Fats and Fatty Acids in Poultry Nutrition and Health

Edited by
Gita Cherian
Reza Poureslami
CONTENTS

Preface iii

PART 1: Fats and fatty acids in egg layers and meat-type broiler birds

1 Fats and fatty acids in laying hens 1
   Sheila E. Purdum and Dana Didde
   Introduction 1
   Requirement for fats and fatty acids 2
   Metabolic disorders due to excess fat intake 3
   Source of fats 3
   Interactions with other nutrients 4

2 Fats and fatty acids in meat-type broiler birds 7
   Enric Esteve-Garcia
   Introduction 7
   Fat deposition 7
   Intramuscular fat 19
   Energy deposition 20
   Fatty acid synthesis de novo and oxidation 22
   Body fat composition 23
   Conjugated linoleic acid 26
   Conclusions 29

3 Lipoproteins and their metabolism in poultry 37
   Rosemary L. Walzem
   Introduction 37
   Availability of genome data expands discovery potential 37
   System essentials 38
   Apolipoprotein-B containing lipoproteins 41
   Conclusion 48

Part II. Fats and fatty acids in poultry products and quality aspects

4 Modifying egg lipids for enhancing human health 57
   Gita Cherian
   Introduction 57
   Egg lipid composition 57
Egg fatty acids
Why modify egg lipid composition? 60
Why omega-3 or n-3 fatty acids? 60
Are all omega-3 (n-3) fatty acids equal? 61
Enriching eggs with omega-3 fatty acids: role of hen’s diet 63
Omega-3 eggs - are they all equal? 63
Human health effects of n-3 fatty acid-modified eggs 65
Egg quality characteristics and consumer acceptance of omega-3 enriched eggs 66
Summary 67
Acknowledgments 68

5 Modifying meat lipids for human health 71
Reza Pourselami and Amy B. Batal
Fatty acids in human diet 71
Fatty acids in poultry nutrition 73
Metabolism of fatty acids in birds 73
Enrichment of poultry products with n-3 fatty acids 76
Source of n-3 fatty acids in poultry diet 77
Impact of dietary manipulation on the fatty acid composition of poultry meat 78
Impact of age and sex on the fatty acid composition of poultry meat 80
Functional properties of n-3 enriched chicken meat 80

6 Oxidative stability of fatty acids 85
Ronald A. Holser
Introduction 85
Chemical structure and oxidation 86
Analysis of oxidation products 88
Control techniques 93
Conclusion 94

Part III. Fats and fatty acids in poultry health

7 Fatty acids in immune health 99
Mark E. Cook
Introduction 99
Mechanisms by which fatty acids affect immunity 101
Formation of bioactive eicosanoids 101
Resolution of inflammation 105
Membrane fluidity and immune response 106
CD1 molecule and lipid antigen presentation 107
Dietary lipids and immune/inflammatory mechanisms in the domestic fowl 108

Introduction 108

Evidence that dietary fatty acids influence formation of bioactive eicosanoids 109

Evidence that dietary lipids are involved in the resolution of inflammation in the domestic fowl 111

Evidence of CD1 molecules for lipid antigen presentation in avian species 111

Role of lipids and specific fatty acids on the immune response of the domestic fowl 112

Dietary lipids and resistance to infection in the domestic fowl 113

Conclusions 114

8 Dietary fat and nutrigenomics for poultry production 121

Ramesh Selvaraj

Nutrigenomics 121

Nutrigenomics: Fatty acids of importance 122

Nutrigenomics before hatch: Fats in breeder diet 122

Epigenetics and fatty acids 123

Fatty acids and nutrigenomics after hatch 124

Nuclear hormone receptors 125

PPARs 126

LXR 127

SREBP 127

Other genes 127

Practical application of nutrigenomics in commercial poultry production 128

Decreasing abdominal fat pad thickness 128

Decreasing the effect of inflammation 129

Improving the health of chickens 130

Nutrigenomics for selection 130

Conclusions 131

9 Dietary fatty acids and male fertility in poultry 139

Brian K. Speake and Peter F. Surai

Introduction 139

Sperm production and function in poultry 144

Current limitation on male fertility of poultry 145

Functional and origins of sperm lipids 146

The importance of 22:6n-3 and 22:4n-6 in sperm function 146

Role of lipids of the sperm head in the acrosome reaction 146

Potential role of sperm tail phospholipids in sperm motility 148

Why is 22:4n-6 the characteristic fatty acid of avian sperm? 149

Origins of the polyunsaturated fatty acids of sperm phospholipid 151
Fatty acids and male fertility in poultry          152
Changes in fertility and sperm fatty acids during the reproductive cycle  152
Supplementation with polyunsaturated oils to improve male fertility        155
Mechanisms for the effects of polyunsaturates on avian male fertility      158
The importance of antioxidants                                            159
Conclusions                                                                160

10 Use of fatty acids to control enteric pathogens in poultry               169
Anup Kollanoor Johny and Kumar Venkitanarayanan

Introduction                                                              169
Enteric foodborne pathogens in poultry                                     170
Pre-harvest control methods                                               171
Short chain fatty acids                                                    172
Medium chain fatty acids                                                  176
Effect of fatty acids on enteric parasites in poultry                      180
Conclusion                                                               180

11 Fatty acids of eggs of wild and domesticated birds and their roles in embryonic development 191
Brian K. Speake, Peter F. Surai and Nicholas A.R. Wood

Introduction                                                              191
Sources of yolk fatty acids                                               193
Determinants of yolk fatty acid composition in eggs of wild birds         195
Relationship between the fatty acid profiles of the diet and the yolk     195
Dietary strategies of avian species in the wild                           195
The effects of interspecies differences in fatty acid metabolism          196
Interspecies variation in yolk fatty acid profiles of birds in the wild   197
Egg collection                                                            197
Comparison with domesticated species                                      197
Eggs from a granivorous species in the wild                               197
Eggs from wild and domesticated herbivorous species                       199
Eggs from wild and domesticated ducks                                     201
Eggs of piscivorous birds in the wild                                     202
Eggs of wild and captive carnivorous birds                               202
Eggs of insectivorous passerine birds in the wild                         204
Eggs of some omnivorous species in the wild                               206
Comparison of the fatty acid profiles of the diet and the yolk in domesticated and wild birds  207
Fatty acid profiles of the yolk lipid classes                             210
The utilisation of yolk fatty acids by the avian embryo                  211
Functions of the various fatty acids in avian embryonic development       211
Effect of interspecies differences in yolk 22:6n-3 content on the proportion of this PUFA in brain phospholipid at hatch  215
Evidence for selective utilisation of 20:4n-6 and 22:6n-3 during development 217
The mechanism of yolk lipid uptake during embryonic development 219
Unique aspects of the uptake and metabolism of 22:6n-3 and 20:4n-6 in the embryo 224
Implications for commercial production 234
Effects of yolk fatty acids on the health of the embryo and chick 234
Consequences of diets in captivity for development in various avian species 237
Possibilities for future studies 240

Part IV. Fats and fatty acids: analytical aspects

12 Appropriate extraction and methylation techniques for lipid analysis 249
Noelia Aldai, John K. G. Kramer, Cristina Cruz-Hernandez, Viviana Santercole, Pierluigi Delmonte, Magdi M. Mossoba, and Michael E. R. Dugan

Introduction 249
Preparation of biological test samples 250
Deciding which methods to use 250
Biological sample collection 250
Homogenization and total lipid extraction 252
Biological fluids (milk, plasma or serum) 253
Tissues or solid samples 254
Digesta or feces 256
Notes on homogenization and lipid extraction 256
Acid digestion 256
Methylation 257
Direct methylation 257
Acid catalyzed methylation 258
Base-catalyzed methylation 259
Combining acid and base methylations 261
Analysis of plasmalogenic lipids 262
GC analysis 265
Selection of a GC column 265
Is there a need to purify the FAMEs before GC analysis? 266
Improving GC separations by adjusting the sample load 266
Differences between 100 m cyanopropyl siloxane GC columns 268
GC column temperature affects elution times 269
Chromatographic separations of FAMEs using a new ionic column 271
Temperature program versus isothermal conditions 271
Quantitation of FAME by GC 272
Commercial FAME mixtures 274
GC autosampler vials 274
Internal standard (IS) 275
Complementary methods to GC analysis 276
Ag⁺-HPLC techniques. 276
Separation of FAMEs using Ag⁺-SPE, Ag⁺-TLC, or Ag⁺-HPLC techniques 277
Mass spectrometry (MS) techniques 277
GC/FTIR and ATR-FTIR spectroscopy 278
Fourier transform near infrared (FT-NIR) spectroscopy 278
FATS AND FATTY ACIDS IN LAYING HENS

Sheila E. Purdum and Dana Didde
Department of Animal Science, University of Nebraska, Lincoln, NE. 68583-0908, USA

Introduction

The laying hen does not have a specific requirement for fat as a nutrient, but rather fats supply the laying hen energy (calories), essential fatty acids, and improved absorption of fat soluble vitamins and other feed supplements such as pigmentors (NRC, 1994). When formulating a laying hen ration, the nutritionist rarely sets a minimum level of fat in the ration. However, a minimum level of the essential fatty acid – linoleic acid (C18:2) will usually be set into the least cost formulation at a rate recommended by the primary breeder or the NRC Nutrient Requirements for Poultry (1994).

Fats can be provided to the laying hen diet from a multitude of ingredients including grains such as corn, oats, wheat; vegetable protein sources such as soybeans, canola, dried distillers grains, peas; animal protein sources such as meat and bone meal, poultry meal, blood meal, and finally from pure fat sources such as vegetable oils, tallow, lard, palm oil, and restaurant grease blends. These fats serve as concentrated sources of energy to the laying hen and add caloric and economic value to laying hen rations. When formulating a least cost laying hen ration, the program will balance for protein and energy, looking for concentrated sources of energy such as fats to meet the hen’s high energy requirements for optimum egg production. It is not uncommon to see 2-4% added fat sources in laying hen rations during peak egg production. The rate of added fat will change depending on the base ingredient price differences when formulating the ration. For example, when corn prices are high and a low price restaurant grease is available, the least cost feed formulation program is likely
Introduction

Dietary fat composition affects the amount of fat and the fatty acid composition of the fat deposited in the body. On one hand, polyunsaturated fatty acids (PUFA) appear to result in lower fat deposition than fats rich in monounsaturated (MUFA) or saturated fatty acids (SFA). Conjugated linoleic acid (CLA) also appears to affect fat deposition, although results are controversial. Since chickens are normally in a positive energy balance, fatty acids are mostly deposited unaltered and the composition of the fat tends to reflect that of the diet, although there are some modifications which are discussed below.

Fat deposition

Fatty acids affect differently the amount of fat deposited in the body of chickens. Diets containing PUFA cause lower fat deposition than diets containing similar amounts of SFA or MUFA. A summary of results is presented in Table 1. Pan et al. (1979) replaced tallow (T) by soybean oil (SO) in broiler diets and observed lower abdominal fat pad (AFP) deposition. Pichasov and Nir (1992) found that high levels of a mixture of sunflower oil (SFO) and SO replacing T also resulted in lower AFP and lower body fat (BF). Vilà and Esteve-Garcia (1996) observed that saturated acid oils, resulted in higher AFP deposition than unsaturated acid oils although they had much lower metabolizable energy. A study was designed to test this effect, and diets differing in their fatty acid profile were compared to determine their effect on AFP deposition. Birds fed SFO -rich in linoleic acid (LA)- and linseed oil (LO) -rich in α-linolenic acid (LNA)- presented better values of feed efficiency than those fed T, AFP and
Introduction

Lipoproteins and their metabolism have been of intense research interest to poultry scientists for a very long time. Lipoproteins are distinctive macromolecular structures assembled in a structurally specific manner that reflects their physiological purpose (Walzem, 1996). While poultry typically consume feed with a very low fat content, lipid transport and tissue lipid composition are of great interest to poultry biologists due to the roles such processes play in determining the nutritional value of poultry products and bird health. Past reviews have summarized the general biochemical features and physiological processes of avian lipoprotein metabolism (Chapman, 1980; Gruffat et al., 1996; Hermier, 1997; Walzem, 1996). However, now that the complete sequence of the avian genome is publically available new molecular detail can be developed to guide further improvement of our understanding of these biologically active nanoparticles. Thus the goal of this chapter is to update biochemical information and, where possible, to provide molecular context for the reader with regard to the processes through which diet and dietary fatty acids influence the multiple aspects of poultry biology covered in other chapters within this book.

Availability of genome data expands discovery potential

Our current understanding of fats and fatty acids in poultry nutrition and health is largely empirical, hard earned through a multitude of feeding trials. However, the availability of the genomes of chickens and species such as humans and...
MODIFYING EGG LIPIDS FOR ENHANCING HUMAN HEALTH

Gita Cherian
Oregon State University, Corvallis, Oregon, USA

Introduction

During the past two decades, several ways of enhancing the nutritional value of food products, especially chicken eggs, have been attempted. These include genetic, pharmacological, dietary, biotechnological and processing methods. Among the different methods, dietary manipulation has been the most successful and most widely adopted. The current chapter will emphasize the role of diet in modifying egg lipid composition to meet the human requirement of essential nutrients and thereby contribute to human health in a holistic and sustainable manner. Research related to modifying egg lipid composition has been well documented, only some of the most recent research and/or reviews are included in the current chapter.

Egg lipid composition

Eggs are store-houses of several essential nutrients and their contribution to the diet is based on size. Table eggs are categorized into small, medium, large or extra large, based on their weights. The nutrient contribution to the diet also varies depending on size. For example, a small egg weighing 38g could provide 50 calories while an extra large egg could contribute over 80 calories. Table 1 shows the lipid, fatty acid and cholesterol content in small, medium, large or extra large table eggs. Among several nutrients in eggs, fats or lipids have attracted the most attention among scientists, media and consumers due to the link between high dietary fat consumption and coronary heart disease.
MODIFYING MEAT LIPIDS FOR HUMAN HEALTH

Reza Poureslami and Amy B. Batal

Department of Poultry Science, University of Georgia, Athens, GA 30602, USA

Fatty acids in human diet

Besides carbohydrates and proteins, lipids are one of the main components of food. Lipids have a crucial role in early development, pregnancy, lactation and provide an energy reserve for the body (Crawford, 1983). Lipids contain essential fatty acids which are needed for growth and development. Essential fatty acids act as precursor for long chain derivatives which are used in cell membrane and for synthesis of prostaglandins and hormone-like substrates involved in cell regulation, reproduction, immunity and blood flow. Fatty acids are the common structural units of lipids. Fatty acids consist of three elements; carbon (C), hydrogen (H) and oxygen (O) arranged as a carbon chain skeleton with a carboxyl group at the end (-COOH). Fatty acids are classified according to their chain length and number, position and configuration of double bonds. The impacts of quantity and quality of the dietary fat on the development of several diseases, including cardiovascular disease (CVD), some cancers and arthritis have been well-established (Simopoulos, 1999).

Dietary fats and oils represent a significant proportion of the caloric intake (>33%) in the United States (Bialostosky et al., 2002). Saturated fatty acids (SFA) are found in every type of food. Long chain SFA (>C12) are most common in animal fats and vegetable oils. Short chain SFA (C4-C10) are mainly found in milk fat. Milk and milk products (e.g., cheese and butter), ruminant meat and meat products are major sources of SFA in food (Givens et al., 2006). Dietary SFA are associated with an increase in LDL and a decrease in HDL, which is a risk factor for coronary heart diseases, risk of obesity and associated disorders (Lesna et al., 2008; Bergouignan et al., 2009). When contrasted to SFA, a high monounsaturated fatty acid (MUFA) content in the diet favors
Introduction

The unsaturated fatty acids docosahexaenoic acid (DHA) and alpha linolenic acid (ALA) have shown numerous benefits including improved nervous system development and cardiovascular health (Harris, 1989; Leaf, 1990; Martinez, 1995). This has generated interest in their use as feed additives (Rising et al., 1990; Kim et al., 1993; Watanabe, 1993; Enjalbert et al., 1997). However, DHA and ALA are particularly susceptible to oxidation due to the high degree of unsaturation. The oxidation of such unsaturated lipids generates malodorous compounds and leads to off flavors and the loss of bioactivity of the original lipid structures.

Fish oils are a rich source of polyunsaturated fatty acids and especially of the more highly unsaturated fatty acids such as DHA. However, when fish oils are used in the feed formulations of laying hens to improve the nutritional value of the eggs there is some decrease in sensory quality reported as fishy off-flavors (Van Elswyk et al., 1995; Van Elswyk, 1997; Gonzalez-Esqerra and Leeson, 2000). This can be alleviated by using marine algae as the primary source of the polyunsaturated fatty acids rather than the fish oil (Herber-McNeill and Van Elswyk, 1998). Similar studies with flaxseed as a source of linolenic acid (ALA) have shown that the polyunsaturated fatty acids do accumulate in the eggs, however, there are anti-nutritional compounds in the flaxseed that have negative effects on production (Bean and Leeson, 2003). When isolated ALA was fed to Shaver hens a reduction in hatchability was observed that could be off-set by supplementing the diet with soybean oil (Muma et al., 2006). These
Introduction

Use of dietary lipids in poultry feed serve as immediate sources of energy, precursors for the synthesis of key metabolites in secondary metabolism, storage for future caloric needs, membrane composition and molecules critical in a variety of signal transduction pathways. With regards to immunity and inflammation in the fowl, lipids in cell membrane structures and their role as signaling molecules are likely the most direct mechanism by which lipids affect immune function. Literature and mechanism by which lipids influence immune and inflammatory responses is both vast and complex. In this chapter, key mechanisms by which fatty acids affect key pathways that direct immune defense and inflammatory response will be briefly introduced, then evidence of these mechanisms acting in avian species will be presented, and finally experimental nutritional trials involving dietary fatty acids and complex fats and oils on the immune response of the bird will be reviewed: where possible, specific fatty acids that are direct contributors to immune responsiveness will be described.

Of the many fatty acids in the bird’s diet, there are few that play a significant role in immune function. Critical fatty acids that serve as precursors for other fatty acids that effect immune events include linoleic acid C18:2, cis 9, cis 12, the conjugated dienes of linoleic acid (namely the most studied C18:2,cis (c) 9 trans (t) 11 and t10c12), and α-linolenic acid (C18:3, c9c12c15). While the conjugated linoleic fatty acids have their biological effects directly, both linoleic acid and α-linoleic acid are desaturated and elongated into fatty acids (linoleic acid to C20:4, c5c8c11c12 or arachidonic acid and alpha linoleic acid to C20:5, c5c8c11c14c17 or eicosapentaenoic acid or C22:6, c4c7c10c13c16c19 or docosahexaenoic acid) that directly influence signal transduction pathways.
Historically, nutritional research in the animal production industry has focused on identifying macronutrients and micronutrients that are essential for normal growth and development of animals. The most important, if not only, goal of nutrition research in the animal production industry has been to achieve maximal production through “least cost formulation.” Least cost formulation ensures that a bird, in the case of poultry, consumes the right balance of nutrients to support increased production performance but at the same time costs the least to the poultry producers. This research approach has resulted in huge advances in reducing feed cost, thus, improving production performance of chickens with increased profit margin for poultry producers. Over the years, the advances owing to such empirical nutrition-based research have reached a plateau and, hence, researchers have started to identify unique interactions between nutrition, biochemistry, environment, gene expression, and immunology that will further advance profit margins achieved through empirical nutrition research. One such area of study is nutrigenomics, which is the study of interactions between dietary nutrients and gene expression.

**Nutrigenomics**

Dietary nutrients alter gene expression either directly or indirectly (Raqib and Cravioto, 2009). Nutrigenomics is the study of food and food-derived products on gene expression and how gene expression affects response to nutrients. From a nutrigenomics viewpoint, nutritional components act as signaling molecules that can activate several sensor systems in a cell, which ultimately alter gene and protein expression and control homeostasis (Muller and Kersten, 2003). Nutrients activate transcription factor sensor systems in the cell, which in
Introduction

Spermatozoa are highly specialised cells with a unique shape and a singular function: the fertilisation of the egg. A typical spermatozoon consists of three main parts: the head, the midpiece, and the tail. Much of the head is occupied by the haploid nucleus, containing the paternal contribution to the genome of the potential embryo. Overlying the nucleus, at the tip of the head, is the acrosome, a Golgi-derived vesicle containing a range of enzymes whose action enables the spermatozoon to penetrate the outer layers of the egg and to fuse with the egg’s plasma membrane. Mobility is provided by rhythmic, whiplash movements of the long, narrow tail, enabling the spermatozoa to move towards the egg and supplying the propulsive force required for fertilisation. These movements are powered by the energy generated by large numbers of mitochondria that are packaged within the midpiece of the sperm cells.

The characteristic long, narrow, extended shape of spermatozoa imparts these cells with a very high surface area in relation to their volume, and therefore with a relatively large amount of plasma membrane. This predominance of cell membrane is accomplished during spermatogenesis in the seminiferous tubules of the testis, where much of the cytoplasm of the sperm precursor cells (spermatogonia) is extruded. Other membranous structures within the cell, including the nucleus, acrosome and mitochondria, make further contributions to the total amount of spermatozoan biomembrane. Since the lipid bilayer of cell membranes consists of phospholipid (PL) plus some free cholesterol (chol), these amphiphilic lipids are seen as major structural components of spermatozoa. In fact, PL forms 70% (w/w) of the total lipid of spermatozoa.
Introduction

Research over the last two decades worldwide has yielded substantial information on the effect of supplemented unsaturated long chain fatty acids on the meat quality of food animals, including poultry (Wood et al., 2008; Qi et al., 2010). However, short-chain and medium chain fatty acids on the other hand have been primarily investigated for improving animal gut health and reducing pathogen colonization. Besides their use as such (Van Immerseel et al., 2002; Kollanoor Johny et al., 2009a; Solis de los Santos et al., 2009, 2010), these fatty acids are also used in animal diet as sodium, potassium or calcium salts, due to their higher solubility in water, odorless nature, low volatility, less corrosive property and easiness to handle in solid form (Huyghebaert et al., 2010; Metcalf et al., 2011). Although a variety of pathogenic organisms, including Salmonella spp., Campylobacter spp., Listeria spp., Clostridium perfringens, Helicobacter pullorum, Arcobacter butzleri and Eimeria spp. colonize the chicken gastrointestinal tract, most of the research on the antimicrobial properties of fatty acids in chickens has focused on the former two pathogens. This is chiefly because Salmonella Enteritidis and Campylobacter jejuni represent the two most common food-borne pathogens transmitted to humans through poultry products, together accounting for more than two-third of the total laboratory-confirmed cases of bacterial gastroenteritis (Anonymous, 2005). Therefore, the microbiological safety of poultry-derived food products are of great concern for the government, regulatory agencies and consumers, thus triggering research on controlling S. Enteritidis and C. jejuni carriage in chickens.

Among different classes of fatty acids, short- and medium- chain fatty acids have been investigated for their potential roles as antimicrobial agents to
11

FATTY ACIDS OF EGGS OF WILD AND DOMESTICATED BIRDS AND THEIR ROLES IN EMBRYONIC DEVELOPMENT

Brian K. Speakea, Peter F. Suraib and Nicholas A.R. Woodb

aAvian Science Research Centre, SAC (Auchincruive), Ayr, KA6 5HW, UK
bWildfowl Consulting and Research, Devon, EX18 7NB, UK

Introduction

When attempting to ascertain the “ideal” mix of maternal dietary fatty acids for supporting egg formation, successful embryonic development and post hatch health, it is worth considering the diversity of yolk fatty acid compositions that are achieved naturally by different species of birds in the wild. Avian yolk is a rich blend of lipids and proteins in aqueous suspension or solution, capable of supporting the growth and development of the embryo to the point of hatch. In fact the nutritive role of the yolk is often sustained for a few days after hatching, when the residual yolk that has not been utilised during the embryonic period is retracted into the body cavity of the chick where it continues to act as a food source. The lipids of the yolk are almost entirely located in sub-microscopic lipoprotein particles, millions of which are packaged within the vitelline membrane. The fatty acids that comprise the yolk lipids are not present in the free form but are esterified to glycerol or cholesterol to give the complex lipids, triacylglycerol (TAG), phospholipid (PL) and cholesterol ester (CE).

Abbreviations: CE, cholesterol ester; chol, free (i.e. non-esterified) cholesterol; FFA, free (i.e. non-esterified) fatty acid; LPL, lipoprotein lipase; MG, monoacylglycerol; PL, phospholipid; PUFA, polyunsaturated fatty acid; TAG, triacylglycerol; VLDL, very-low density lipoprotein; YSM, yolk sac membrane.
APPROPRIATE EXTRACTION AND METHYLATION TECHNIQUES FOR LIPID ANALYSIS

Noelia Aldai 1, John K. G. Kramer 2*, Cristina Cruz-Hernandez 3, Viviana Santercole 4, Pierluigi Delmonte 5, Magdi M. Mossoba 5, and Michael E. R. Dugan 6

1 Food Science and Technology, Faculty of Pharmacy, Universidad del Pais Vasco/Euskal Herriko Unibertsitatea, 01006 Vitoria-Gasteiz, Spain; 2 Agriculture and Agri-Food Canada, Guelph, ON, Canada (see current address below); 3 Nestle Research Center, Lausanne, Switzerland; 4 Dipartimento di Medicina, Settore Ispedizione degli Alimenti di Origine Animale, Via Vienna, 2 07100 Sassari, Italy; 5 Food and Drug Administration, College Park, MD, USA; 6 Agriculture and Agri-Food, Lacombe, AB, Canada

Introduction

A common question often asked when conducting lipid research using animals is what needs to be analyzed to support the hypothesis under consideration. Studies based on feeding specific lipid enriched diets or feeding components that affect lipid metabolism in animals may involve investigating digestion, absorption, tissue accretion, fatty acid (FA) metabolism, or their effects on other

Abbreviations: Alk-1-enyl methyl ether, AME; American Oil Chemists’ Society, AOCS; Association of Analytical Communities, AOAC; attenuated total reflection, ATR; cholesterol ester, CE; conjugated linoleic acid, CLA; diazomethane, DAM; dimethyl acetal, DMA; dimethyloxazoline, DMOX; empirical correction factor, ECF; fatty acid, FA; fatty acid methyl ester, FAME; flame ionization detector, FID; Fourier transform infrared, FTIR; Fourier transform near infrared, FT-NIR; free fatty acids, FFA; gas chromatography, GC; gas liquid chromatography, GLC; high performance liquid chromatography, HPLC; internal standard, IS; international organization for standards, ISO; Japanese Oil Chemists’ Society, JOCS; partially hydrogenated vegetable oil, PHVO; mass spectrometry, MS; phospholipid, PL; polyethylene glycol, PEG; solid phase extraction, SPE; triacylglycerol, TAG; thin-layer chromatography, TLC; polyunsaturated fatty acid, PUFA; trimethylsilyl-diazomethane, TMS-DAM.
References


