

**Effects of feeding omega-3 fatty acids
and vitamin E on the chemical
composition and microbial population of
broiler meat**

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Summary

Title: Improving the nutritional value of broiler meat through increased omega-3 fatty acid and vitamin E content.

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Lipids remain one of the most important nutrients required by broilers. The growing awareness that some Western societies have too high a dietary ratio of n-6/n-3 polyunsaturated fatty acids is of direct relevance to broiler nutrition and lipid metabolism. Meaningful quantities of n-3 polyunsaturates have been incorporated into major poultry tissues, so that the production of broiler meat with high n-3 polyunsaturates becomes advantageous for the broiler industry as they are perceived as having a 'healthier' lipid profile. Unfortunately, such broiler meat is rather susceptible to oxidative deterioration, and oxidation often determines shelf life of poultry meat products. The addition of α -tocopherol (vitamin E) to broiler diets is an effective means of improving the oxidative stability of broiler meat. Elevated α -tocopherol levels in broiler feeds increase tissue concentrations thereof resulting in improved stability of membranal structures which may be expected to increase the oxidative stability of broiler meat and meat products.

Three investigations were done at Mariendahl Poultry Research Station in Stellenbosch. The broilers were kept in 1 x 0.4 x 0.5 m cages in a broiler rearing house. All the trials started with day-old chicks, except experiment 1 where 3-week old broilers were used. At the end of trials 2 and 3 the 6-week old broilers were slaughtered and the carcasses prepared for chemical analysis.

Experiment 1: **Metabolisable energy of Canola acid oil and Famarol acid oil for broiler chickens.**

In trials with 21-day-old male broilers the true metabolisable energy value, corrected for nitrogen retention (TMEn) was determined by the balance method for Canola acid oil (CAO) and Famarol acid oil (FAO). The trials were duplicated, each time using different samples of the two oils from the same source (experiment 1 and 2). Each of the two oils were blended in two ratios with a basal diet to form the test diets, viz. 100% Basal; 96% Basal: 4% Oil; 92% Basal: 8% Oil. In experiment 3, 50 % bran was added to the maize to form the basal diet. The balance trials lasted for 3 days after an adaptation period of 4 days. The TMEn values determined by regression for the broilers of CAO did not differ significantly ($P>0.05$) between experiments 1 and 2. However, the value for experiment 3 was significantly ($P<0.05$) higher than those for experiments 1 and 2. The TMEn values of FAO also did not differ significantly ($P>0.05$) between experiments 1 and 2, although the value for experiment 3 was significantly higher than that of experiment 1. The addition of 50 % bran to the basal diet in experiment 3 could have stimulated the digestive breakdown process and hence increase the secretion of digestive enzymes. This could lead to an increase in the utilisation of the test lipid and therefore an increase in the TMEn value. The TMEn values of CAO differed significantly ($P<0.05$) from those of FAO for all three the experiments (exp. 1: 30.6 ± 0.399 MJ/kg for CAO vs. 25.9 ± 0.441 MJ/kg for FAO; exp. 2: 31.0 ± 0.633 MJ/kg for CAO vs. 26.1 ± 0.668 MJ/kg for FAO; exp. 3: 32.1 ± 0.867 MJ/kg for CAO vs. 27.1 MJ/kg for FAO).

Experiment 2: Effects of various dietary n-6/n-3 fatty acid ratios on the performance and body composition of broilers.

The dietary effects of various combinations of Canola acid oil (CAO, a high level of C18:3n-3 and MUFA) and Famarol acid oil (FAO, a high level of 18:2n-6 and SFA) on tissue fatty acid composition were studied in broiler carcasses and abdominal fat pads. From day-old to six weeks, chicks were fed one of six diets containing 100% FAO, 80% FAO-20% CAO, 60% FAO-40% CAO, 40% FAO-60% CAO, 20% FAO-80% CAO, 100% CAO. There were no statistical differences ($P>0.05$) in average daily gain (1.71 ± 0.059 g) or feed conversion ratios (1.97 ± 0.051) among dietary groups. No statistical differences ($P>0.05$) were found in the chemical proximate composition of the carcasses for the moisture (66.20 ± 0.112 %), protein (17.63 ± 0.484 %), lipid (15.92 ± 1.507 %) and ash (0.95 ± 0.115 %) content among dietary groups. No statistical differences ($P>0.05$) were found in the chemical proximate composition of the abdominal fat pads for the moisture (28.77 ± 0.112 %), protein (3.03 ± 0.484 %), lipid (63.32 ± 9.789 %) and ash (0.45 ± 0.135 %) content among dietary groups. With the increase in dietary CAO levels, the percentages of C18:2n-6 and C20:4n-6 in the carcasses decreased respectively with 1.78 % from 20.88 % and 0.35 % from 1.05 %, whilst C18:3n-3 and longer chain n-3 fatty acids such as C20:5n-3 and C22:6n-3 increased respectively with 2.25 % from 1 %, 0.1 % from 0.1 % and 0.67 % from 0.2 %. The same tendency was seen in the abdominal fat pads where C18:2n-6 and C20:4n-6 decreased respectively with 1.55 % from 20.75 % and 0.98 % from 1.2 % with an increase in dietary CAO, whilst C18:3n-3, C20:5n-3 and C22:6n-3 increased respectively with 2.13 % from 1.15 %, 0.45 % from 0.03 % and 0.95 % from 0.05 %. The n-3/n-6 ratio in the carcasses and abdominal fat pads increased respectively with 0.16 % from 0.06 % and 0.19 % from 0.06 % with an increase in dietary CAO. These results clearly indicate that dietary CAO enriched with α -linolenic acid lower saturated fatty acids respectively in broiler carcasses and abdominal fat pads with 4.88 % from 31.6 % and 10.63% from 31.1 %, whilst increasing monounsaturated fatty acids with 3.87 % from 44.95 % and 7.25 % from 46.7 % respectively and polyunsaturated fatty acids with 1.02 % from 23.45 % and 2.38 % from 23.2 % respectively.

Experiment 3: Effect of dietary vitamin E on the performance of broilers and oxidative stability, colour, microbiological stability, fatty acid composition and pH of broiler meat during refrigerated and frozen storage.

Experiment 1 was carried out with 220 one-day-old broiler chicks to evaluate the effect of eleven concentrations of vitamin E (0, 20, 40, 60, 80, 100, 120, 140, 160, 180 and 200 mg α -tocopheryl acetate / kg diet) on their production performance and the oxidative stability of their frozen broiler carcasses. The diets with vitamin E levels 0 to 100 mg were fed from day-old to 42 days of age while the diets with vitamin E levels 120 to 200 mg were fed from 21 to 42 days of age. The oxidative stability, evaluated by thiobarbituric acid reactive substances (TBARS) values, was determined after 30, 90, 120 and 150 days of storage at -20°C . There were no statistical differences ($P>0.05$) in average daily gain (1.85 ± 0.111 g) or feed conversion ratios (2.29 ± 0.397) among dietary groups. TBARS values increased significantly ($P<0.05$) with increasing time of storage (basal diet: day 30 = 1.71 ± 0.51 ; day 150 = 4.89 ± 0.51), but decreased significantly ($P<0.05$) with increasing vitamin E levels (day 150: basal = 4.89 ± 0.51 ; 100 mg / kg = 1.09 ± 0.27). Experiment 2 was carried out with day-old broiler chicks to evaluate the effect of five concentrations of vitamin E (0, 40, 80, 120 and 160 mg α -tocopheryl acetate / diet) on their performance and the oxidative stability of their refrigerated carcasses. The experimental diets were fed from day-old to 42 days of age. The oxidative stability, evaluated by TBARS values, colour deterioration and microbiological stability were determined after 0, 4, 8, 10 and 12 days of storage at 4°C . Fatty acid analysis was done on the samples of days 0 and 12. There were no statistical differences ($P>0.05$) in average daily gain (1.88 ± 0.117 g) or feed conversion ratios (2.37 ± 0.467) among dietary groups. TBARS values increased significantly ($P<0.05$) with increasing time of storage, but decreased significantly ($P<0.05$) with increasing vitamin E levels. There were no statistical differences ($P>0.05$) in colour measurements for L^* (44.97 ± 0.662), a^* (5.23 ± 0.315) or b^* (12.76 ± 0.321) values between treatments. Microbiological counts increased significantly ($P<0.05$) over time with vitamin E concentration showing no effect. There were no statistical differences ($P>0.05$) for any of the fatty acid groups measured (SFA: Day 0 = $26.1 \pm 1.13\%$, Day 12 = $26.1 \pm 1.17\%$; MUFA: Day 0 = $41.4 \pm 1.46\%$, Day 12 = $40.2 \pm 2.28\%$; PUFA: Day 0 = $32.4 \pm$

1.95%, Day 12 = $33.8 \pm 2.52\%$) among dietary groups. Similarly, none of the fatty acids showed statistical significant ($P>0.05$) concentration changes over time. There were no statistical differences ($P>0.05$) in pH (6.01 ± 0.206) among dietary groups.

Opsomming

Titel:	Verbetering van die voedingswaarde van braaikuikenvleis deur die verhoging van die omega-3 vetsuurinhoud en dié van vitamien E.
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Lipiede is steeds een van die mees belangrike voedingstowwe wat deur braaikuikens benodig word. Die groeiende bewuswording dat sekere Westerse gemeenskappe 'n te hoë verhouding van n-6/n-3 poli-onversadigde vetsure in hul dieet het, is direk relevant vir braaikuikenvoeding en lipiedmetabolisme. Betekenisvolle hoeveelhede n-3 poli-onversadigde vetsure is geïnkorporeer in die belangrikste hoendersnitte, met die gevolg dat die produksie van braaikuikenvleis met hoë n-3 poli-onversadigde vetsure voordelig is vir die braaikuikenindustrie en geag word 'n meer "gesonde" beeld te hê. Ongelukkig is sodanige braaikuikenvleis redelik vatbaar vir oksidatiewe bederf, en oksidasie bepaal dikwels die rakleeftyd van hoendervleisprodukte. Die byvoeging van α -tokoferol (vitamien E) by braaikuikendiëte is 'n effektiewe manier om die oksidatiewe stabiliteit van braaikuikenvleis te verbeter. Verhoogde α -tokoferol vlakke in braaikuikenvoere verhoog die weefselkonsentrasie wat verhoogde stabiliteit van die membraanstrukture en derhalwe moontlike verhoogde oksidatiewe stabiliteit van braaikuikenvleis en -produkte tot gevolg het.

Drie ondersoekes is onderneem by Mariendahl Pluimvee Navorsingstasie te Stellenbosch. Die braaikuikens is aangehou in 1 x 0.4 x 0.5m hokke in braaikuikenhuise. In al die proewe is dagoud kuikens gebruik, behalwe eksperiment 1 waar drie-week oue kuikens gebruik is. Aan die einde van proewe 2 en 3 is die ses-week oue braaikuikens geslag en die karkasse voorberei vir analise.

Eksperiment 1: Metaboliseerbare energie van Canola voergraadolie en Famarol voergraadolie vir braaikuikens.

Die ware metaboliseerbare energie waarde van Canola voergraadolie (CAO) en Famarol voergraadolie (FAO), gekorregeer vir stikstof retensie (WMEn), is by wyse van proewe op 21 dae oue braaikuikenhaantjies bepaal deur van die balansmetode gebruik te maak. Die proewe is tweemaal herhaal vir verhoogde akkuraatheid, met die gebruik van verskillende monsters van die twee olies vanaf dieselfde bron. Die olies is in twee verhoudings met 'n basale diëet gemeng om die proef diëet te vorm, nl. 100% Basaal; 96% Basaal: 4% Olie en 92% Basaal: 8% Olie. Die balans proewe het 3 dae geduur na afloop van 'n aanpassingsperiode van 4 dae. Die WMEn waardes van CAO, bepaal deur middel van regressie analise, het nie betekenisvol verskil ($P>0.05$) tussen eksperimente 1 en 2 nie. Die waarde van eksperiment 3 was betekenisvol hoër ($P<0.05$) as die van die eerste twee eksperimente. Die WMEn waardes van FAO het ook nie betekenisvol verskil ($P>0.05$) tussen eksperimente 1 en 2 nie, maar die waarde vir eksperiment 3 was betekenisvol hoër as dié van eksperiment 1. Die WMEn waardes van COA het betekenisvol verskil ($P<0.05$) van dié van FAO vir al die eksperimente (exp. 1: 30.6 ± 0.399 MJ/kg vir CAO vs. 25.9 ± 0.441 MJ/kg vir FAO; exp. 2: 31.0 ± 0.633 MJ/kg vir CAO vs. 26.1 ± 0.668 MJ/kg vir FAO; exp. 3: 32.1 ± 0.867 MJ/kg vir CAO vs. 27.1 MJ/kg vir FAO).

Eksperiment 2: Die invloed van verskeie rantsoen n-6/n3 vetsuurverhoudings op die produksie en liggaamsamestelling van braaikuikens.

Die rantsoeneffek van verskeie kombinasies Canola voergraadolie (CAO, 'n hoë vlak van C18:3n-3 en mono-onversadigde vetsure) en Famarol voergraadolie (FAO, 'n hoë vlak van 18:2n-6 en versadigde vetsure) op die weefselvetsuursamestelling is bestudeer in braaikuikenkarkasse en abdominale vetneerlegging. Die kuikens is van dagoud tot op ses-weke ouderdom een van ses diëte gevoer met die volgende samestellings: 100% FAO, 80% FAO-20% CAO, 60% FAO – 40%CAO, 40% FAO – 60% CAO, 20% FAO – 80% CAO, 100% CAO. Daar was geen statistiese verskil tussen die rantsoengroepe ($P>0.05$) in die gemiddelde daaglikse toename (1.71 ± 0.059 g) of die voeromsetverhoudings (1.97 ± 0.051) nie. Geen statistiese verskil ($P>0.05$) is gevind in die chemiese samestelling van die karkasse vir vog (66.20 ± 0.112 %), proteïen (17.63 ± 0.484 %), lipied (15.92 ± 1.507 %) en as (0.95 ± 0.115 %) inhoud tussen die rantsoen groepe nie. Geen statistiese verskille ($P>0.05$) is gevind in die chemiese samestelling van die abdominale vetneerlegging vir vog (28.77 ± 0.112 %), proteïen (3.03 ± 0.484 %), lipied (63.32 ± 9.789 %) en as (0.45 ± 0.135 %) inhoud onder die rantsoengroepe nie. Met die verhoging in die rantsoen CAO vlakke het die persentasie van C18:2n-6 en C20:4n-6 in die karkasse verminder met 1.78 % en 0.35 % respektiewelik, terwyl C18:3n-3 en langer ketting n-3 vetsure soos C20:5n-3 en C22:6n-3 respektiewelik met 2.25 %, 0.1 % en 0.67 % verhoog het. Dieselfde tendens is opgemerk in die abdominale vetneerlegging waar C18:2n-6 en C20:4n-6 afgeneem het met 1.55 % en 0.98 % respektiewelik met die verhoging van rantsoen CAO, terwyl C18:3n-3, C20:5n-3 en C22:6n-3 verhoog het met 2.13 %, 0.45 % en 0.95 % respektiewelik. Die n-3/n-6 verhouding in die karkasse en abdominale vetneerlegging het verhoog met 0.16 % en 0.19 % respektiewelik met die verhoging van die rantsoen CAO. Die resultate toon onomwonde aan dat rantsoen CAO verryk met α -linoleïensuur, verlaag versadigde vetsure in braaikuikenkarkasse en –abdominale vetneerleggings met 4.88 % en 10.63% respektiewelik, terwyl die mono-onversadigde vetsure met 3.87 % en 7.25 % respektiewelik verhoog word en poli-onversadigde vetsure met 1.02 % en 2.38 % respektiewelik verhoog word.

Eksperiment 3: Die invloed van vitamine E op die produksie van braaikuikens en die oksidatiewe stabiliteit, kleur, mikrobiologiese stabiliteit, vetsuursamestelling en pH van braaikuikenvleis gedurende verkoelde en bevrore berging.

Eksperiment 1 is uitgevoer met 220 dagoud braaikuikens ten einde die effek van elf konsentrasies van vitamine E (0, 20, 40, 60, 80, 100, 120, 140, 160, 180 en 200 mg α -tokoferyl acetate / kg voer) op hul produksieprestasie en die oksidatiewe stabiliteit van hul gevriesde braaikuikenkarkasse te evalueer. Die diëte met vitamine E vlakke 0 tot 100 mg is vanaf dagoud tot 42-dae-ouderdom gevoer, terwyl die diëte met vitamine E vlakke van 120 tot 200mg gevoer is vanaf 21 tot 42-dae-ouderdom. Die oksidatiewe stabiliteit, soos geëvalueer deur tiobarbituriese suur reaktiewe stowwe (TBARS) waardes, is bepaal na 30, 90, 120 en 150 dae van berging teen -20°C . Daar was geen statistiese verskille ($P>0.05$) in die gemiddelde daaglikse toename (1.85 ± 0.111 g) of voeromsetverhoudings (2.29 ± 0.397) tussen die rantsoengroepe nie. TBARS waardes het betekenisvol toegeneem ($P<0.05$) met die verhoging in bergingsperiode, maar het betekenisvol afgeneem ($P<0.05$) met verhoogde vitamine E vlakke. Eksperiment 2 is uitgevoer met dagoud braaikuikens ten einde die effek van vyf konsentrasies van vitamine E (0, 40, 80, 120 and 160 mg α -tokoferyl acetate / kg voer) op hul prestasie en die oksidatiewe stabiliteit van hul verkoelde karkasse te evalueer. Die eksperimentele diëte is gevoer vanaf dagoud tot 42-dae-ouderdom. Die oksidatiewe stabiliteit, geëvalueer deur middel van TBARS waardes, kleur afname en mikrobiologiese stabiliteit is bepaal na 0, 4, 8, 10 en 12 dae van berging teen 4°C . Vetsuuranalises is gedoen op die monsters van dae 0 en 12. Daar was geen statistiese verskille ($P>0.05$) in die gemiddelde daaglikse toename (1.88 ± 0.117 g) of voeromsetverhoudings (2.37 ± 0.467) tussen die rantsoengroepe nie. TBARS waardes het betekenisvol verhoog ($P<0.05$) met die verlengde bergingsperiode, maar het betekenisvol afgeneem ($P<0.05$) met verhoogde vitamine E vlakke. Daar was geen statistiese verskille ($P>0.05$) in kleur metings vir L^* (44.97 ± 0.662), a^* (5.23 ± 0.315) of b^* (12.76 ± 0.321) waardes tussen behandelings nie. Mikrobiologiese tellings het betekenisvol verhoog ($P<0.05$) oor tyd met die vitamine E

konsentrasie wat geen effek getoon het nie. Daar was geen statisties betekenisvolle verskille ($P>0.05$) vir enige van die vetsuurgroepe tussen die behandelings nie. Soortgelyks het geen van die vetsure statisties betekenisvolle ($P>0.05$) konsentrasieveranderings oor tyd aangetoon nie. Daar was geen statistiese verskil ($P>0.05$) in die pH (6.01 ± 0.206) tussen die rantsoengroepe nie.