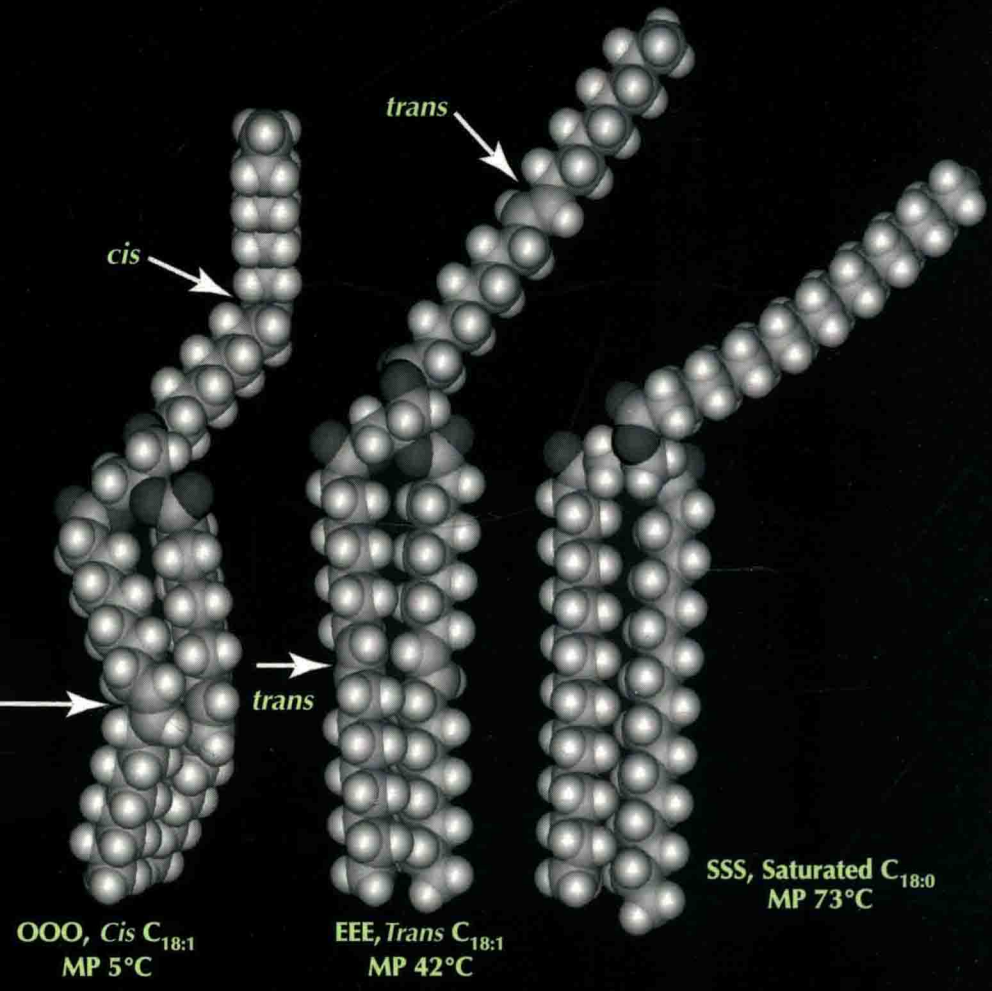
Trans Fats
Alternatives

Editors
Dharma R. Kodali and Gary R. List



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AOCS Mission Statement
To be the global forum for professionals interested in lipids and related materials through the exchange of ideas, information, science, and technology.

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Preface

The date January 1, 2006, is significant to all of us in the fats and oils industry. On that date, the Food and Drug Administration (FDA) will require the mandatory declaration of the amount of *trans* fat present in foods. The regulations do not require food product manufacturers to reformulate their products to reduce/eliminate *trans* fats, but it requires declaring the amount of *trans* fat in grams per serving on the "Nutrition Facts" label. Since the FDA *trans* fats ruling two years ago, extensive media coverage around the country has made the public aware of *trans* fats and their influence on heart disease. The negative perception associated with *trans* fats has strongly influenced the food product manufacturers to eliminate or reduce the *trans* fats in their products. Scientists around the world are working to create solutions or alternatives to the *trans* fat dilemma. In an effort to address this problem at this critical juncture, we have gathered the best in the fats and oils business to create this compendium to educate public and pundits of fats and oils alike to deal with the new *trans* fat labeling requirements.

This book is principally for everyone who is interested to know more about *trans* fats, food product manufacturers who would like to provide the *trans* fat solutions and to the researchers who would like to create innovative solutions. Part of the inspiration and the subject matter for this book comes from a one day symposium on "*trans* FATS Food for Thought" that took place in Chicago a year ago. Fats and oils processors, food product manufacturers, and researchers from industry, academia and government attended this symposium. We hope this book will draw attention from a broad non-technical and technical audience.

The contents of this book can be divided into three parts. Chapters 1 to 3 covers the background and the fundamental aspects of *trans* fats. Chapter 1 is a chemists' view of the *trans* fats problem, the current status and an insight into possible future solutions. Chapter 2 provides the background, scientific basis and the details of new *trans* fats regulation. Chapter 3 discusses the collective summary of *trans* fats clinical trials and the dietary guidelines from various professional health organizations. The second part of the book from chapters 4 to 6 covers the practical aspects of *trans* fats. Chapter 4 evaluates and summarizes the state-of-the-art analytical methods to determine the *trans* fats. Chapter 5 gives an account of the *trans* fat problem, its implications and the potential solutions. Chapter 6 provides insight into the consumer interpretation of the *trans* fats information. The last part, chapter 7 and the Appendix, deal with the commercial aspects of *trans* fats. Chapter 7 is a primer for food product reformulators to consider various practical issues before making the decision on a suitable solution(s). This chapter brings out the importance of various business objectives before reformulation. The Appendix brings the reality of what actual commercial solutions exist to address the *trans* fats in food products. Fats and oils suppliers, such as Aarhus, ADM, Bunge, Cargill, Loders Croklaan, and Premium Vegetable Oils address this issue by providing the actual *trans* fats solutions that they currently offer to their customers.

Bringing this book to reality was a great challenge to contributors, the AOCS staff and us, as it was compiled within a time span of 7 weeks. We greatly appreciate strong commitment and cooperation from all the contributors. Without their unwavering involvement, this book would not have been possible. We express our special thanks to AOCS books, special publications committee members, and its chair for their approval of the project. We gratefully acknowledge the help, guidance and the logistical support from AOCS staff Jodey Schonfeld and Daryl Horrocks, as well as the editorial help from Sithara Kodali.

We hope the information contained in this book helps ease the transition to the new FDA regulations for *trans* fats. We invite readers to contact us and/or any of our contributors with questions or comments to learn more. The readers can find more information about the contributors from the short bio and the contact information provided in the beginning of the book. We hope that this book provides a useful and timely reference in an era of nutritional change in the United States that marks a paradigm shift for fats and oils suppliers worldwide.

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March 25, 2005

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Contents

Chapter 1

Trans Fats—Chemistry, Occurrence, Functional Need in Foods and Potential Solutions

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Introduction

Natural oils and fats are liquids or semisolids consisting primarily of triacylglycerols (TAG). In literature, TAG are often referred to as triglycerides, even though this latter term is less accurate in representing the molecular structure of this class of compounds. The distinction between fats and oils is seen by their physical state at ambient temperature; the fats are solid and the oils are liquid. The two major sources of oils and fats are from animals and plants. Greater than 90% of commercial oils and fats used for human consumption are plant-derived vegetable oils. Unrefined natural oils and fats, after extraction from the source, comprise mostly TAG containing less than 5% of minor components such as sterols, phospholipids, tocopherols, fatty acids and partial glycerol esters. The minor components and their concentration in the crude oil depend upon the origin and method of oil extraction. The crude oils are subjected to various processing steps like degumming and alkali refining (to remove phospholipids and fatty acids), bleaching (to remove colored and polar matter) and steam stripping or deodorization (to remove volatile components) to make them suitable for human consumption. Oils subjected to these steps are usually referred to as RBD (refined, bleached and deodorized) oils and contain about 99% TAG.

The major vegetable oils of commerce are soybean, cottonseed, canola, sunflower, corn, peanut, palm, palm kernel and coconut oils. Other vegetable oils like olive, rice bran, safflower, sesame and other specialty oils are not used extensively due to availability and cost. A typical chemical structure of TAG is shown in Figure 1.1. The TAG contains a glycerol backbone with three hydroxyls esterified to three long linear carboxylic acids called fatty acids. The glycerol portion of TAG is constant in all oils and fats. The type of fatty acid structure and the position of esterification on glycerol differ from one TAG to another. Glycerol is a prochiral molecule capable of forming two different TAG stereoisomers when esterified with different fatty acid chains at the 1- and 3-positions. These stereoisomers when differentiated from one another are identified as stereospecifically numbered, -*sn*-glycerol derivatives (Kodali *et al.*, 1984, 1989a). Even though biological systems can recognize the isomeric -*sn*-glycerol derivatives, the physical and chemical properties of these isomers are very similar. For all functional and practical purposes they are treated as one and the same.

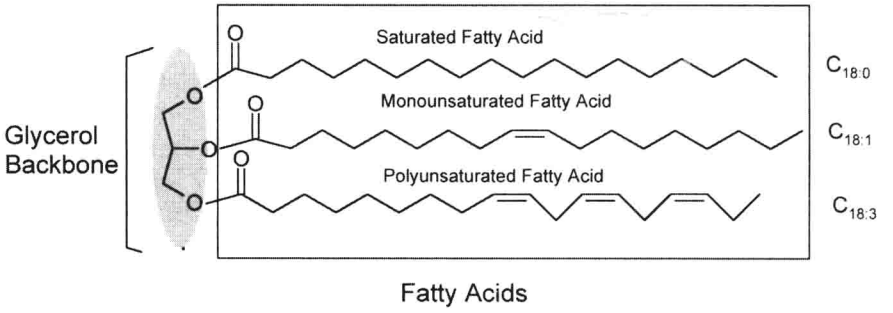

Fig. 1.1. A typical molecular structure of a triacylglycerol showing the glycerol backbone region esterified with three different fatty acids: stearic, oleic, and linolenic acids.

Vegetable oils contain a mixture of specific TAG molecules of given concentrations. Fatty acid structures differ from each other in carbon chain length and the number of double bonds. Most of the naturally occurring fatty acids are even numbered, 4 to 24 carbon atoms long. They are synthesized by the biological systems from two-carbon unit acetyl coenzyme A. More prevalent saturated fatty acids with no double bonds that occur in oils and fats are lauric (C_{12}), myristic (C_{14}), palmitic (C_{16}) and stearic (C_{18}) acids. The number in the parenthesis shows the number of carbon atoms corresponding to the fatty acid chain length. Sometimes a zero after the number indicates that there are no double bonds. The predominant unsaturated fatty acids are oleic ($C_{18:1}$), linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) acids. The numbers in the parenthesis show the carbon chain length followed by the number of double bonds. The position of double bonds in the chain and the double bond configuration are also very important. In oleic acid it is at carbon-9, in linoleic at 9 and 12 and in linolenic at 9, 12 and 15. Most of the unsaturated fatty acids that occur in natural fats and oils –with few exceptions, have the double bonds in *cis* configuration. The fatty acids that contain a single double bond are referred to as "monounsaturated" and others with more than one double bond are "polyunsaturated" fatty acids. Even though there are hundreds of different fatty acids that occur in oils and fats, the fatty acids referred above are most common and abundant in natural oils and fats.

The predominant vegetable oils in commerce can be divided into three types based on carbon chain length—lauric, palmitic and oleic oils. The lauric oils, mostly coconut and palm kernel oils, contain high levels of 12-carbon lauric acid. The common palmitic oil, palm oil, contains 16-carbon palmitic acid in high concentration. The lauric and palmitic oils are high in saturated fatty acids and are semisolids at ambient temperature. Because coconut, palm and palm kernel oils are grown in the temperate regions, they are referred to as tropical oils. Oleic oils predominantly contain 18- carbon fatty acids, stearic, oleic, linoleic and linolenic acids. The soybean, cottonseed, canola, corn and peanut oils belong in this category. The major types of edible oils that are consumed in North America are soybean, corn and canola. Palm oil is not extensively used in the United States but is more common in Asia and