Preface

Lipids are biomolecules with complicated structural variability and they constitute a significant amount of biomass in the earth. There are many classes of lipids based on polarity or on chemical structure. The polar lipids are, for instance, phospholipids, while the nonpolar (neutral) lipids are, for instance, triacylglycerol. Besides, lipids could be classified based on their chemical structure that could be either abundant lipids or degraded lipid metabolites such as Fatty acids (FA) and Mono/Di-glyceride (MG, DG). Thus, there are so many classes of lipids with precise nomenclature. Plants constitute a large part of vivant organisms in earth. Lipids and in particular plant lipids are of increasing interest because of their multiple roles such as in food technology and medicine as they could be potential sources of dietary essential polyunsaturated fatty acids (FUFAs) in significant amounts. They could be involved in many processes such as in nutrition and storage of energy and are of relevance for signal transduction processes, cell differentiation and phagocytosis (Yeung, Ozdamar, Paroutis, & Grinstein, 2006).

In general, the ability of any organism (e.g., plants) to make any particular product (lipids in our context) is predicated on its capability for the secretion of a particular set of enzymes (lipolytic enzymes).

Lipolytic enzymes play essential roles dealing with the turnover of the large amount of lipids in our planet. These enzymes are without doubt, biologically significant proteins, besides; they found many applications such as in the fields of lipid metabolism, biochemistry, medicine, nutraceutical and food technology.

Studying lipolytic enzymes from plants would be very promising as these enzymes; in particular, phospholipases might play important roles in plant growth, development and stress response. Many reports have focalized in studying the mechanism of action of such enzymes and their diverse functions (Matlashewski, Urquhart, Sahasra-dudhe, & Altosaar, 1982; Pokotylo, Pejčhar, Potocky, Kocourkova, Krckova, Ruelland, Kravets, & Martinec, 2013; Pokotylo, Kolesnikov, Kravets, Zachowski, & Ruelland, 2014; Hong, Zhao, Guo, Kim, Deng, Wang, Zhang, Li, & Wang, 2016).

Within the last decades, the interest in lipolytic enzymes, e.g. lipases and phospholipases, has increased considerably and due to the importance of such enzymes, this interest would probably be gradually increased so far and in the future.

Recent advances in protein chemistry, biochemistry, and enzymology have promoted research on lipolytic enzymes. Novel and potent tools for related disciplines like crystallography, NMR technology and molecular modelling would endorse revealing new sequences of amino acids and three-dimensional structures of lipases and phospholipases.

The investigation and understanding of relationship of proteomes and lipidomes would be an outstanding feature in recent development in biotechnology. The mechanism of action of major lipolytic enzymes and their roles in lipid signaling in particular in plants remain to be elucidated. High performance analytical techniques as well as bioinformatics analysis would be very interesting research tools to accelerate discovering of novel proteins (enzymes) as well as lipids using the *de novo* sequencing approaches.

We would like to try to cover major aspects of plant lipolytic enzymes research from genomics, proteomics and phylogenies to related annotated functions.

The book entitled *Unique Sequence Signatures in Plant Lipolytic Enzymes: Emerging Research and Opportunities* addresses the importance of lipases and phospholipases from plants. The major focus of this compendium is on the structural aspects of these enzymes. Insights into their functions and their phylogenetic evolution would also be discussed in the current book via previous publications that seemed to offer helpful information regarding the biochemistry of lipolytic enzymes.

Lipases are lipolytic enzymes that catalyze mainly hydrolysis of oil, i.e. triglycerides. Plant lipases received scrutiny of investigation especially in seeds since 1890, for instance, lipase from castor bean (*Ricinus communis*), which was first described in the seed (Green, 1890).

Phospholipases are grouped in plants into phospholipase C (PLC), phospholipase D (PLD) and phospholipases A (PLA1 and PLA2) according to the site of glycerophospholipid hydrolysis (Wang, Ryu, & Wang, 2012; Wang, 2001). Moreover, within each group, there are different kinds of enzyme clustered into families or subfamilies that differ in their structures, substrate selectivities and reaction conditions (Wang, 2001; Wang, 2004; Wang, Ryu, & Wang, 2012). Plant phospholipases play critical roles in growth and development of plants as well as their response to abiotic and biotic stresses and thus, many researchers have paid attention in recent years toward the characterization of such enzymes (Wang, Ryu, & Wang, 2012; Hong, Zhao, Guo, Kim, Deng, Wang, Zhang, Li, & Wang, 2016).

Phospholipase C (PLC) hydrolyzes the phosphodiester bond on the glycerol side of phospholipids to produce diacylglycerol (DAG) and a phosphorylated head group. PLCs in plants can be divided into three groups according to substrate specificity and cellular functions: Non-specific PLC (NPC) that acts on the common phospholipids, e.g. PC and PE, Phosphoinositide-specific PLC (PI-PLC) that hydrolyzes phosphoinositides, and the Glycosylphosphatidylinositol (GPI)-PLC that hydrolyzes GPI-anchored proteins (Wang, 2001; Hong, Zhao, Guo, Kim, Deng, Wang, Zhang, Li, & Wang, 2016).

Phospholipase D (PLD) is an enzyme that catalyzes the hydrolysis of the phosphodiester bond of phospholipids (PLs) to produce phosphatidic acid (PA) and an alcohol moiety. PLD can also catalyze the interconversion of polar head groups of PLs by transphosphatidylation reaction. This latter reaction leads to synthesis naturally less abundant PLs such as phosphatidylglycerol (PG), phosphatidylserine (PS), or phosphatidylethanolamine (PE) from highly abundant ones such as lecithin or phosphatidylcholine (PC) (Damnjanovic & Iwasaki, 2013). The activity of PLD was first demonstrated in plants in the report of Hanahan and Chaikoff (1947), and since then this enzyme has been investigated for its role in membrane lipid metabolism. Besides, PLD could be implicated in many plant processes such as in signal transduction (Cockcroft, 1984; Bocckino, Blackmore, Wilson, & Exton, 1987).

Plant phospholipases C and D have been given particularly much interest in the report of Hong et al. (2016) not only because they are the most thoroughly investigated plant lipolytic enzymes, but also because they might be of great importance to plant growth and have diverse functions especially in stress responses.

We hope that this book will be a convincing valuable compendium to pertinent researchers and motivate us to pursue such research.

This book, as such targets a rich array of readers that includes academics from medical and biochemical disciplines as well as professionals from biotechnological industries.

The current book would likely be of particular interest to nutraceutical and biotechnology companies as the lipidomics, i.e., lipids and related enzymes are widely used in industrial interests.

Therefore, *Unique Sequence Signatures in Plant Lipolytic Enzymes: Emerging Research and Opportunities* focuses on the biochemistry of lipolytic enzymes, particularly, plant lipases and phospholipases as well as their structures and catalytic mechanisms. The book explores the conserved domains and motifs of plant lipolytic enzymes by identifying the main residues involved in catalysis in such type of enzymes, the phylogeny of some important plant lipolytic enzymes and calculates the evolutionary distance in those enzymes. Organized into six chapters, this book begins with an overview of general aspects of plant lipolytic enzymes. It then proceeds with a discussion on the importance of plant lipases and phospholipases, including their essential functions in plant growth as well as their external applications. The next three chapters look at the characterization of plant lipases, phospholipases C and phospholipases D. Moreover, the book talks about the identification of the main conserved domains/motifs, phylogenetic analysis and evolutionary distance calculation in these kinds of enzymes. A chapter discussing the evolutionary history of lipolytic enzymes among plant kingdom and the other kingdoms of life concludes this book. Such book would be a valuable resource aiding scientists and researchers working in the field of lipolytic enzymology.

ORGANIZATION OF THE BOOK

The book is organized into six chapters. A brief description of each of the chapters follows:

Chapter 1 reviews the general features of lipolytic enzymes from plants. The chapter aim to implement the proteomic and lipidomic techniques to identify proteins and lipids associated with the growth of plants including, for instance, the presence of lipolytic enzymes such as phospholipases. Besides, oils, enzymes and other related biomolecules of nutraceutic or dietary usage from plants would be valorized for this purpose. Here we will target academics, researchers and industrial applications by the valorization of such plant biomolecules for use, for instance, in food, pharmaceutical and biotechnology companies.

Chapter 2 presents an overview of the diverse functions of lipases and phospholipases from plants. The chapter addresses the issue of the importance regarding the functions of plant lipolytic enzymes not only for plants but also for external applications of such enzymes especially in industrial applications such as in food, pharmaceutical and biotechnology companies.

Chapter 3 describes the main authored plant lipases. The structural characterization into these lipolytic enzymes as well as their importance would be the focus of this chapter.

Chapter 4 analyses the main features of plant phospholipases C (PLCs). In fact, three groups of PLCs in plants were existed according to the specificity of substrate and the cellular functions. These groups are non-specific PLC (NPC), phosphoinositide-specific PLC (PI-PLC) and glycosylphosphatidylinositol (GPI)-PLC. The chapter will highlight the progress made on such enzymes.

Chapter 5 analyses structural insights into plant phospholipases D and their importance in internal functions of plants and in external applications.

Chapter 6 concludes on the importance of overviewing the potential evolutionary history of lipolytic enzymes. This chapter aims to identify the zonal distribution of lipases and phospholipases from plant kingdom and related organisms. It should reveal some interesting findings especially between such plant enzymes and those from algae.

REFERENCES

Bocckino, S. B., Blackmore, P. F., Wilson, P. B., & Exton, J. H. (1987). Phosphatidate accumulation in hormone-treated hepatocytes via a phospholipase D mechanism. *The Journal of Biological Chemistry, 262*, 15309–15315. PMID:3117799

Cockcroft, S. (1984). Ca^{2+}-dependent conversion of phosphatidylinositol to phosphatidate in neutrophils stimulated with fMet-Leu-Phe or ionophore A23187. *Biochimica et Biophysica Acta, 795*(1), 37–46. doi:10.1016/0005-2760(84)90102-4 PMID:6432054

Damnjanovic, J., & Iwasaki, Y. (2013). Phospholipase D as a catalyst: Application in phospholipid synthesis, molecular structure and protein engineering. *Journal of Bioscience and Bioengineering, 116*(3), 271–280. doi:10.1016/j.jbiosc.2013.03.008 PMID:23639419

Green, J. R. (1890). On the germination of the seed of the castor plant (*Ricinus communis*). *Proceedings of the Royal Society of London, 48*(292-295), 370–392. doi:10.1098/rspl.1890.0044

Hanahan, D. J., & Chaikoff, I. L. (1947). A new phospholipide-splitting enzyme specific for the ester linkage between the nitrogenous base and the phosphoric acid grouping. *The Journal of Biological Chemistry*, *169*, 699–705. PMID:20259103

Hong, Y., Zhao, J., Guo, L., Kim, S. C., Deng, X., Wang, G., ... Wang, X. (2016). Plant Phospholipases D and C and their diverse functions in stress responses. *Progress in Lipid Research*, *62*, 55–74. doi:10.1016/j.plipres.2016.01.002 PMID:26783886

Matlashewski, G. J., Urquhart, A. A., Sahasra-dudhe, M. R., & Altosaar, I. (1982). Lipase activity in oat flour suspensions and soluble extracts. *Cereal Chemistry*, *59*, 418–422.

Pokotylo, I., Kolesnikov, Y., Kravets, V., Zachowski, A., & Ruelland, E. (2014). Plant phosphoinositide-dependent phospholipases C: Variations around a canonical theme. *Biochimie*, *96*, 144–157. doi:10.1016/j.biochi.2013.07.004 PMID:23856562

Pokotylo, I., Pejchar, P., Potocky, M., Kocourkova, D., Krckova, Z., Ruelland, E., ... Martinec, J. (2013). The plant non-specific phospholipase C gene family. Novel competitors in lipid signaling. *Progress in Lipid Research*, *52*(1), 62–79. doi:10.1016/j.plipres.2012.09.001 PMID:23089468

Wang, G., Ryu, S., & Wang, X. (2012). Plant phospholipases: An overview. *Methods in Molecular Biology (Clifton, N.J.)*, *861*, 123–137. doi:10.1007/978-1-61779-600-5_8 PMID:22426716

Wang, X. (2001). Plant phospholipases. *Annual Review of Plant Physiology and Plant Molecular Biology*, *52*(1), 211–231. doi:10.1146/annurev.arplant.52.1.211 PMID:11337397

Wang, X. (2004). Lipid signaling. *Current Opinion in Plant Biology*, *7*(3), 329–336. doi:10.1016/j.pbi.2004.03.012 PMID:15134755

Yeung, T., Ozdamar, B., Paroutis, P., & Grinstein, S. (2006). Lipid metabolism and dynamics during phagocytosis. *Current Opinion in Cell Biology*, *18*(4), 429–437. doi:10.1016/j.ceb.2006.06.006 PMID:16781133