



# **Increasing Efficiency of Lean Tissue Deposition in Broiler Chickens**

**A report for the Rural Industries  
Research and Development Corporation**

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# Foreword

Genetic selection of broilers for growth over the last 30 years has resulted in an average weight gain increase of 40 grams per year. Associated with this are an increase in fatness and a loss of reproductive ability – both obviously undesirable both economically and socially.

This project, by University of New England researchers, outlines two experiments, which were conducted to examine the effects of dietary manipulations on lean growth in broilers. One experiment examined graded levels of dietary organic chromium and leucine on performance and body composition, while the other experiment examined the influence of four different fat sources (linseed oil, lard, fish oil and safflower oil) at two dietary levels on lean growth in broilers.

This project was funded from industry revenue which is matched by funds provided by the Federal Government and is an addition to RIRDC's diverse range of over 600 research publications. It forms part of our Chicken Meat R&D program, which aims to support increased sustainability and profitability in the chicken meat industry by focusing research and development on those areas that will enable the industry to become more efficient and globally competitive and that will assist in the development of good industry and product images.

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# Preface

The Rural Industries Research and Development Corporation funded this work as a pilot project for a duration of 12 months. One of the authors, Mr Adam Naylor, who was doing his Honours Degree in Animal Science, took up the project in February 1997 and completed it in February 1998. This report is largely a shortened version of Mr Naylor's thesis entitled "Nutritional Manipulation of Lean Tissue Deposition in Broiler Chickens".

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# Executive Summary

Two experiments were conducted to examine the effects of dietary manipulations on lean growth in broilers.

Experiment 1 examined graded levels of dietary chromium and leucine on performance and body composition. Chromium picolinate at 0.5ppm significantly ( $P<0.05$ ) lowered the carcass fat level. Gut weight and carcass water content were increased as a result of chromium treatment. Body weight, plucked weight, carcass weight, abdominal fat pad weight, breast yield and feed efficiency were unaffected by chromium treatment. Leucine did not interact with chromium to effect lean growth. Dietary leucine above the recommended maintenance level (1.2% of diet) markedly ( $P<0.001$ ) reduced the breast muscle yield.

Experiment 2 was conducted to examine the influence of different fat sources at two dietary levels on lean growth in broilers. The addition of fish oil to broiler diets reduced ( $P<0.05$ ) the abdominal fat pad weights compared to birds on linseed diets. Fish oil is believed to improve lean growth through the effects of long chain polyunsaturated fatty acids in lowering the very low density lipoprotein levels and triglyceride in the blood, in the mean time increasing glucose uptake into the muscle tissue in blood and by minimizing the negative impact of the immune system on protein breakdown. The amount of fat in the diet (2% or 4%) did not affect body composition.

# 1. Introduction

Genetic selection for growth over the last 30 years has resulted in an average weight gain increase of 40g/year. Associated with this are an increase in fatness and a loss of reproductive ability. Modern broilers contain 150 to 200 g fat per kg body weight, over 85% of which is physiologically inessential. Fatness in poultry has three major attributes: a) it depresses feed efficiency; b). some adipose tissues are of little economic value, ie, abdominal fat is removed by evisceration, thus decreasing processing yield; and c). consumption of saturated fat is associated with increased incidence of cardiovascular risks in humans. Increased fat content in the chicken meat is therefore undesirable both economically and socially.

Nutritional manipulations taken to counter excessive body fatness include feed restriction, changing protein to energy ratio and manipulation of the balance of individual amino acids. Although some of these measures have yielded favourable results their practical use has been limited. This project has examined the effect of graded levels of organic chromium and leucine, and four different fat sources on the body composition of broiler chickens.

## 2. Background

### 2.1 Branched Chain Amino Acids

An extensive amount of literature has been published on the effects of branched-chain amino acids (BCAA's) on the processes of protein synthesis and protein degradation (Chua *et al.*, 1979; Li *et al.*, 1978; Buse and Weigand, 1977; Morgan *et al.*, 1981). It is known that skeletal muscle in particular is affected by the supply of amino acids, especially the BCAA's which exert an anabolic effect on muscle protein. The observation that heart and skeletal muscles can readily oxidise the BCAA's brought about the proposal that a catabolic product of the BCAA's might be responsible for their stimulatory effects on protein deposition (Lindsay and Buttery, 1980).

It was confirmed by Garlick and Grant (1988) that the only amino acids that can regulate protein synthesis in muscle tissue were the BCAA's and they proposed the mode of action was through changes in the sensitivity of muscle protein synthesis to insulin. Of the BCAA's, leucine alone has been demonstrated to be as effective in promoting protein synthesis as a combination of all three BCAA's (Chua *et al.*, 1979). Leucine, not isoleucine or valine, can regulate the rate of protein turnover in skeletal and heart muscles. In heart tissue, leucine has been demonstrated to accelerate protein synthesis by around 50% and inhibit protein degradation by up to 30%.

These effects were reflected by a number of BCAA metabolites, including alpha-ketoisocaproate, isovalerate, acetoacetate, isobutyrate and acetate, but not for isoleucine or valine. The metabolites of leucine, however, did not mimic leucine's effects in skeletal muscle (Morgan *et al.*, 1981). The precise mode of action of leucine remains unclear. Effects of leucine on protein synthesis are exerted during mRNA translation and seem to involve altering the rate of peptide chain initiation (Buse, 1981). Studies *in vivo* have shown that leucine or a combination of all three BCAA's reduces protein degradation by increasing the proportion of polysomes to subunits in preparations of psoas muscle (Buse 1981).

### 2.2 Chromium

Insulin release is influenced by dietary trace minerals. Chromium (Cr) has been shown to be involved in normal glucose metabolism and is necessary for optimal insulin function and glucose uptake by insulin-sensitive cells (Amoikon *et al.*, 1995). Chromium deficiency can lead to a diminished responsiveness of tissues to insulin (Mertz, 1979). Animals deficient in chromium have impaired pancreatic beta-cell functions and an altered glucose tolerance curve similar to that seen in non insulin-dependent diabetes in humans (Striffler *et al.*, 1995). Other factors associated with insufficient chromium levels are increased levels of circulating insulin, impaired growth, higher percent body fat, lower lean body mass and increased mortality rate. Lindemann *et al.* (1994) reported an increased sensitivity of skeletal muscle to insulin as a result of chromium supplementation in pigs. A significant difference was noted in both carcass composition and feed utilization between chromium supplemented and control animals. Similar observations have led to the conclusion that conventional animal diets have chromium levels far too low for optimal production, and this can be alleviated through the addition of chromium to the diet. In a later study pigs supplemented with chromium at

0.5ppm resulted in a greater percentage of lean tissue and a higher feed conversion ratio, than pigs fed control diets (Wenk, 1995). It is known that dietary and environmental stresses (including temperature, humidity and pathogens) can alter the animal's requirements for nutrients such as chromium. Chromium supplementation improves the performance of stressed animals (Kegley and Spears, 1995). Current literature supports the belief that chromium is usually suboptimal in the diet and an animal's requirement for chromium is strongly influenced by stress (Lindemann *et al.*, 1994, Kegley and Spears, 1995; Wenk, 1995).

Only trivalent chromium Cr(III) is biologically active. Metallic chromium cannot be absorbed and Cr(IV) is toxic. Adequate absorption of chromium occurs only when it is associated with a specific organic molecule such as chromium tripicolinate (CrPic) or as high-chromium yeast (Kitchalong *et al.*, 1995). Cr(III) exerts its physiological effects through its presence in the multiunit complex, the glucose tolerance factor (GTF). The GTF is a large molecule composed of the trivalent chromium linked with nicotinic acid and three amino acids - glycine, glutamic acid and cysteine (Mowat, 1993). This chromium containing compound was first described in brewers yeast and is reported to enhance the hypoglycaemic action of insulin in pigs (Amoikon *et al.*, 1995; Wenk, 1995; Striffler *et al.*, 1995). The physiological mechanisms by which the GTF enhances glucose tolerance are not clear, but suggested action is through improving the binding affinity of insulin to its specific receptors (Mowat, 1993). It is known that chromium positively effects protein synthesis. Wenk (1995) reported that chromium supplementation increased protein deposition and reduced fat deposition in growing pigs. The anabolic effects of chromium picolinate in pigs was attributed to a potentiation of insulin function, measured by an increase in the concentration of insulin binding to RBC plasma membranes and isolated fat cells (Amoikon *et al.*, 1995). It has also been postulated that chromium may have a regulatory role in the maintenance of normal beta-cell glucose sensitivity (Striffler *et al.*, 1995). The mechanism of action of chromium on glucose tolerance and the insulin sensitivity of cells remains unclear. Chromium supplementation is beginning to be used commercially around the world. Chromium as chromium yeast has been permitted in pig diets in Switzerland since January 1994 (Wenk, 1995). Chromium may become a common microingredient for animals in the future, especially during periods of stress. Further research into the effect of chromium on animals under stressful and normal conditions is required before dietary guidelines can be suggested.

### **2.3 Long chain fatty acids**

A high polyunsaturated fatty (PUFA) acid content in the diet reduces fat accretion in chickens (Pinchasov and Nir, 1992). Omega - 3 fatty acids present in fish oils, namely docosahexaenoic(DHA) and eicosapentanoic acids(EPA), reduce fat deposition by reducing the circulating very low density lipoprotein (VLDL) levels in the blood. Fish oil has been reported to improve feed efficiency in broilers (Farrell, 1995) but its impact on growth performance remains unclear. Some long chain PUFAs, including linoleic acid and DHA, reduce the protein wasting which is associated with immune response (Chin *et al.*, 1994). Linoleic acid is generally converted to arachidonic acid, a long chain PUFA which is a precursor for the eicosanoids. Eicosanoids are local messenger molecules which regulate the rates of protein synthesis and degradation (Reeds, 1987). This investigation was designed to test the effect of differing long chain polyunsaturated fatty acids on lean tissue deposition. Fat sources high in omega-3 fatty acids (fish oil) and linoleic acid (safflower oil and lard) were tested against linseed oil to assess lean growth in broilers.

*Polyunsaturated Fatty Acids:* Polyunsaturated fatty acids (PUFAs) contain two or more double bonds in their carbon skeleton. The double bonds are generally separated by a methylene group (i.e. -CH=CH-CH<sub>2</sub>-CH=CH-) and rarely conjugated (alternating double and single bonds i.e. -CH=CH-CH=CH-) (Lehninger, 1993). A high percentage of PUFAs in the diet (over 1.44g/100g of feed) inhibits lipogenesis and depresses fat deposition in broilers (Pinchasov and Nir, 1992).

*Conjugated Linoleic Acid:* The major sources of conjugated linoleic acid (CLA) are animal products, beef tallow having around 2.6% of its fat as CLA. Plants possess a far lower CLA content, their oils ranging from 0.1% CLA (coconut oil) to 0.7% (safflower oil). The c-9, t-11 CLA isomer has been isolated as the active compound, it is this isomer which is incorporated into the phospholipid bilayer in animal tissues (Chin *et al.*, 1992). In beef lard, 84% of the CLA occurs in this active form, whilst in plants the c-9, t-11 isomer represents less than 50% of the total CLA. CLA has been shown to improve feed efficiency and increase the body weight in rats possibly through its effects on prostaglandin synthesis and signal transduction pathways (Chin *et al.*, 1994). CLA has the ability to decrease the catabolic response generated by the immune system without altering the normal immune systems functioning (Chin *et al.*, 1994). Reducing this response minimizes the breakdown of skeletal muscle and thus improves feed conversion and enhances lean growth. Thus, CLA at a level of 0.5% of diet reduced body fat and increased lean tissue deposition (Albright *et al.*, 1996).

*Arachidonic Acid:* Arachidonic Acid (AA) is an important biological compound present in most cells in the plasma membrane. AA is a precursor for the eicosanoids, a group of biologically potent messenger molecules, which affect tissues near the cells that produce them. AA is released from the plasma membrane in a reaction catalyzed by phospholipase A<sub>2</sub> (Lehninger, 1993). AA in the cell is converted to the eicosanoids by the enzymes of the smooth endoplasmic reticulum. Free AA is oxidized by two enzymes, cyclooxygenase and lipoxygenase. The cyclooxygenase pathway converts AA into prostaglandins and the thromboxanes. The third group of eicosanoids, leukotrienes are the result of AA being metabolized through the lipoxygenase pathway. These different eicosanoid classes exhibit different physiological actions. Prostaglandin acts on local tissues to control micro-circulation, reduce blood pressure and exhibit an effect on reproduction. Thromboxane induces blood vessel constriction and platelet aggregation, while the leukotrienes are involved in many inflammatory and immune hypersensitivity reactions (Clarenburg, 1992).

AA also has a reported role in the regulation of ion channels, enzyme activity and growth. The exact mechanisms of action remain unclear. Changes in AA metabolism alter the rates of protein degradation. The prostaglandin PGE<sub>2</sub> has been identified as a regulator of the rates of protein synthesis and degradation. Also the addition of prostaglandins alone could stimulate protein synthesis in skeletal muscle (Reeds, 1987). AA and other long chain PUFAs also enhance tumor growth by promoting cell proliferation and reducing apoptosis (Tang *et al.*, 1997).

*Omega-3 Fatty Acids:* A high intake of fish oil is beneficial in the fight against heart disease, hypertension, rheumatoid arthritis and psoriasis. This protective quality is associated with the high levels of long chain omega-3 (n-3) PUFA's, namely eicosapentaenoic acid (C20:5, n-3)

(EPA) and docosahexaenoic acid (C22:6, n-3) (DHA). These n-3 fatty acids have a pharmacological impact on the thrombic and inflammatory systems. EPA and DHA influence haemostatis and the vascular system, and behave as regulators of inflammation. Like CLA, fish oils rich in n-3 fatty acids reduce the catabolic response induced by immune stimulation and effectively may promote growth (Chin *et al.*, 1994). Omega-3 fatty acids also reduce the very low density lipoprotein (VLDL) levels in blood, acting to lower the circulating free low density lipoprotein (LDL) concentration. Omega-3 fatty acids lower the blood levels of free LDLs (which are normally delivered to tissues for fat storage or is deposited directly in the arteries) and reduce the rate of triglyceride synthesis in the liver. Diets fortified with fish oils may effectively reduce the abdominal fat pad and overall body fat levels in broilers. Fish oil increases the feed conversion efficiency of broiler diets (Farrell, 1995), but it's effect on growth and body fat deposition is unclear.

One consideration in the use of fish oil as the n-3 fatty acid source is it's off flavour in bird diets and the reduced shelf life of the chicken meat. A combination of preserving agents and antioxidants may be used to increase shelf life and conceal the distasteful flavours (Farrell, 1995).

## 3. Materials and Methods

The following experiments were designed to test the influence of different nutritional manipulations on lean growth in broilers.

Experiment 1 examined the effect of graded levels of chromium and leucine on lean tissue growth. Balanced, wheat based diets with various levels of chromium and leucine (Table 3.1) were fed *ad libitum* to mixed - sexed broilers from days 1 to 42. Weekly feed intakes and bird weights were recorded and feed conversion efficiency determined. At day 43, after a 24 hour fast, the birds were processed and whole bird, plucked, carcass, breast fillet, entrail and abdominal fat pad weights recorded. Carcass water percentage and carcass fat content were determined on a 25 % subset of birds from each treatment.

Experiment 2 was undertaken to test the influence of various fat sources, at two dietary levels, on lean growth. Diets containing linseed oil, lard, fish oil and safflower oil at 2% and 4% of diet were fed *ad libitum* to male broiler chicks from days 1 to 42. Feed intakes and bird weights at day 21 and day 42 were measured and feed efficiency calculated. On day 43 all birds were slaughtered. Body, plucked, carcass, gut, abdominal fat pad weights and breast yield were recorded.

### 3.1 Experiment 1

This experiment was conducted to examine if dietary chromium as chromium picolinate improves protein deposition in broilers.

#### ***Husbandry***

Mixed sex broiler chickens (300) were supplied by Baiada Poultry, Tamworth. Upon arrival at UNE, 216 healthy day old chicks were weighed and housed in electrically heated brooders. These brooders consisted of wire mesh floors with galvanized cage partitions with slide-in excreta trays, and external feeders and water troughs. At 21 days of age the birds were moved to Harrison carry-on cages ( 4 birds per cage for 54 pens). These wire mesh cages were also fitted with external galvanized feeders, external water troughs and slide-in excreta trays (Appendix 2). Brooders and cages were located in an insulated room. Room temperature was maintained between 23-28<sup>0</sup>C. The floor was wetted each morning to increase the humidity in the rooms and to keep the dust levels to a minimum. The floor was regularly swept to remove spilt feed and excess dust and feathers. Excreta trays were cleaned and water troughs scrubbed and refilled regularly. All birds were individually weighed upon arrival to UNE (one day old). Birds in the weight range of 47-53 grams were accepted for the experiment, other weights were rejected. Birds were then weighed weekly. Birds showing obvious sickness or leg weakness (such as tibial dischondroplasia), which hindered their ability to access water or food, were euthanised by cervical dislocation.

#### ***Experimental Design***

Table 3.1 displays the experimental design used in trial 1. This 3 x 3 factorial design included three increments of chromium and three levels of leucine. Overall there were nine separate diets which were used to determine the dietary effects of chromium or leucine. The nine diets were randomized between 216 mixed-sex broilers (9 replicates of 24 birds per treatment).

Table 3.1 **Experimental Design of Trial 1**

Diet No.	Diet Id.	Diet Design
1	Control	Control (recommended level of leucine - 1.2% digestible)
2	L1	Control + 1.88% digestible leucine
3	L2	Control + 2.40% digestible leucine
4	Cr1	Diet 1 + 0.5 mg/kg digestible chromium
5	Cr1L1	Diet 2 + 0.5 mg/kg digestible chromium
6	Cr1L2	Diet 3 + 0.5 mg/kg digestible chromium
7	Cr2	Diet 1 + 1.0 mg/kg digestible chromium
8	Cr2L1	Diet 2 + 1.0 mg/kg digestible chromium
9	Cr2L2	Diet 3 + 1.0 mg/kg digestible chromium

### **Diets and Feeding**

Both starter and finisher diets were kindly formulated by Inghams Enterprises Pty Ltd, Leppington, NSW, using the feed formulation software Agridata. Chromium was obtained from Ridley AgriProduct in Tamworth as chromium picolinate and synthetic leucine from Masashi Australia in Melbourne. Birds were fed a starter diet for the first three weeks. At 21 days of age the birds were transferred onto the finisher diet until slaughter. During the trial feed was available *ad libitum*. Feed was removed from the feed troughs 24 hours before the trial was terminated. Water was also provided *ad libitum* throughout the trial and access was continued until slaughter. The starter and finisher feed ingredients are displayed in Tables 3.2 and 3.3, respectively. To the required diets chromium was added (Table 3.4).

Table 3.2: **Ingredients in Experiment 1 Starter Diets**

Ingredients	Diets	Diets	Diets
	1,4,7	2,5,8	3,6,9
Wheat (11.5% C.P.)	50.04	49.44	49.84
Barley (10% C.P.)	10.00	10.00	10.00
Rice Pollard (13% C.P.)	6.00	6.00	6.00
Cottonseed	4.00	4.00	4.00
Meat and Bone Meal (50% C.P.)	10.00	10.00	10.00
Soyabean Meal (48% C.P.)	15.00	15.00	15.00
Lime	0.50	0.50	0.50
Tallow	3.03	3.03	3.03
DL Methionine	0.23	0.23	0.23
Lysine	0.31	0.31	0.31
Bicarbonate Soda	0.18	0.18	0.18
Salt	0.10	0.10	0.10
Choline	0.08	0.08	0.08
Premix (vitamins & minerals)	0.50	0.50	0.50
<b>Synthetic Leucine</b>	<b>0.00</b>	<b>0.60</b>	<b>1.20</b>
<b>Total</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>

M.E. = 12.59 MJ/kg      Crude Protein = 21.79%

Table 3.3: **Ingredients in Experiment 1 Finisher Diets**

<b>Ingredients</b>	<b>Diet 1,4,7</b>	<b>Diet 2,5,8</b>	<b>Diet 3,6,9</b>
Wheat (11.5% C.P.)	61.35	60.85	60.35
Barley (10% C.P.)	9.00	9.00	9.00
Rice Pollard (13% C.P.)	4.00	4.00	4.00
Cottonseed	4.00	4.00	4.00
Meat and Bone Meal (50% C.P.)	8.13	8.13	8.13
Soyabean Meal (48% C.P.)	10.00	10.00	10.00
Lime	0.40	0.40	0.40
Tallow	1.83	1.83	1.83
DL Methionine	0.18	0.18	0.18
Lysine	0.23	0.23	0.23
Bicarbonate Soda	0.14	0.14	0.14
Salt	0.15	0.15	0.15
Choline	0.02	0.02	0.02
Premix (vitamins & minerals)	0.50	0.50	0.50
<b>Synthetic Leucine</b>	<b>0.00</b>	<b>0.50</b>	<b>1.00</b>
<b>Total</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>

M.E. = 12.58 MJ/kg      Crude Protein = 18.92%

Table 3.4: **Chromium Addition to Experiment 1 Diets.**

<b>Diet No.</b>	<b>Diet Identification.</b>	<b>Chromium (mg/kg Feed)</b>
1	Control	0.0
2	Control + 1.88% digestible leucine (L1)	0.0
3	Control + 2.40% digestible leucine (L2)	0.0
4	Diet 1 + 0.5 mg/kg digestible chromium (Cr1)	0.5
5	Diet 2 + 0.5 mg/kg digestible chromium (Cr1L1)	0.5
6	Diet 3 + 0.5 mg/kg digestible chromium (Cr1L2)	0.5
7	Diet 1 + 1.0 mg/kg digestible chromium (Cr2)	1.0
8	Diet 2 + 1.0 mg/kg digestible chromium (Cr2L1)	1.0
9	Diet 3 + 1.0 mg/kg digestible chromium (Cr2L2)	1.0

The major ingredients (grains, soybean meal, meat and bone meal etc) were mixed together in a large feed mixer. Minor ingredients including vitamins, feed enzymes, synthetic amino acids salt etc, were separately weighed and mixed in a small mixer, then the mix was combined with the major ingredients. Fat was melted and poured over the mixing feed ingredients, to create a consistent fat content throughout the food.

The diets were divided and the increments of leucine and chromium added accordingly (refer to experimental design section 3.1.2). These trace ingredients were first added to a small quantity of the minor ingredients. This was gradually diluted up to an amount which could assure homogenous ingredient mix when added to the rest of the ingredients. The mixed feed was cold pelleted. The freshly pelleted diets were placed in a dry room to cool down and become isoanhydrogenous with the surroundings. This process was carried out to balance the water content of the food and to reduce the risk of bacteria or mould spoiling the feed.

### **Measurements**

**Feed Intake:** All birds were weighed upon arrival. They were again weighed at weekly intervals and after slaughter. Feed intake was recorded weekly and the feed conversion measured. Mortalities were recorded and weekly feed conversion was adjusted accordingly. The calculation used was:

$$\text{FEED CONVERSION EFFICIENCY (FCE)} = \frac{\text{FINAL WEIGHT (g)} - \text{INITIAL WEIGHT (g)}}{\text{TOTAL FEED INTAKE (g)}}$$

**Body Parameter Measurements:** At 6 weeks of age the birds were fasted overnight in preparation for processing. Birds were killed by cervical dislocation and transported to the processing room in labelled plastic buckets. Each bird was weighed, then immersed in 67<sup>0</sup>C water for 40-50 seconds. The animal was then plucked using a custom made, automated chicken plucker fitted with 15cm rubber fingers. The weight of each plucked bird was recorded (Appendix 3). The bird was then manually eviscerated with care taken to collect all of the abdominal fat pad (Appendix 3). The fat pads and visceral weights were recorded.

From the carcass, both breast muscles were removed and weighed (Appendix 4). The carcass and filleted breast muscles were placed in labelled polythene bags and stored at -23<sup>0</sup>C for further analysis.

**Moisture Determination:** A subset (25%) of the 216 birds was randomly selected from each treatment for body water and fat content measurements. Moisture analysis was carried out on a 50 gram subsample. Each frozen carcass was cut into 25mm x 25mm strips on a band saw then refrozen (Appendix 4). A homogenate was created after each carcass was doubly minced. Processing through the mincer twice resulted in a uniform homogenate. Subsamples were taken as a representation of the total carcass for moisture and fat analysis.

**Freeze Drying:** Total body water was calculated on 50 gram subsamples. Samples were placed on predried 12.5cm square foam meat trays. The trays were dried overnight in a 60<sup>0</sup>C oven and cooled in a dessicator. The 50 grams of chicken mince were spread evenly over the polystyrene tray and freeze dried using two Dynavac Freeze Driers at CSIRO, Chiswick Laboratory.

After freeze-drying of the 50 gram sample was complete the trays were placed in a 60<sup>0</sup>C oven overnight. They were then desiccated and their dry weight recorded. Once the dry sample weights were obtained, the carcass moisture content was calculated using the following equation:

$$\text{MOISTURE CONTENT (\%)} = \left( \frac{\text{INITIAL Wt.} - \text{FINAL Wt.}}{\text{INITIAL Wt.}} \right) \times 100$$

**Carcass Fat Analysis:** The fat content was determined using Soxlet extraction method. Solvent (chloroform) extraction was performed on a 5-6 gram subsample of the freeze-dried mince. All samples were analyzed in duplicate.

The dried samples were ground to a powder in a 1000 watt kitchen blender, and stored in airtight bags in a 4<sup>0</sup>C cool room until required for extraction. Clean soxlet thimbles were

labelled with lead pencil and placed (along with cotton wool plugs) in a 105<sup>0</sup>C oven overnight. The dried thimbles were then removed (using tweezers - Soxlet thimbles should never be handled) and placed in a dessicator to cool down for 45 minutes. The thimbles were then weighed, and 5-6 grams of the powdered sample was placed under the cotton wool plug. The thimbles along with the sample were returned to the oven. After overnight drying the thimbles with samples were removed from the heat and desiccated for 45 minutes. The dry samples and thimbles were then weighed - this figure being the initial weight for the extraction.

The heating mantle and glassware were set up in a fume cupboard and all chloroform was handled in fume hoods. Round bottom flasks were filled with 220ml of chloroform and ceramic boiling chips. The prepared thimbles containing the dry samples were placed in the extraction chamber, duplicates grouped together. With water running through the condensing tubes, the mantle was turned on and the chloroform gently boiled. The boiled chloroform condenses above the Soxlet thimble and drips onto and soaks through the sample. The extraction chamber continues to fill as the thimble bathes in the solvent. The chamber empties automatically when the chloroform levels reach a certain level (around 190ml), and the solvent containing extracted fats reenters the boiling chamber.

After a constant, steady condensation rate is reached, the unit is left to run for 24 hours as the fat extraction proceeds. After 24 hours the heat was turned off and the fatty chloroform removed and set aside for re-distillation. The soxlet thimbles were carefully removed and drained in a fume hood for three hours. The thimbles were then placed in a 105<sup>0</sup>C oven overnight and then cooled in a dessicator for 45 minutes. Soxlet thimbles were weighed and cleaned for later extractions.

The fat content (% dry weight) was calculated using the following formula:

$$\text{FAT CONTENT (\%)} = \left( \frac{\text{INITIAL Wt.} - \text{FINAL Wt.}}{\text{INITIAL Wt.}} \right) \times 100$$

### 3.2 Experiment 2

This experiment was conducted to test the effect of long chain and conjugated fatty acid sources on lean tissue deposition in broilers.

#### ***Husbandry***

Day old birds (48) were randomly housed in individual temperature control brooders in a climate control room. The temperature of the room was maintained between 31.5 - 33.5<sup>0</sup>C, with a relative humidity of 55%. As a safety precaution the brooders were fitted with 40 watt light bulbs, which switched on through a thermostat control if the room temperature fell below 31<sup>0</sup>C. The birds were maintained in this room until week three when they were transferred to larger individual cages (Appendix 2).

Handling of the birds was as per Experiment #1 with the exception that the birds were weighed at three weeks intervals (weeks three and six).

### **Experimental Design**

Experiment two was a 2 x 4 factorial design. Two different increments (2% and 4%) of four fatty acid sources (linseed oil, lard, safflower oil and fish oil) were used in formulating the eight diets. Six birds were designated to each diet. Linseed in this experiment was considered the control diet as it contained little linoleic acid and EPA and DHA are not present. The tallow diet consisted of a higher proportion of saturated fats than the other diets. The tallow diet did, however, contain traces of arachidonic acid and high content of its linoleic acid as the c-9, t-11 isomer. Safflower oil was used as a rich source of linoleic acid (over 77% of total fatty acid content). Fish oil treatments were trialed as they supply high levels of the omega-3 fatty acids EPA and DHA. The commercial fish oil used in this experiment had an unknown fatty acid composition. The fish oil composition displayed in Table 3.5 is a representation of a fish oil's specific fatty acid levels (cod oil from Tacon, 1990).

**Table 3.5: The Fatty Acid Composition of Fat Treatments.**

Fatty Acid	Common Name	Fat Source			
		Linseed	Tallow	Safflower	Fish *
12:0	lauric	-	0.1	-	-
14:0	myristic	-	3.2	0.1	3.7
16:0	palmitic	6	24.5	6.5	12.6
18:0	stearic	4	19	2.4	2.3
20:0	arachidic	-	0.1	-	-
16:1, n-7	palmitoleic	-	3.3	-	9.3
18:1, n-9	oleic	16	42.6	13.1	22.7
20:1, n-9	gadoleic	-	0.6	-	7.5
22:1, n-9	erucic	-	-	-	6.2
18:2, n-6	linoleic	15	2.6	77.7	1.5
18:3, n-3	alpha-linolenic	59	0.7	-	0.6
18:3, n-6	gamma-linolenic	-	0.2	0.2	-
20:4, n-6	arachidonic	-	0.4	-	1.4
20:5, n-3	EPA	-	-	-	12.9
22:5, n-3	adrenic	-	-	-	1.7
22:6, n-3	DHA	-	-	-	12.7

\* Cod oil (source = Tacon, 1990)

### **Diets and Feeding**

Both the starter and grower diets were formulated at UNE using FEEDMANIA software package (Mania Software, ABRI, UNE.) (Table 3.6 and Table 3.7 respectively).. The difference between diets was the differing fat sources and levels. Feed and water were available to the birds ad libitum.

Table 3.6: **Starter Diets (ME = 12.31 MJ/kg; Protein = 21.19%)**

<b>Ingredients</b>	<b>2% FAT</b>	<b>4% FAT</b>
	(% as feed)	
Sorghum (9% C.P.)	41.21	39.21
Barley (9% C.P.)	15.00	15.00
Rice Pollard (13% C.P.)	5.30	5.30
Cottonseed	5.00	5.00
Meat and Bone Meal (50% C.P.)	3.00	3.00
Soyabean Meal (48% C.P.)	24.80	24.80
Limestone	1.50	1.50
Dicalcium Phosphate	0.70	0.70
DL Methionine	0.40	0.40
Lysine	0.28	0.28
Threonine	0.11	0.11
Salt	0.20	0.20
Premix (vitamins & minerals)	0.50	0.50
<b>Fat</b> (lard, safflower, linseed or fish oil)	<b>2.00</b>	<b>4.00</b>
<b>Total</b>	<b>100.00</b>	<b>100.00</b>

Table 3.7: **Finisher Diets (ME=12.34 MJ/kg; Protein = 20.81%)**

<b>Ingredients</b>	<b>2% FAT</b>	<b>4% FAT</b>
	(% as feed)	
Sorghum (9% C.P.)	46.32	41.32
Barley (9% C.P.)	10.00	10.00
Rice Pollard (13% C.P.)	5.00	8.00
Cottonseed	10.00	13.00
Meat and Bone Meal (50% C.P.)	3.00	3.00
Soyabean Meal (48% C.P.)	20.00	17.00
Limestone	1.70	1.70
Dicalcium Phosphate	0.60	0.60
DL Methionine	0.30	0.30
Lysine	0.20	0.20
Threonine	0.03	0.03
Salt	0.35	0.35
Premix (vitamins & minerals)	0.50	0.50
<b>Fat</b> (lard, safflower, linseed, or fish oil)	<b>2.00</b>	<b>4.00</b>
<b>Total</b>	<b>100.00</b>	<b>100.00</b>

## Measurements

Feed Intake and FCE: During this experiment feed intake and FCE were determined every three weeks. The birds were weighed upon arrival, at three weeks (when cages and rooms were changed) and at slaughter.

Body Parameters: The same body parameters were measured as a representation of growth in the animal. All of the birds were processed on the same day. The techniques employed were the same as those used in Experiment 1. Liveweight, carcass weight, abdominal fat pad, breast muscles, and visceral weight were measured.

### **3.3 Statistical Analysis of Data**

Data from both experiments were analyzed using Statgraphics statistical analysis software. Any effects of diet which were likely to have occurred by chance less than five times in 100 test repeats (i.e.,  $P < 0.05$ ) were declared statistically significant. Duncans multiple range test was used to separate means and test for specific treatment effects.

# 4. Effects of Chromium Supplementation and Elevated Levels of Leucine on Body Composition in Broilers Chickens

## 4.1 Introduction

Reducing broiler fat levels is an important goal of poultry producers because it is associated with improved lean gain, increased feed efficiency and is consistent with consumer requirements. The amount of fat in birds can be reduced in several ways altered through choice of breed (or sex), nutritional restriction and refeeding or through altering the composition of the diet. The study reported here was undertaken to determine the effect of specific alteration of diet composition on lean tissue growth in broilers. This experiment examined the effect of dietary addition of organic chromium and leucine (an essential branched chain amino acid) on body composition and growth of broilers

## 4.2 Results

All results are presented in Tables 4.1, 4.2 and 4.3.

### *Feed Conversion Efficiency and Growth*

Levels of leucine or chromium did not affect feed conversion efficiency (FCE). There was no significant difference in FCE between the nine diets. The average FCE for all of the birds at 6 weeks of age was 0.58. There were no interactions between the diets and body weight, plucked weight or the carcass weight. The average bird weighed 2068.5g at 42 days. Pen averages ranged from 1662g to 2412g. The mean plucked weight was 1948.8g with no significant difference between treatments. Carcass weight in this experiment included the head and feet although these are removed during commercial processing. There was no significant effect of chromium or leucine on carcass weight.

### **Body composition**

*Gut weight:* Chromium included at 1mg/kg level had a significant ( $P<0.05$ ) effect on gut weight. It increased the average gut weight of the birds from 198.2g of the controls to 210.2g.

*Abdominal fat pad:* The average fat pad weight was 26.0 g. Neither Cr nor leucine had a significant effect on fat pad weight.

*Breast muscle weight:* Chromium had no effect on breast tissue yield. Leucine reduced ( $P<0.001$ ) breast muscle weight. Control birds receiving the recommended level of digestible leucine (1.2% of diet) had an average breast muscle weight of 329.4g. Birds fed leucine at the L<sub>2</sub> level (control+2.40% digestible leucine) had 15% lighter breast muscles less than control birds.

*Carcass Water Content:* Leucine had no significant effect on the water content of the carcass. The average water content of each carcass was 64.8%. The addition of Cr increased the average water percentage with the difference between Cr<sub>0</sub> and Cr<sub>1</sub> being significant ( $P<0.05$ ).

*Carcass Fat Content:* Chromium reduced ( $P < 0.05$ ) carcass fat content. Whereas, increased dietary leucine tended to increase it ( $14.2\text{g} \pm 0.39$ ,  $14.8 \pm 0.39$  and  $14.8 \pm 0.39$  for L<sub>0</sub>, L<sub>1</sub> and L<sub>2</sub>, respectively).

**Table 4.1: Effect of Chromium Treatment on Body Parameters**

DIET Id.	Body Wt.(g)	Plucked Wt.(g)	Carcass Wt.(g)	Gut Wt(g)	Fat Pad Wt.(g)	Breast Wt.(g)
Cr0 L0	2080.5	1960.9	1744.2	193.3	23.6	330.8
Cr0 L1	2111.2	1987.4	1760.6	198.7	28.1	310.4
Cr0 L2	1992.2	1877.5	1647.8	202.8	26.8	283.0
Cr1 L0	2082.6	1964.2	1741.4	199.3	23.3	329.9
Cr1 L1	2004.3	1883.7	1654.8	200.8	23.2	302.7
Cr1 L2	1998.6	1884.8	1658.5	201.5	25.8	272.3
Cr2 L0	2128.8	2003.7	1771.4	207.5	26.5	327.4
Cr2 L1	2174.7	2051.1	1809.8	213.8	27.6	310.1
Cr2 L2	2043.5	1925.7	1687.3	209.3	29.3	286.6
<b>Mean:</b>	<b>2068.5</b>	<b>1948.8</b>	<b>1719.5</b>	<b>202.9</b>	<b>26.0</b>	<b>305.9</b>

Cr0 = 0mg Cr/kg feed      Cr1 = 0.5 mg Cr/kg feed      Cr2 = 1.0 mg Cr/kg feed  
L0 = 1.20% leucine      L1 = 1.88% leucine      L2 = 2.40% leucine

**Table 4.2: Analysis of Variance Results for Experiment 1.**

Treatment	Count	42-d FCE	Body Wt.	Carcass Wt.	Gut Wt.	Fat Pad	Breast Wt.
<b>Chromium</b>							
Cr0	18	0.59	2061.28	1717.50	198.22 <sup>a</sup>	26.17	308.06
Cr1	18	0.58	2028.47	1684.92	200.53 <sup>a</sup>	24.08	301.64
Cr2	18	0.58	2115.67	1756.17	210.17 <sup>b</sup>	27.78	308.03
<b>P Value</b>		<b>0.28</b>	<b>0.21</b>	<b>0.29</b>	<b>0.01</b>	<b>0.11</b>	<b>0.74</b>
<b>Leucine</b>							
L0	18	0.57	2097.31	1752.33	200.00	24.44	329.36 <sup>a</sup>
L1	18	0.57	2096.69	1741.75	204.40	26.28	307.72 <sup>b</sup>
L2	18	0.58	2011.42	1664.50	204.50	27.31	280.64 <sup>c</sup>
<b>P Value</b>		<b>0.07</b>	<b>0.15</b>	<b>0.11</b>	<b>0.42</b>	<b>0.25</b>	<b>0.01</b>
<b>Chromium x Leucine</b>							
Cr0 x L0	6	0.57	2080.50	1744.17	193.25	23.58	330.75
Cr0 x L1	6	0.60	2111.17	1760.58	198.66	28.08	310.42
Cr0 x L2	6	0.58	1992.17	1647.75	202.75	26.83	283.00
Cr1 x L0	6	0.57	2082.58	1741.42	199.25	23.25	329.92
Cr1 x L1	6	0.58	2004.25	1654.83	200.83	23.17	302.67
Cr1 x L2	6	0.58	1998.58	1658.50	201.50	25.83	272.33
Cr2 x L0	6	0.57	2128.80	1771.42	207.50	29.25	327.42
Cr2 x L1	6	0.58	2174.67	1809.83	213.75	27.58	310.08
Cr2 x L2	6	0.58	2043.50	1687.25	209.25	29.25	286.58
<b>P Value</b>		<b>0.39</b>	<b>0.79</b>	<b>0.72</b>	<b>0.86</b>	<b>0.82</b>	<b>0.97</b>

Cr0 = 0mg Cr/kg feed      Cr1 = 0.5 mg Cr/kg feed      Cr2 = 1.0 mg Cr/kg feed  
L0 = 1.20% leucine      L1 = 1.88% leucine      L2 = 2.40% leucine

a,b,c = different superscripts in separate columns within a treatment differ significantly at  $P < 0.05$ .

Table 4.3: **Analysis of Variance Data For Carcass Water and Fat.**

<b>Treatment</b>	<b>Count</b>	<b>Carcass H<sub>2</sub>O %</b>	<b>Carcass Fat %</b>
<b>Chromium</b>			
Cr0	18	64.25	15.27 <sup>a</sup>
Cr1	18	65.29	13.78 <sup>b</sup>
Cr2	18	64.75	14.70 <sup>c</sup>
<b>P Value</b>		<b>0.13</b>	<b>0.03</b>
<b>Leucine</b>			
L0	18	64.93	14.17
L1	18	64.61	14.79
L2	18	64.75	14.71
<b>P Value</b>		<b>0.82</b>	<b>0.43</b>
<b>Chromium x Leucine</b>			
Cr0 x L0	6	65.03	14.64
Cr0 x L1	6	62.96	16.57
Cr0 X L2	6	64.77	14.59
Cr1 x L0	6	65.31	13.25
Cr1 x L1	6	65.83	13.49
Cr1 x L2	6	64.73	14.59
Cr2 x L0	6	64.46	14.61
Cr2 x L1	6	65.05	14.32
Cr2 x L2	6	64.74	15.19
<b>P Value</b>		<b>0.09</b>	<b>0.16</b>

a,b,c = different superscripts in separate columns  
within a treatment differ significantly at P<0.05.

Cr0 = 0mg Cr/kg feed  
L0 = 1.20% leucine

Cr1 = 0.5 mg Cr/kg feed  
L1 = 1.88% leucine

Cr2 = 1.0 mg Cr/kg feed  
L2 = 2.40% leucine

### 4.3 Discussion

This study shows that altering the dietary concentration of organic chromium and leucine in broiler diets affected deposition of fat and protein. Chromium added as chromium picolinate at 0.5 mg/kg decreased carcass fat deposition (as measured by chemical fat content) without a commensurate change in carcass weight, breast weight or water content. This observation is consistent with reports in pigs (Amoikon *et al.*, 1995; Wenk, 1995) that chromium supplementation reduces fat deposition. The mechanism of action is not properly understood, but is thought to be due to potentiation of insulin function through both enhanced secretion and an increase in cellular sensitivity to insulin, possibly through increased insulin receptor numbers (Buse, 1981). Chromium is a known micronutrient and thought to be part of a complex of factors which increase tolerance to variation in blood glucose. Its use has not previously been reported in broilers.

The lack of effect of chromium on deposition of lean is consistent with reports from other species. Chromium was without effect on growth of rats (Striffler *et al.*, 1995), and growing pigs (Amoikon *et al.*; 1995, Lindemann *et al.*, 1995; Wenk, 1995). In the current study, body weight and breast muscle tissue are unaffected by chromium treatment.

Chromium supplementation usually improves performance during periods of stress (Kitchalong *et al.*, 1995; Wenk, 1995). Stress alters nutrient metabolism and ultimately increases the dietary requirements for specific nutrients. It has been proposed that chromium may normally be at sub-optimal levels in the diet, principally because of marginal deficiency in grains. Stress, which increases rate of carbohydrate utilisation, may create a demand for chromium and thus a deficient state (Lindemann *et al.*, 1995). Supplementation with Chromium has been shown to improve the growth and performance of stressed animals (Mowat, 1993).

Additional dietary leucine had no influence on efficiency of feed use and had no impact on carcass fat content. Moreover, additional leucine significantly reduced breast muscle weight. It was surprising that leucine had these effects. Reduction in growth was unexpected until it was realised that the branched chain amino oxidase complex is not specific for leucine, but has similar affinity for isoleucine and valine. Moreover, it has been shown in rats (Block and Harper, 1984) that excess dietary leucine decreases the circulating concentration of iso-leucine and valine, by increasing the activity of branched chain amino acid oxidase (and BCAA oxidation) in muscle, and branched chain keto acid dehydrogenase in liver. Given that chickens are susceptible to marginal deficiencies in isoleucine, it is possible that in this study, excess leucine has generated a functional decrease in isoleucine availability and through this mechanism reduced muscle weight gain. It was surprising that this occurred with no significant change in body weight, or in feed conversion efficiency.

# 5. Effects of Dietary Fatty Acids on Lean Growth in Broiler Chickens

## 5.1 Introduction

Reducing fatness in poultry is a current industry goal to improve the efficiency of diets and to provide a leaner product for consumers. Nutritional manipulation provides an opportunity for reducing production costs and improving carcass quality. Feed restriction regimes and alterations in the protein to energy ratio of feed have some success in increasing leanness in broilers (Van Weerden, 1989). Unfortunately their commercial practice is limited.

Fats are required for normal growth and development. The essential fatty acids (EFAs) linoleic and linolenic acids cannot be synthesized by birds and therefore must be supplied in the feed. They are required for the production of eicosanoids, local mediators of metabolism. Suboptimal amounts in the diet reduce performance. These polyunsaturated fatty acids including docohexaenoic acid (found in fish oils) have been reported to promote cell proliferation and reduce apoptosis rate (Tang *et al.*, 1997).

High dietary polyunsaturated fatty acid levels (over 1.4% of the diet) reduce fat deposition in broilers (Pinchasov and Nir, 1992). The omega-3 fatty acids present in fish oils (specifically eicosapentanoic and docohexaenoic acid) lower the circulating very low density lipoprotein levels in the blood, effectively reducing fat deposition in arteries and tissues. Fish oil improves the feed conversion efficiency of broiler diets (Farrell, 1995) but its role in growth and leanness is unclear.

The following study examined the effect of different fatty acid sources, at two dietary levels, on lean growth. Linseed oil, lard, fish oil and safflower oil were added to broiler diets at 2% and 4% levels. Birds receiving the linseed based diets reported significantly heavier abdominal fat pad weights than broilers on the fish oil diets. Fat source had no effect on feed efficiency or other body parameters. The amount of fat in the diet, 2% or 4%, had no significant influence on lean growth.

## 5.2 Results

### *Feed Conversion Efficiency and Growth*

There was no effect of dietary fat source and level on feed efficiency and body weight, the plucked weight or carcass weight of the birds (Table 4.6).

### *Body composition*

*Viscera Weight* : The average viscera weight at 42 days was 205.6g. The type of fat in the diet and the amount present did not influence weight.

*Abdominal Fat Pad*: The abdominal fat pad weighed an average of 22.9g. There was a significant ( $P < 0.05$ ) difference between the fat pad weights of birds fed fish oil compared to those on the linseed based diets, thus fat pad of birds fed the diet containing fish oil was 19.6g

for 2% inclusion and 21.6g for 4% inclusion compared with 28.7g for 2 % linseed and 26.8g for 4% linseed inclusion (Table 4.4).

The amount of fat in the diet did not affect the fat pad weight. Diets containing 4% fat resulted in slightly heavier abdominal fat pads than those with 2% fat (2% fat = 22.5g ± 1.45 and 4% fat = 23.4g ± 1.45).

*Breast Muscle Weight:* The average breast weight for the trial was 348.2g. The level of fat in the diet did not influence the breast yield. The birds receiving linseed oil had the lowest breast weights, with an average weight of 336.9g (Table 4.5), whereas birds receiving the lard had the highest breast yield, with an average weight of 357.0g.

**Table 4.4: Effect of Fat Source on Abdominal Fat Pad Weight.**

Fat Source	% Addition	Fat Pad Wt.(g)
Fish Oil	2	19.6
	4	21.6
Linseed Oil	2	28.7
	4	26.8
Safflower Oil	2	22.6
	4	20.7
Lard	2	18.9
	4	24.6

**Table 4.5: Effect of Fat Source on Body Parameters**

DIET No.	DIET ID	Body Wt.(g)	Carcass Wt.(g)	Gut Wt.(g)	Fat Pad Wt.(g)	Breast Wt.(g)
1	2% Fish Oil	2177.3	1905.2	206.4	19.6	365.2
2	2% Lard	2147.8	1794.5	208.1	18.9	336.8
3	2% Linseed	2002.7	1656.2	204.2	28.7	336.5
4	2% Safflower	2244.8	1877.6	205.8	22.6	372.8
5	4% Fish Oil	2083.7	1736.9	196.0	21.6	334.3
6	4% Lard	2204.8	1850.4	199.9	24.6	377.2
7	4% Linseed	2128.8	1771.4	202.8	26.8	337.3
8	4% Safflower	2093.7	1719.0	221.8	20.7	325.3
<b>Mean:</b>		2135.5	1788.9	205.6	23.0	348.2

Table 4.6: Analysis of Variance Results for Experiment 2.

Treatment	Count	42-d FCE	Body Wt.	Plucked Wt.	Gut Wt.	Fat Pad Wt.	Breasts Wt.
<b>Fatpercent</b>							
2	24	0.69	2143.17	2036.97	206.12	22.47	352.83
4	24	0.68	2127.75	1997.96	205.11	23.42	343.54
<b>P Value</b>		<b>0.71</b>	<b>0.82</b>	<b>0.55</b>	<b>0.88</b>	<b>0.64</b>	<b>0.58</b>
<b>Treatment</b>							
Fish Oil	12	0.68	2130.50	2042.85	201.21	20.59a	349.75
Lard	12	0.69	2176.33	2048.17	203.96	21.77ab	357.00
Linseed	12	0.68	2065.75	1945.08	203.50	27.78ab	336.92
Safflower	12	0.69	2169.25	2033.75	213.80	21.66b	349.08
<b>P Value</b>		<b>0.17</b>	<b>0.66</b>	<b>0.64</b>	<b>0.61</b>	<b>0.07</b>	<b>0.86</b>
<b>Fat % by Treatment</b>							
2% Fish Oil	6	0.69	2177.33	2131.20	206.38	19.60	365.17
2% Lard	6	0.69	2147.83	2021.50	208.07	18.93	336.83
2% Linseed	6	0.68	2002.67	1889.17	204.20	28.73	336.50
2% Safflower	6	0.69	2244.83	2106.00	205.83	22.62	372.83
4% Fish Oil	6	0.67	2083.67	1954.50	196.03	21.58	334.33
4% Lard	6	0.69	2204.83	2074.83	199.85	24.60	377.17
4% Linseed	6	0.69	2128.83	2001.00	202.80	26.83	337.33
4% Safflower	6	0.69	2093.67	1961.50	221.77	20.70	325.33
<b>P Value</b>		<b>0.14</b>	<b>0.46</b>	<b>0.32</b>	<b>0.55</b>	<b>0.51</b>	<b>0.26</b>

a,b,c = data bearing different superscripts in a column within a treatment differ significantly at  $P < 0.05$ .

### 5.3 Discussion

The type of fat in the diet can influence glucose and lipid metabolism in broiler chickens (Newman *et al.*, 1998). In the current study, the effect of linseed oil, lard, fish oil and safflower oil included at 2% and 4% levels on body composition of broiler chickens was examined. The level and type of fats had no effect on body weight, carcass weight, gut weight or feed efficiency in male broilers. Birds receiving diets fortified with fish oil developed significantly smaller abdominal fat pads than birds receiving the linseed oil treatment.

This effect is possibly through the influence of polyunsaturated fatty acids, eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) in lowering the circulating very low density lipoprotein (VLDL) levels. These complexes are normally delivered to tissues for fat storage, including the abdominal fat pad.

The omega-3 fatty acids in fish oil may have reduced the catabolic response induced by the immune system (Chin *et al.*, 1994), reducing protein turnover levels and effectively promoting lean growth. This is supported by the findings of Newman *et al.* (1998) that fish oil increases glucose uptake into the muscle tissue and decreases plasma triglyceride concentration in broiler chickens. The level of fat in the diet (2 or 4% of diet) had no significant effect on feed efficiency or lean growth.

## 6. Implications and Recommendations

The studies have shown that (a) moderate level of chromium can reduce carcass fat content in broilers, and (b) fats containing high levels of polyunsaturated fatty acids, i.e., eicosapentenoic acid (EPA) and docosahexanoic acid (DHA), can reduce abdominal fat pad weight in broilers. The current industry practice does not have any particular provision for chromium in the least cost feed formulation. Also various fats and oils are only used as energy sources except that linoleic acid which is an essential fatty acid for poultry. The chicken carcass contains 13-17% fat and any decrease in the fatness of broilers is favourable in terms of production cost and meat quality. It is important that provisions be made for chromium levels and some polyunsaturated fatty acids in practical feed formulations to take advantage of their effect on energy utilisation and carcass fat content.

Although the data reported here are not extensive, they highlight need for future work as follows:

1. Large scale experiments should be conducted to confirm the current findings that chromium picolinate supplemented at moderate levels can reduce carcass fat deposition.
2. The role of organic chromium in stressed and unstressed broilers should be investigated.
3. The effect of graded leucine on lean tissue deposition in broilers should be examined in conjunction with other branched chain amino acids in the diet.
4. A study on the effect of polyunsaturated fatty acids, i.e., EPA and DHA, and conjugated linoleic acid on protein deposition and energy metabolism in broilers may yield very useful information for the poultry industry.

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