY FATTY ACIDS ON PRODUCTION AND EGG QUALITY OF LAYERS

by

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DECLARATION

I hereby declare that this dissertation submitted by me to the University of the Free State for the degree, **Magister Scientiae Agriculturae**, is my own independent work and has not previously been submitted by me at another University/Faculty. I further cede copyright of the dissertation in favour of the University of the Free State.

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ABSTRACT

The objectives of this study was to determine the long-term effects of dietary fatty acid saturation on the production performance, egg- and bone quality characteristics of laying hens at end-of-lay (58 – 74 weeks of age). Five *iso-energetic* (12.6 MJ AME/kg DM) and *iso-nitrogenous* (170 g CP/kg DM) diets were formulated using different lipid sources at a constant 30 g/kg inclusion level. The control diet consisted of a blend (50 : 50) of linseed- and fish oil. The other treatments consisted of pure fish oil (n-3), sunflower oil (n-6), high oleic acid (HO) sunflower oil (n-9) and tallow (saturated fatty acids). Two hundred, Hy-Line Silver-Brown laying hens were randomly allocated to the five dietary treatments (n = 40 replicates/treatment) at 20 weeks of age.

During 58, 62, 66, 70 and 74 weeks of age, all eggs produced were recorded and individually weighed while feed intake, as well as body weights of birds were determined. During the specific collection weeks, twenty eggs/treatment/day (n = 140 eggs/treatment/week) were selected for determining internal- and external egg quality parameters. During week 66 of age, twenty four eggs/treatment (n = 24/treatment) were randomly selected for the analysis of egg yolk fatty acid methyl esters (FAMEs) and lipid oxidation. At the end of the experimental period (74 weeks of age) ten birds per treatment (n = 10/treatment) were randomly selected for the determination of bone quality characteristics. Data were statistically analysed ($P<0.05$) using a fully randomised one-way ANOVA procedure of SAS (2012).

The polyunsaturated n-3 (PUFA n-3) treatment had the lowest ($P<0.05$) feed intake (97.5 g/b/d), while that of the polyunsaturated n-6 (PUFA n-6) treatment (102.4 g/b/d) were the highest. Dietary treatment had no effects ($P>0.05$) on egg production, feed efficiency or body weight of hens. Also, no effect ($P>0.05$) was recorded on any of the external eggshell quality parameters. Although bone quality parameters were influenced ($P<0.05$) by dietary fatty acid saturation, results were variable and no significant trend could be established. The monounsaturated n-9 (MUFA n-9) treatment resulted in the highest ($P<0.05$) humerus weight (5.65 g), femur weight (10.34 g), tibia- (51.07%) and femur ash content (52.99%). The mean humerus weight was the lowest ($P<0.05$) for the control treatment (4.88 g), while the SFA treatment had the lowest ($P<0.05$) tibia ash (46.15%), femur ash (46.56%) and percentage femur bone (0.517%). Percentage femur bone (0.570%) was the highest ($P<0.05$) for the PUFA n-3 treatment.

Besides yolk colour (P<0.001), all other internal egg quality parameters remained unaffected (P>0.05). Additionally, egg yolk fat-, dry matter- and moisture content were not affected (P>0.05) by dietary fatty acid saturation, while the egg FAME were altered (P<0.001) according to the dietary FAME. Eggs from the control treatment resulted in the highest (P<0.05) thiobarbituric acid reactive substances (TBARS) for both fresh (0.229 mg malonaldehyde/kg fat) and stored eggs (0.225 mg malonaldehyde/kg fat), while also having the highest (P<0.05) peroxide value (PV) for stored eggs (3.159 milliequivalent peroxide value/kg fat). The MUFA n-9 treatment resulted in the lowest (P<0.01) TBARS for both fresh (0.165 mg malonaldehyde/kg fat) and stored eggs (0.160 mg malonaldehyde/kg fat), as well as the lowest (P<0.05) PV for stored eggs (1.871 milliequivalent peroxide value/kg fat).

Finally it can be concluded that the long term exposure of laying hens to fatty acid enriched diets will generally not have a significant detrimental effect on egg production or egg quality characteristics. However, it remains important to minimise the level of lipid oxidation in fatty acid enriched diets. The role of n-9 MUFAs and long chain n-3 PUFAs in promoting bone quality warrants further studies. Lastly, the financial viability and consumer preference for fatty acid enriched eggs must be quantified within the South African market.

OPSOMMING

Die doelwitte van die studie was om die lang termyn effekte van die dieet lipied versadigheid op die eier produksie sowel as eier- en been kwaliteitseienskappe van lêhenne te bepaal tydens die einde van produksie (58 – 74 weke oud). Vyf energie- (12.6 MJ AME/kg DM) en proteïen ekwivalente (170 g CP/kg DM) diëte is geformuleer deur gebruik te maak van verskillende lipied bronne teen ‘n konstante insluitingsvlak van 30 g/kg. Die kontrole behandeling het bestaan uit ‘n kombinasie (50 : 50) van lynsaad- en visolie. Die ander behandelings het bestaan uit suiwer visolie (n-3), sonneblomolie (n-6), hoë oleïensuur sonneblomolie (n-9) en beesvet (versadigde vetsure). Twee honderd, Hy-Line Silwer-Bruin lêhenne is ewekansig ingedeel in die vyf dieet behandelings (n = 40 herhalings/behandeling) gedurende 20 weke ouderdom.

Gedurende 58, 62, 66, 70 en 74 weke ouderdom, is alle eiers wat geproduseer is aangeteken en individueel geweeg, terwyl voerinname sowel as liggaamsgewig van die henne individueel bepaal is. Gedurende dié spesifieke weke is twintig eiers/behandeling/dag (n = 140 eiers/behandeling/week) geselekteer vir die bepaling van interne en eksterne eier kwaliteitseienskappe. Gedurende 66 weke ouderdom is vier en twintig eiers/behandeling (n = 24/behandeling) ewekansig geselekteer vir die bepaling van die eiergeel vetsuurprofiele en lipied oksidasie. Aan die einde van die eksperimentele tydperk (74 weke ouderdom) is tien henne per behandeling (n = 10/behandeling) ewekansig geselekteer vir die bepaling van been kwaliteitseienskappe. Data is statisties ontleed ($P<0.05$) deur middel van ‘n volledige ewekansige ANOVA prosedure van SAS (2012).

Die poli-onversadigde n-3 behandeling het die laagste ($P<0.05$) voerinname (97.5 g/hen/dag) gehad, terwyl die voerinname van die poli-onversadigde n-6 behandeling (102.4 g/hen/dag) die hoogste was. Dieet behandelings het geen effek ($P>0.05$) op eier produksie, voerdoeltreffendheid of liggaamsgewig van die henne gehad nie. Net so, was daar ook geen effek ($P>0.05$) op enige van die eksterne eierdop kwaliteitseienskappe nie. Alhoewel die been kwaliteitseienskappe beïnvloed is ($P<0.05$) deur die dieet se vetsuurversadigheidsvlakke, was die resultate wisselvallig en kon geen merkwaardige tendense waargeneem word nie. Die mono-onversadigde n-9 behandeling het die hoogste ($P<0.05$) humerus gewig (5.65 g), femur gewig (10.34 g), tibia- (51.07%) en femur (52.99%) as-inhoud gehad. Die gemiddelde humerus gewig was die laagste ($P<0.05$) vir die kontrole behandeling (4.88 g), terwyl die versadigde behandeling die laagste ($P<0.05$) tibia

(46.15%), en femur (46.56%) as-inhoud gehad het, sowel as die laagste persentasie persentasie femur been (0.517%). Persentasie femur been (0.570%) was die hoogste (P<0.05) vir die PUFA n-3 behandeling.

Afgesien van eiergeel kleurtelling (P<0.001), is geen ander interne eier kwaliteitseienskappe beïnvloed nie (P>0.05). Verder is die eiergeel se vet-, droë materiaal- en voginhoud ook nie beïnvloed (P>0.05) deur die dieet se vetsuurversadigheidsvlakke nie, terwyl die eier se vetsuurprofiel wel betekenisvol (P<0.001) verander het op grond van die dieet se vetsuur profiel. Die kontrole behandeling het tot die hoogste (P<0.05) tiobarbituursuur reaktiewe bestanddele (TBARS) in vars (0.229 mg malonaldehied/kg vet) en gestoorde eiers (0.225 mg malonaldehied/kg vet) gelei, asook die hoogste (P<0.05) peroksied waardes (PW) vir gestoorde eiers (3.159 milliekwivalent peroksied/kg vet). Die mono-onversadigde n-9 behandeling het die laagste (P<0.01) TBARS vir beide vars (0.165 mg malonaldehied/kg vet) en gestoorde eiers (0.160 mg malonaldehied/kg vet) gehad, asook die laagste (P<0.05) PW vir gestoorde eiers (1.871 milliekwivalent peroksied/kg vet).

Ten slotte kan die gevolgtrekking gemaak word dat die lang termyn blootstelling van lêhenne aan vetsuur verrykte diëte oor die algemeen geen merkwaardige nadelige effek op eier produksie of eier kwaliteit het nie. Dit bly egter belangrik om die vlakke van lipied oksidasie in die vetsuur verrykte diëte tot ‘n minimum te beperk. Die rol van n-9 mono-onversadigde vetsure en lang ketting n-3 poli-onversadigde vetsure in been kwaliteitseienskappe moet verder ondersoek word. Laastens, moet ‘n finansiële lewensvatbaarheidstudie en die verbruiker se voorkeure vir vetsuur verrykte eiers gekwantifiseer word binne die Suid-Afrikaanse mark.