ASSESSMENT OF OMEGA-3 LONG CHAIN POLYUNSATURATED FATTY ACID INCORPORATION IN BROILER CHICKEN MEAT FOLLOWING THE CONSUMPTION OF OMEGA-3 RICH VEGETABLE OILS

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ABSTRACT

Dietary omega-3 long chain polyunsaturated fatty acids (n-3 LCPUFAs), eicosapentaenoic acid (EPA, 20:5n-3), docosapentaenoic acid (DPA, 22:5n-3) and docosahexaenoic acid (DHA, 22:6n-3), have beneficial health effects and hence increasing the consumption of these fatty acids is recommended by health authorities. The most common dietary source of EPA, DPA and DHA is seafood, but few Australians habitually consume fish and on average eat less than one meal of fish per week. Thus if Australians are to meet the dietary guidelines for n-3 fatty acid intake, there is a need to develop a source of n-3 rich foods that fit into a typical Australian diet. Feeding fish oils rich in n-3 LCPUFA to chickens has proven problematic due to alteration in organoleptic properties. The incorporation of vegetable oils rich in n-3 PUFA, alpha-linolenic acid (ALA, 18:3n-3) into the diet of chickens is potentially an alternative way to provide meat rich in n-3 LCPUFAs as ALA is the precursor of EPA and DHA. However, most vegetable oils also contain the n-6 (n-6) PUFA, linoleic acid (LA, 18:2n-6) which competes with ALA for the same enzymes in their metabolism to LCPUFA.

This thesis addressed two crucial issues relating to the conversion of ALA into EPA, DPA and DHA of chicken tissues. The objectives of the first experiment were to examine the effects of increasing the ALA content of diets on the conversion of ALA into EPA, DPA and DHA by measuring their accumulation in chicken meat (breast and thigh) and to determine if there was an optimum level of ALA (at a fixed level of LA) in this process. The ratio of LA to ALA of the diets ranged from 10.5:1 to 0.6:1.

The findings in this study demonstrated that there was no optimum level of dietary ALA and as indicated by the observation that EPA, DPA and DHA continued to increase in breast and thigh as the ratio of LA to ALA decreased in the diet. In general, DPA achieved higher levels than DHA. The experimental diets with the lowest LA to ALA ratio elevated the incorporation of EPA and DHA into breast and thigh meat to levels 5 and 4-fold, respectively relative to birds fed the highest LA to ALA ratio. In contrast, arachidonic acid (AA, 20:4n-6) in all groups reduced with decreasing LA to ALA ratio in the diets. The results indicated that the dietary treatments did not significantly change the growth performance of chickens.

The objective of the second experiment was to assess the regulatory effect of dietary LA on the conversion of ALA into EPA, DPA and DHA. While in the first experiment the diets varied in the level of ALA but had a constant LA level, in this experiment the level of ALA in the diets was held constant and the level of LA was varied. The LA to ALA ratio of experimental diets ranged from 1.4:1 to 2.1:1. The results of this study indicated that the highest LA to ALA ratio (2.1:1) resulted in the lowest n-3 LCPUFAs, EPA, DPA and DHA in meat samples. For example, the total n-3 LCPUFA levels in the breast meat of birds fed with the lowest LA to ALA ratio was 16% higher than the n-3 LCPUFA in the breast of birds fed the highest LA to ALA ratio. This study indicated that the strongest influence on EPA, DPA and DHA accumulation in chicken tissues was the level of ALA in the diet. The experimental diets did not appear to affect the growth performance of chickens.

In conclusion, increasing the ALA content of chicken diets may result in a meat source high in n-3 LCPUFAs that may reduce pressure on diminishing marine stocks as well as offering health benefits to Australians.

DECLARATION

I declare that this thesis is a record of original work and contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text.

I give consent to a copy of my thesis being made available in the University Library.

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Lilik Retna Kartikasari Date 12 February 2009

POSTER AND ABSTRACT ARISING FROM THIS THESIS

POSTER/ORAL PRESENTATION

Lilik R Kartikasari, Robert J Hughes, Mark S Geier and Robert A Gibson. Effect of Vegetable Oils on Omega-3 Long Chain Polyunsaturated Fatty Acid (LCPUFA) Levels in Broiler Chicken Meat. School of Agricultural, Food and Wine, Research Day. The University of Adelaide, November 2008.

ABSTRACT

Lilik R Kartikasari, Robert J Hughes, Mark S Geier and Robert A Gibson. Effect of Vegetable Oils on Omega-3 Long Chain Polyunsaturated Fatty Acid Levels in Broiler Chicken Meat (Experiment I and II). Postgraduate Symposium. The University of Adelaide, September 2008.

Lilik R Kartikasari, Robert J Hughes, Mark S Geier and Robert A Gibson. Effect of Vegetable Oils on Omega-3 Long Chain Polyunsaturated Fatty Acid Levels in Broiler Chicken Meat (Experiment I). School of Agricultural, Food and Wine, Research Day. The University of Adelaide, November 2008.

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ABBREVIATIONS

AA	Arachidonic acid (20:4n-6)
ALA	Alpha (α)-linolenic acid (18:3n-3)
ANOVA	Analysis of variance
BHA	Butylated hydroxyanisol
CHD	Coronary Heart Disease
CVD	Cardiovascular diseases
DHA	Docosahexaenoic acid (22:6n-3)
DPA	Docosapentaenoic acid (22:5n-3)
EFA	Essential fatty acid
EPA	Eicosapentaenoic acid (20:5n-3)
FAME	Fatty acid methyl ester
GLA	γ-linolenic acid
GC	Gas chromatograph
H	Hydrogen
H_2SO_4	Sulphuric acid
ISSFAL	International Society for the Study of Fatty Acids and Lipids
LA	Linoleic acid (18:2n-6)
MUFA	Monounsaturated fatty acid
NS	Not significant
n-3	Omega 3
n-6	Omega 6
n-9	Omega 9
Na_2SO_4	Sodium sulphate
NHMRC	National Health and Medical Research Centre
NNS	National Nutrition Survey
PUFA	Polyunsaturated fatty acid
LCPUFA	Long chain polyunsaturated fatty acid
RVH	Right ventricle hypertrophy
SARDI	South Australia Research and Development Institute
SFA	Saturated fatty acid
SDA	Stearidonic acid
TLC	Thin layer chromatography
UV	Ultraviolet

UNITS

°C	Celcius
cm	Centimetre
d	Day
et al.	and others
g	Gram
h	Hour
kg	Kilogram
L	Litre
mg	Milligram
mL	Millilitre
m^2	Square metre
µ	Micro
v/v	Volume by volume