

Natural Sources of Plasmalogens

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Introduction

What are Plasmalogens ?

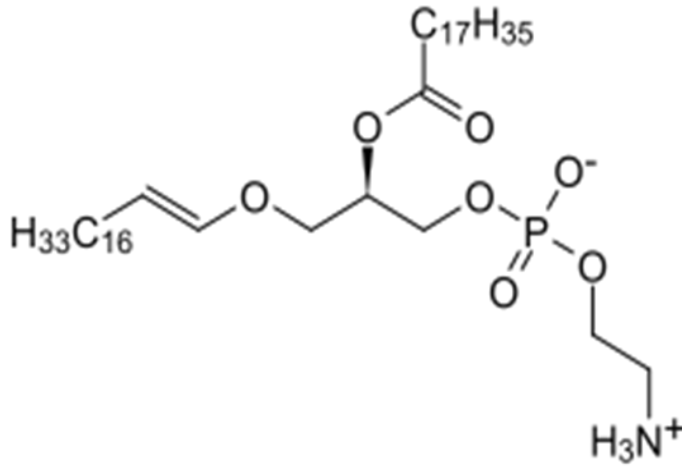
Potential health benefits

Survey of natural sources

Stability

Methods of enrichment

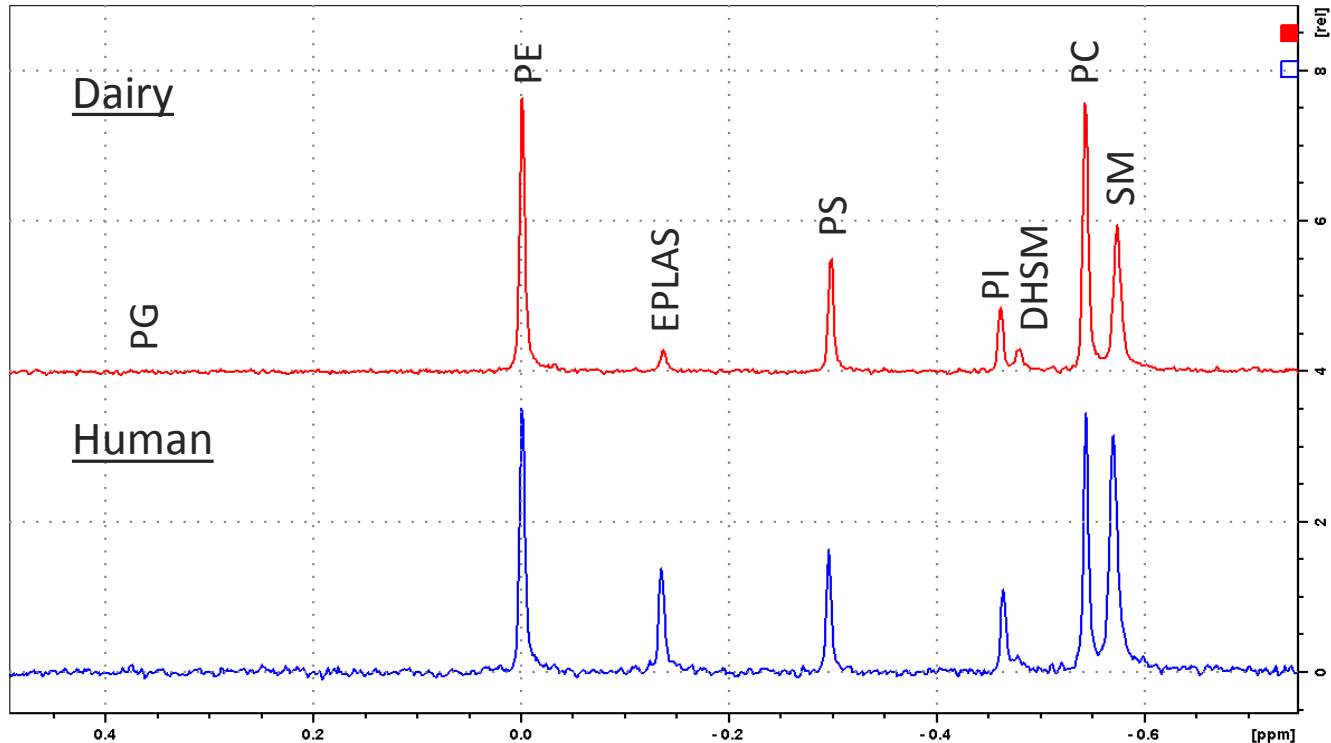
Plasmalogens



- Lipid
- Phospholipid with a fatty acid at the sn-2 position, and a long chain vinyl ether at the sn-1 position of the glycerol
- Most commonly ethanolamine plasmalogen (EPLAS) and choline plasmalogen (CPLAS)

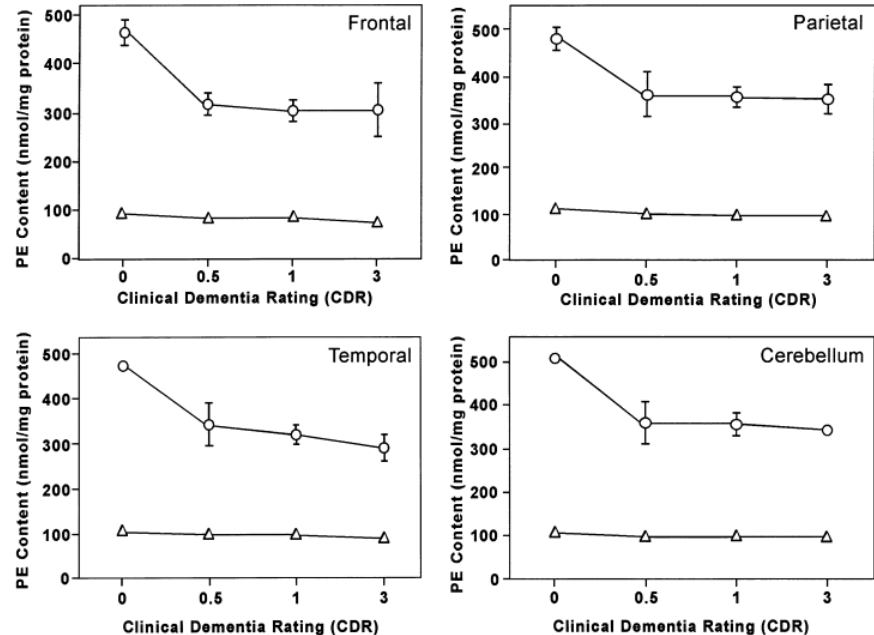
Relevance - Milk

- Plasmalogen content is significantly higher in human milk (>30% of total PE) than in cow milk (<8% of total PE)
- Humanising Infant formula



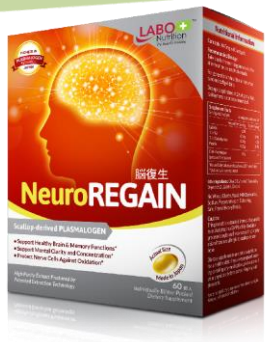
Plasmalogens and Disease

- Plasmalogen content is greatly reduced in the brain of Alzheimer's patients, also people with Down syndrome, Parkinson's disease, Niemann Pick Type C and Zellweger syndrome.
- "a dramatic decrease of up to 40 mol% in plasmalogen content of white matter in early AD stages." Braverman and Moser (2012).



Braverman, N.E. and Moser, A.B., Functions of plasmalogen lipids in health and disease. *Biochimica et Biophysica Acta* **1822**, 1442-1452 (2012)

Han, H., Holtzman, D.M and McKeel, D.W.Jr, Plasmalogen deficiency in early Alzheimer's disease subjects and in animal models: characterisation using electrospray ionization mass spectrometry. *Journal of Neurochemistry* **77**, 1168-1180 (2001)



Plasmalogen Supplements

There are products on the market which claim to lessen the effects of different types of dementia.



Most amazing improvement seen by the research team!

“This Lewy body dementia patient was initially expressionless, she became more responsive after consuming Scallop-derived PLASMALOGEN for 2 weeks. The hallucinations that she used to experience have also disappeared.”



2 weeks



1 mg/day



^{31}P NMR Analysis

NMR = Nuclear Magnetic Resonance

Non-destructive method

i.e. sample can easily be recovered

Only phosphorus is observed

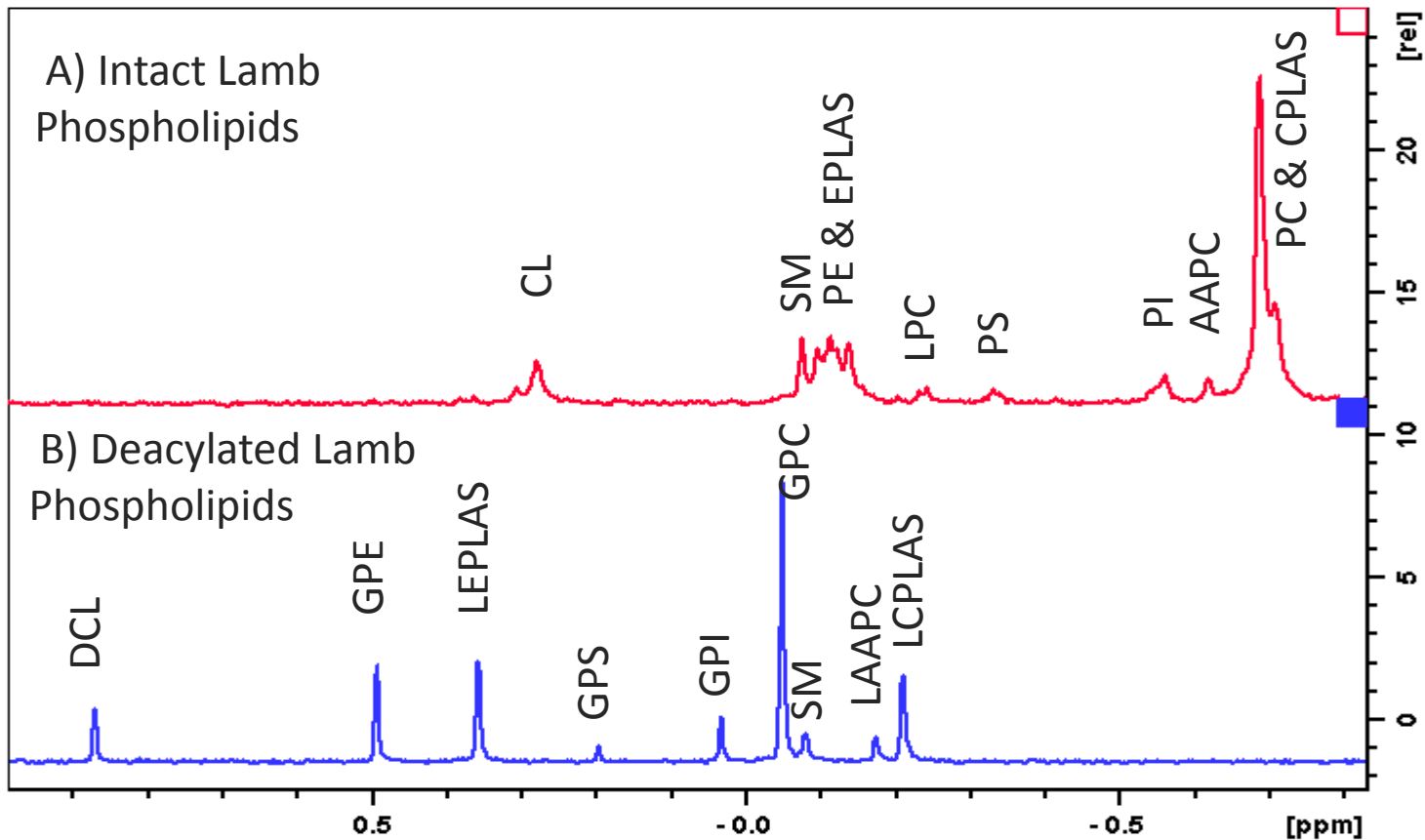
- Non-phosphorus containing molecules (e.g. triglycerides, glycolipids) are not seen
- Crude mixtures (e.g. some milk powders) can be analysed without any extraction required
- Chemical shift (peak position) is determined by the environment surrounding the P atom.

Method is Quantitative

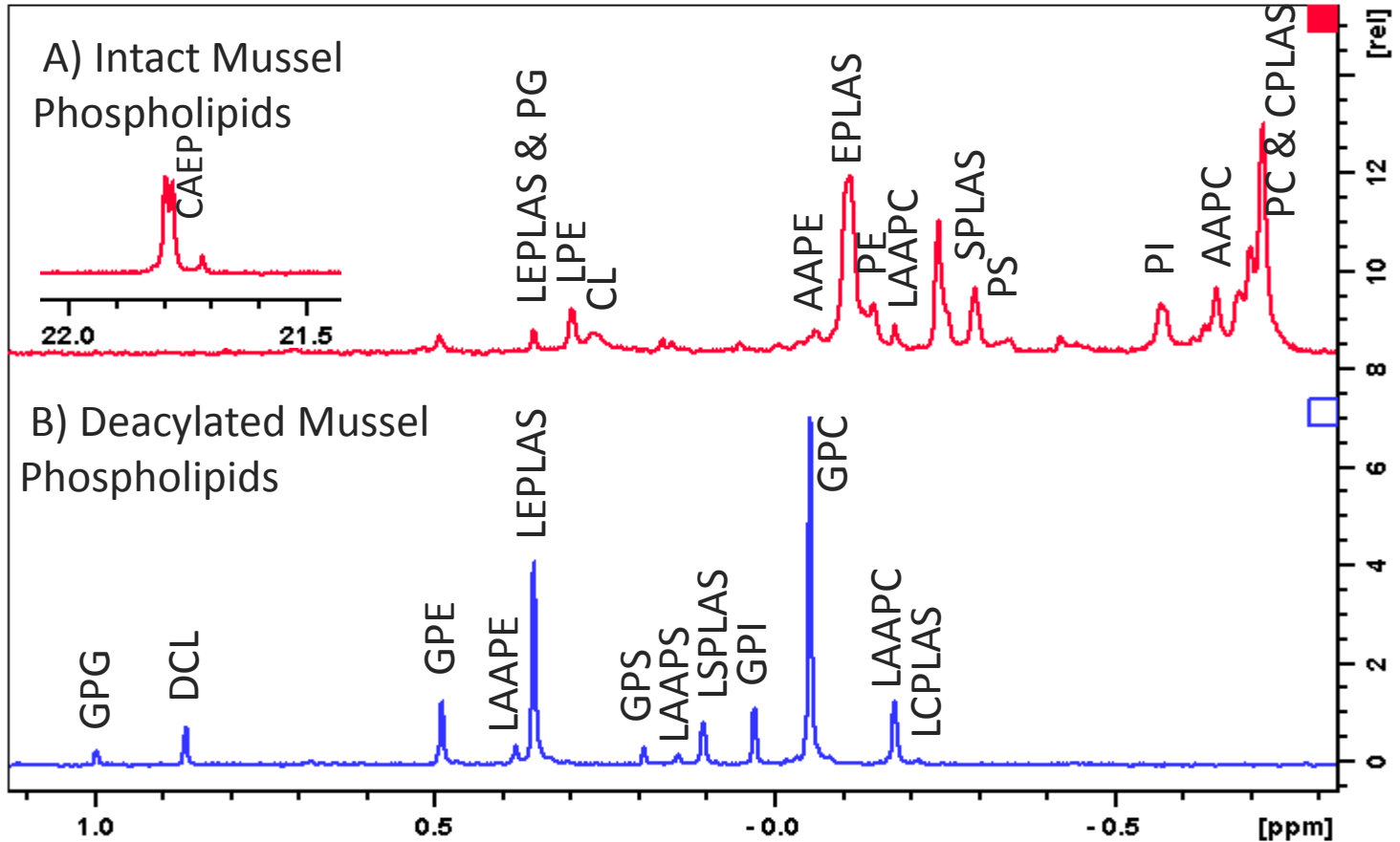
- Individual lipid standards are not required for calibration
- MW needs to be known (can be calculated from fatty acid profiles, or MS data)



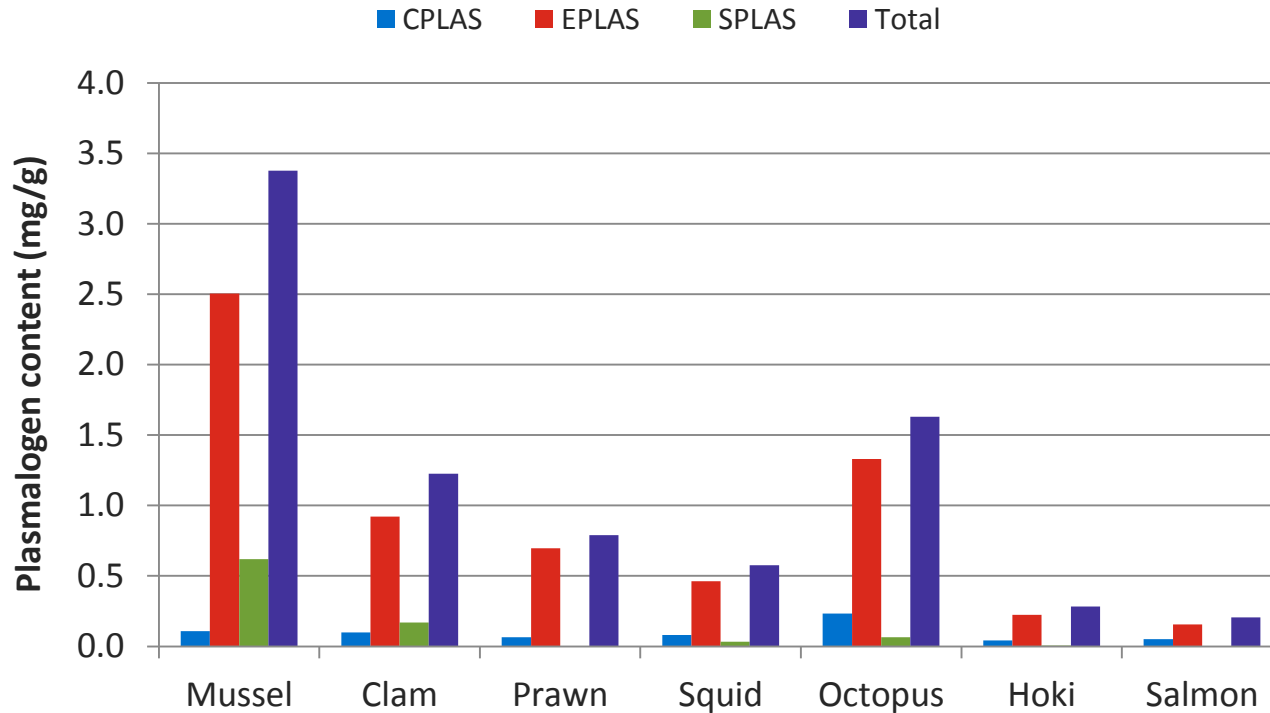
^{31}P NMR Analysis – Lamb steak



^{31}P NMR Analysis – Mussel



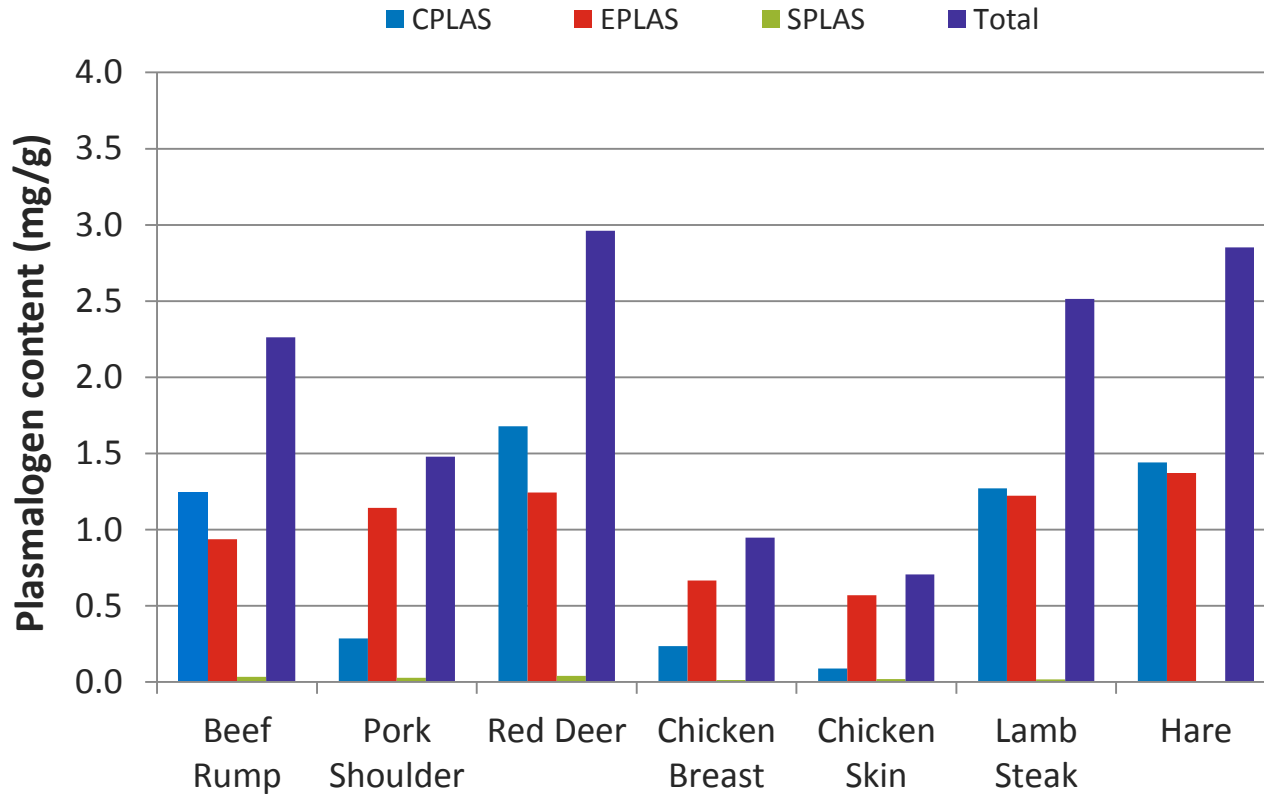
Food Sources - Seafood



Plasmalogen content of various seafoods

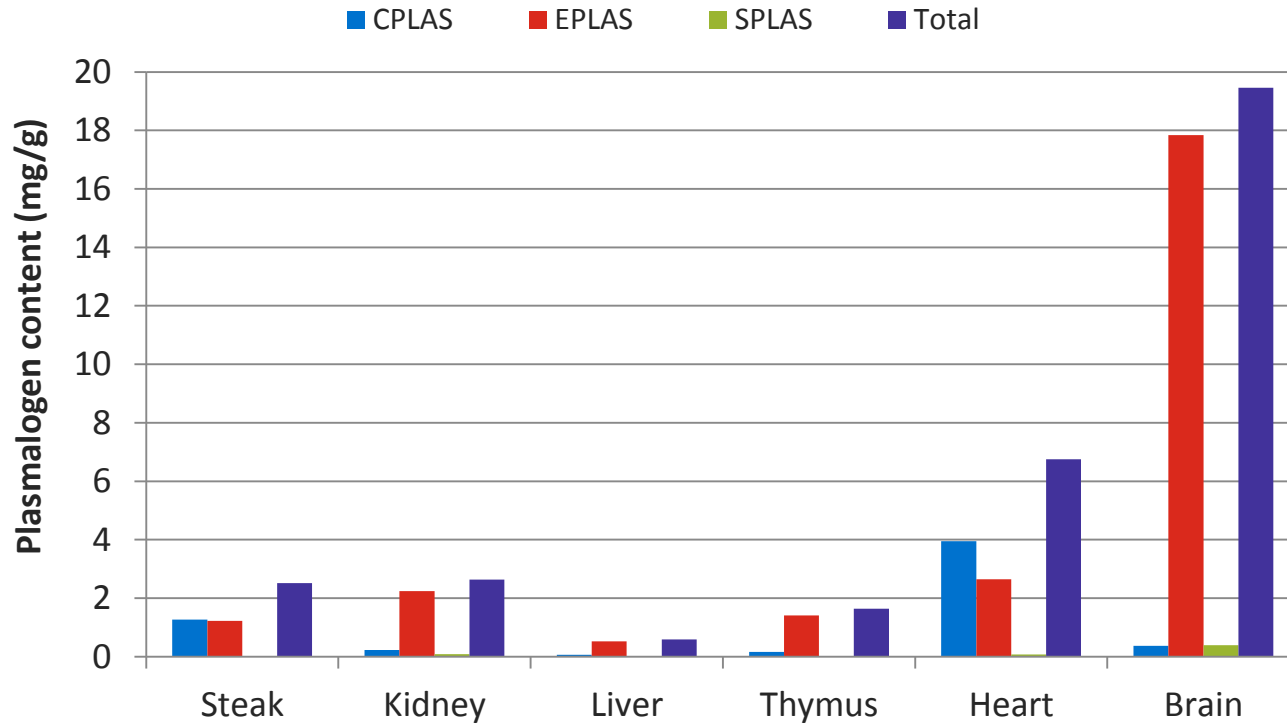
(Mussel, clam, prawn, squid and octopus were a precooked and frozen packaged mixture. Other samples were fresh)

Food Sources - Meat



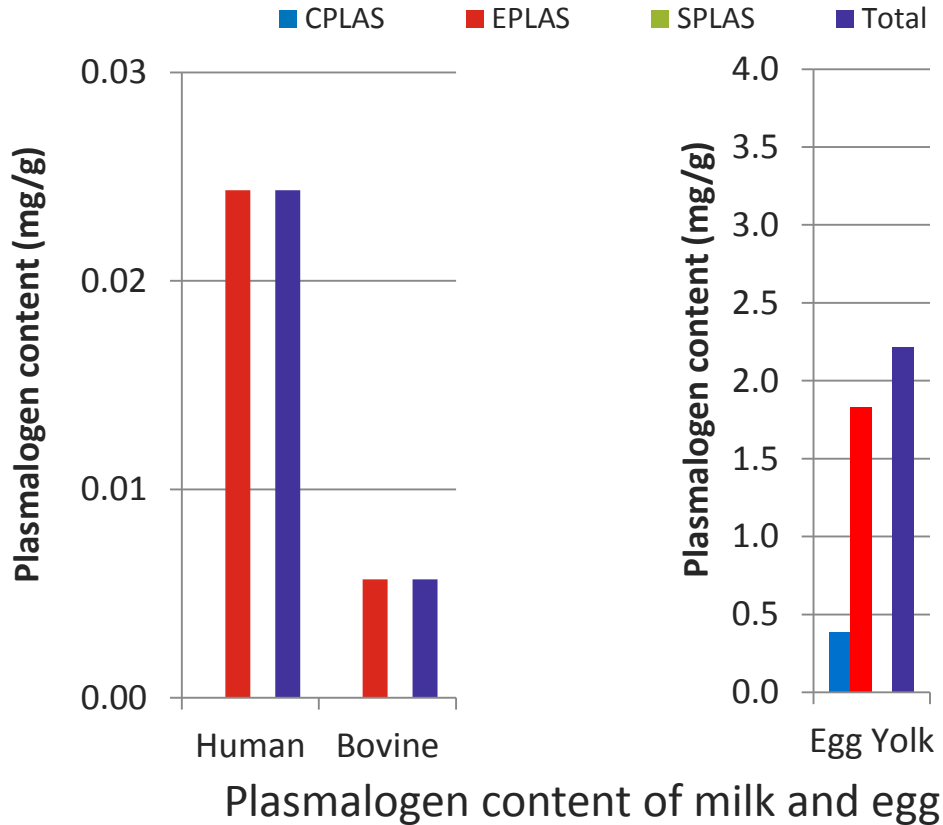
Plasmalogen content of various meats

Food Sources – Lamb organs



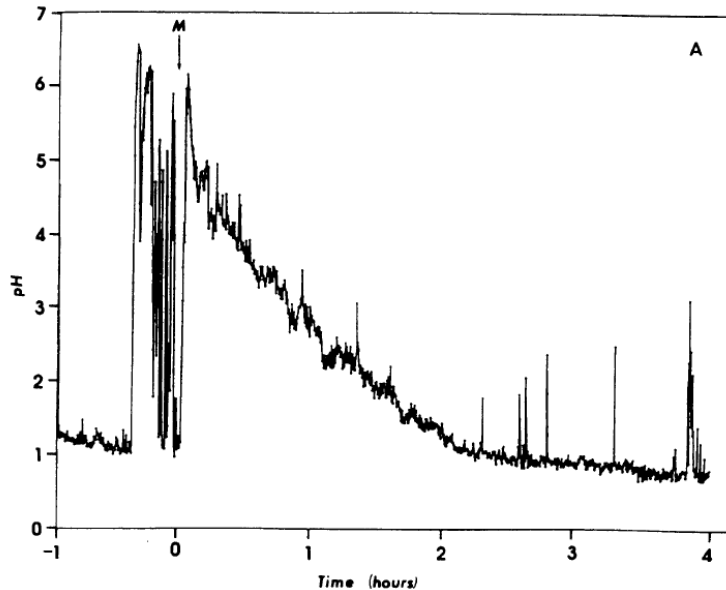
Plasmalogen content of lamb organs

Food Sources – Milk and Egg



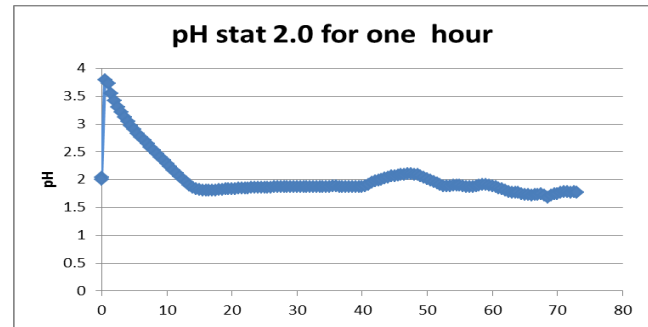
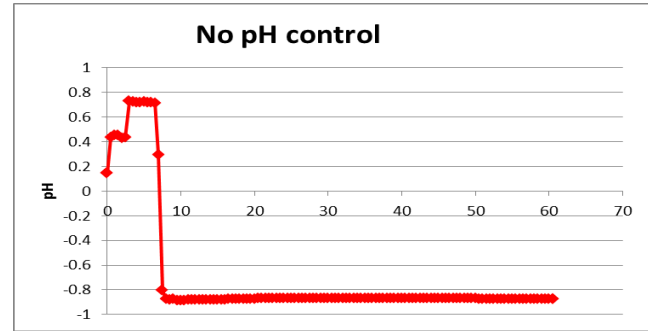
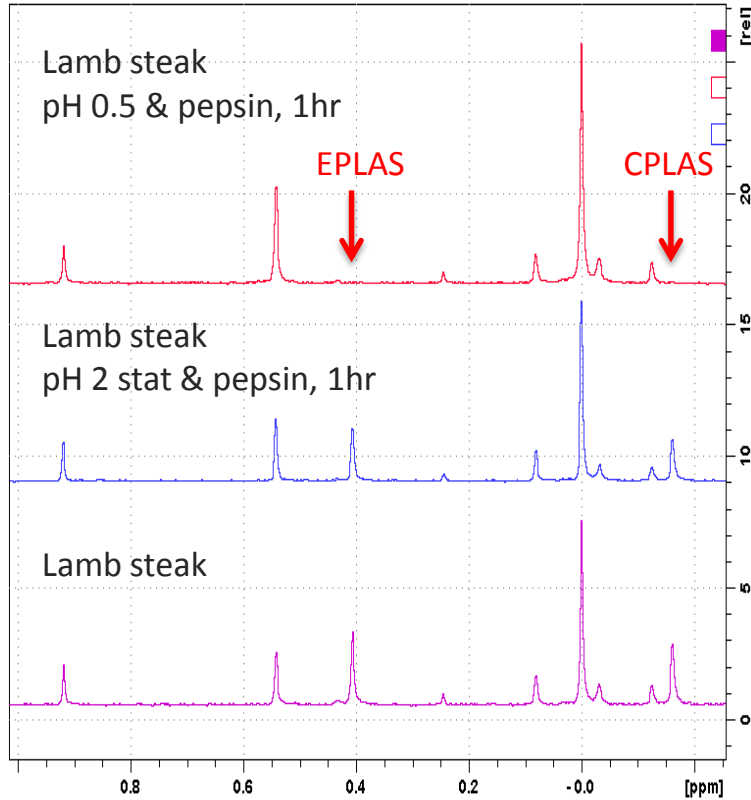
Does stomach acid destroy plasmalogens?

- The ether bond in plasmalogens is very unstable in acidic conditions.
- The vinyl ether group is cleaved to form a fatty aldehyde
- Can plasmalogens survive stomach acid? (gastric juice pH <1.5)

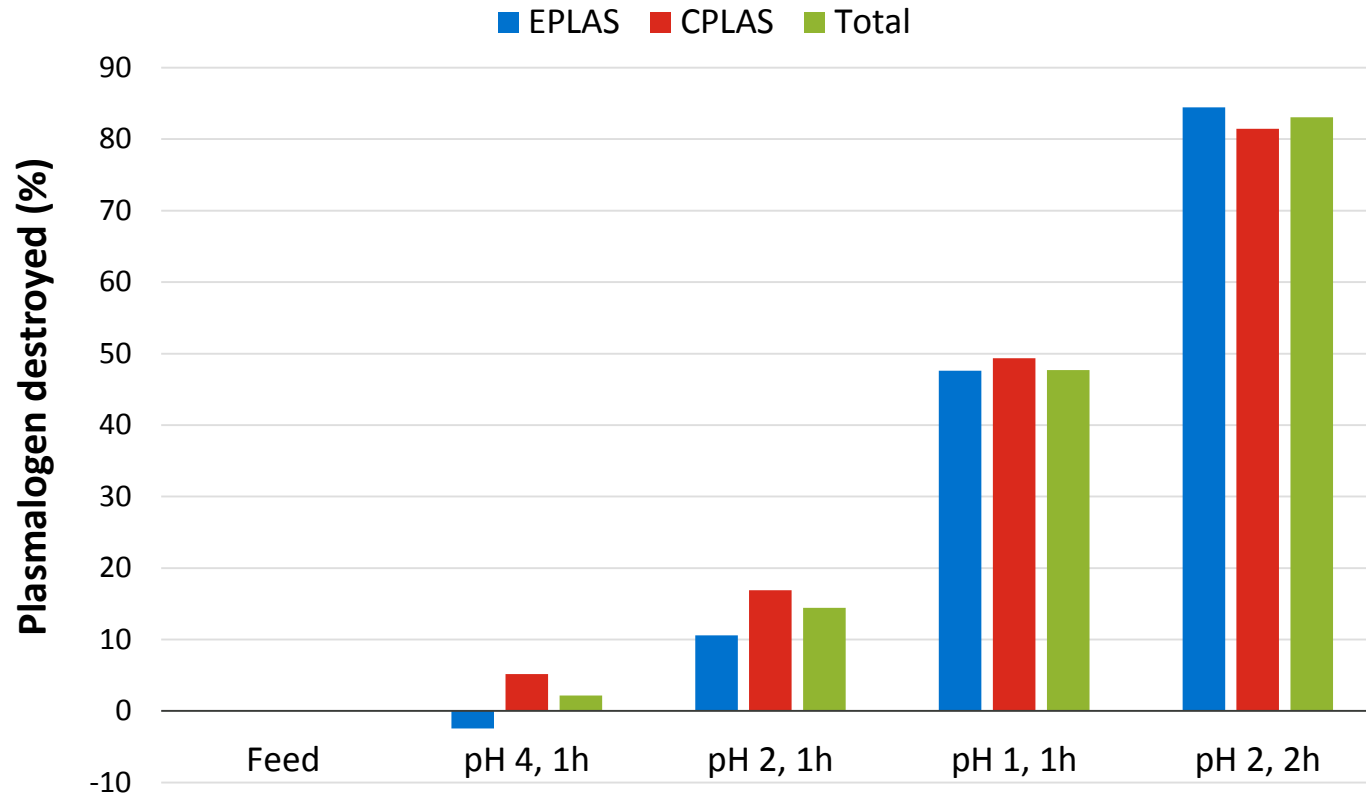


Typical pH profile in gastric phase after eating a meal.
Dressman, et. al. (1990)

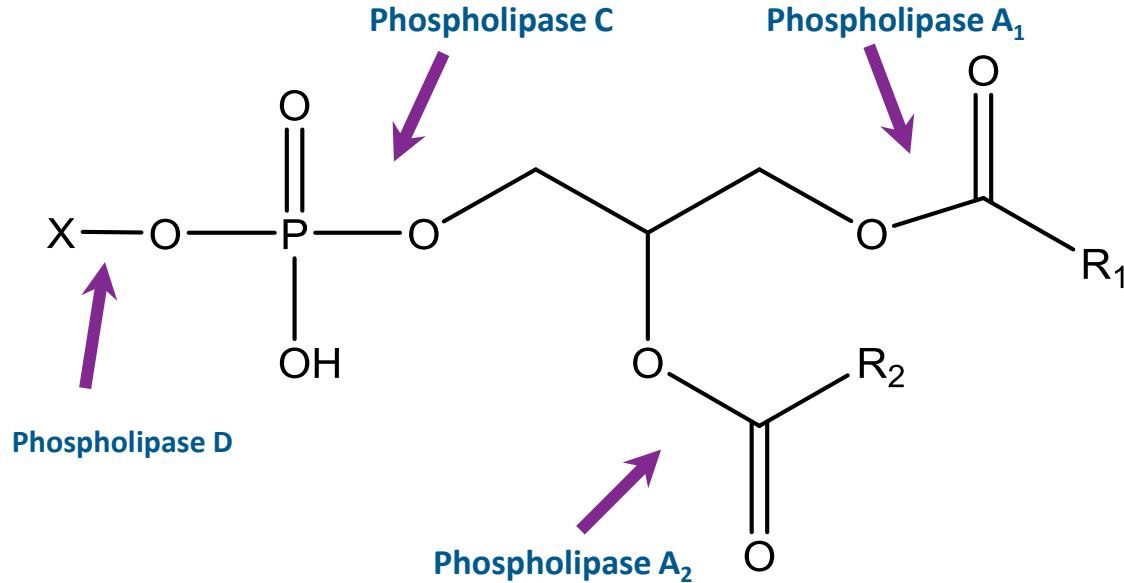
Acidic Digestion



Acidic digestion – Effect of pH and time

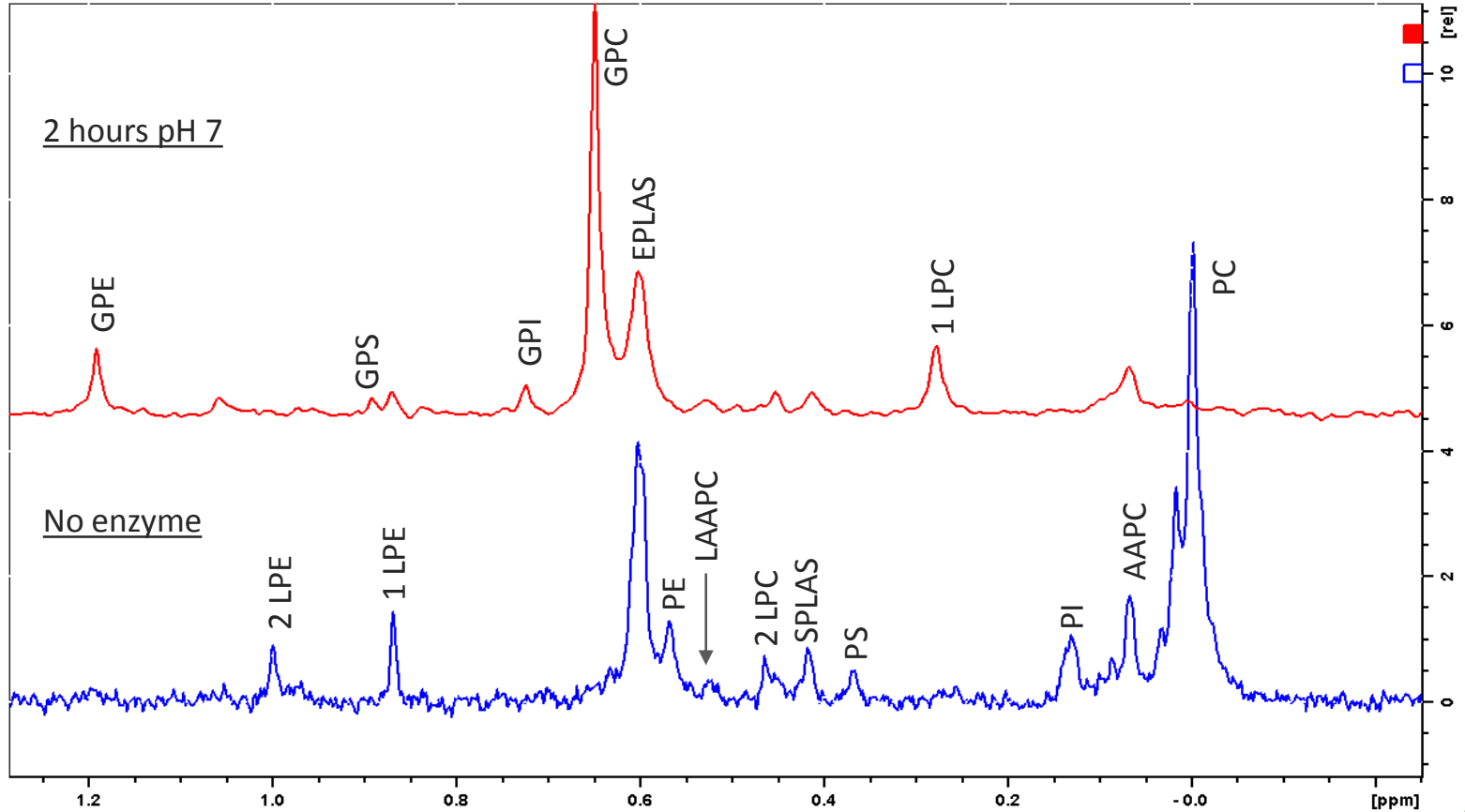


Phospholipases mode of action



X =H, choline, ethanolamine, inositol, serine, etc.

Enrichment using PLA₁ - Mussel



Summary

- Plasmalogens are already being sold in Japan and Singapore as a health supplement especially aimed at AD.
- Levels of plasmalogen consumed in a normal diet are well above the supplement levels and appear to survive short exposure to stomach acid.
- Mussel is a rich source of plasmalogen with high levels of EPLAS (and SPLAS).
- Mussel powder is already produced and processed in NZ. The residual powder from that processing contains the phospholipids and therefore the plasmalogens.
- Further work needs to be done to better mimic stomach conditions.
- Enzyme modification can be used to enrich or prepare desirable compounds.