



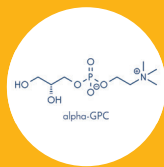
CHOLINE

The *(unknown)* essential micronutrient.



WHAT IS CHOLINE?

Choline plays a fundamental role in human health across the life cycle.^{1,2} Alpha-GPC (Alpha glycerylphosphorylcholine) delivers choline to the brain.



ESSENTIAL IN PREGNANCY

Higher maternal choline intake reduces:

- Risk factors for pre-eclampsia³
- Risk of neural tube defects^{4,5}
- The production of cortisol, which may in turn reduce the incidence of stress-related diseases (hypertension, obesity, diabetes and depression) later in life.⁶



ARE WE GETTING ENOUGH?⁹

- Research shows, less than 4% of the adult population in Australia are consuming the Adequate Intake (AI) levels of choline as set by the National Health and Medical Research Council (NHMRC).
- Pregnant Australian women have the lowest average choline intake a day, with 99% not meeting the AI.
- Australian research shows one third (33%) of children aged 2-3 years are falling below the set AI levels for choline. This rises to 80% in children aged 4-8 years.
- In both males and females, aged nine years onwards, less than 10% of the population meet AI levels for choline. This means that more than 90% of the population (aged nine years and over) are consuming less choline than what has been set by the NHMRC.

ESSENTIAL FOR HEALTHY GROWTH AND DEVELOPMENT

Higher maternal choline intake improves:

- Foetal growth⁷
- Brain development and information processing speeds – learning, memory and attention⁸
- Health over the long term – supporting cell membrane structure and integrity, hormones, muscle function and neurotransmission.⁷

IMPORTANCE LATER IN LIFE

- Choline may play a role in preventing Alzheimer's disease and cognitive decline, although more research is needed.
- There is also evidence that a choline-rich diet builds stronger bones⁹ and favourable body composition (such as lower BMI and lower waist circumference).¹⁰

CHOLINE AND EGGS

- In the Australian population as a whole, the highest contributing food group to choline intake is eggs. Eggs are also one of the top three ranked food sources of choline when analysed by gender and age group.¹¹

AUSTRALIAN ADEQUATE INTAKE (AI) LEVELS*

Table 1: Choline AI levels across age groups (327mg choline per 1 serve eggs)¹¹

Age Group	Adequate Intake (AI) ¹	% AI in 1 serve of eggs
7-12 months infants	150mg	218%
1-3 years old children	200mg	164%
4-8 years old children	250mg	130%
9-13 years old children	375mg	87%
14-18 years old males	550mg	59%w
14-18 years old females	400mg	81%
19+ years (males) Adults	550mg	59%
19+ years (females) Adults	425mg	77%
Pregnancy (14-18 yrs)	415mg	79%
Pregnancy (19+)	440mg	74%
Lactation (19+)	550mg	59%

*AI levels set by the National Health and Medical Research Council (NHMRC)



On the 19th of July, 2019 the *Australian Nutrition Advisory Council for Eggs (ANACE)* met to address recent research showing that 90% of Australians are consuming less than the NHMRC adequate intake (AI) amounts for this essential nutrient.^{1,2}

The following action plan for further research is the result of this discussion:

ACTION PLAN FOR FURTHER RESEARCH:

- Raise awareness among HCPs that most Australians are consuming choline at well below the AI.
- Include information on choline in continuing medical education programs on optimal nutrition at key life stages.
- Encourage further research to assess the benefits of adequate choline intake and, in particular, to review its importance for a healthy start to life and healthy ageing.
- Conduct further research to fully ascertain the implications of a low choline diet. Recommendations include: **i)** systematic literature review and meta-analysis of the existing body of choline research; **ii)** identification of gaps in the knowledge base; **iii)** development of protocols for interventions and RCTs; and **iv)** seeking Australian and International collaborations, and funding, for choline-specific research.
- Focus on research that improves outcomes for vulnerable life-periods including the first 1000 days of life (covering conception, pregnancy, lactation, and infancy) and explores links between choline deficiency and cognitive decline in the elderly.
- Recommend that the NHMRC nutrient reference value report is updated to include the most recent choline research.
- Develop Estimated Average Requirements (EARs) for choline when the research evidence becomes available to establish optimal levels.

THE AUSTRALIAN NUTRITION ADVISORY COUNCIL FOR EGGS:

Dr Mei Ling Doery, MBBS, BMedSci, MPH

Professor Tim Green, BSc, MSc, PhD, Discipline of Paediatrics, University of Adelaide, South Australia Health & Medical Research Institute, Adelaide, SA

Frances Jewell, BBus, Marketing & Communications Manager, Australian Eggs

Dr Ginni Mansberg, BMed, GAICD, GradDip (Journalism), General Practitioner, Sans Souci Medical Practice, Sydney, NSW

Melanie McGrice, BScNutr, Hons, MNutrDiet, AdvAPD, MAICD, Dietitian, Nutrition Plus Enterprises Pty Ltd, Melbourne, VIC

Sharon Natoli, BSc BNutDiet, Grad Dip (Bus), Dietitian, Food & Nutrition Australia

Dr Yasmine Probst, MSc (NutrDiet), MHLthInfo, GradCertBus, PhD, FACHI, AdvAPD, Senior Lecturer, University of Wollongong, Wollongong, NSW

Dr Judith Riseley, MBBS, General Practitioner, Glen Waverley, VIC

Professor Richard Saffery, BSc, PhD, Grad Dip Law (IP), Murdoch Children's Research Institute, Melbourne, VIC

Gemma Wyburn, BNatSci, BNatSci, Grad Dip (Psych), Innovation Program Manager, Australian Eggs

University of Wollongong Choline database and Australian intake project. In 2018, Australian Eggs commissioned Dr Yasmine Probst from the University of Wollongong to undertake an analysis of choline intake in the Australian population and to determine how egg intake was associated with choline intake. To do this, UOW researchers developed a choline database of foods which was then used to calculate choline intake of Australians.

References 1. Zeisel, S.H., Klatt, K.C. & Caudill, M.A. Choline. *Adv Nutr* 9, 58-60 (2008). 2. Leermakers, E.T., et al. Effects of choline on health across the life course: a systematic review. *Nutr Rev* 73, 500-522 (2015). 3. Jiang X., et al. A higher maternal choline intake among third-trimester pregnant women lowers placental and circulating concentrations of the antiangiogenic factor fms-like tyrosine kinase-1 (sFLT1). *FASEB J*; 27:1245-1253 (2013). 4. Zhang, J. et al. Phosphatidylethanolamine N-methyltransferase (PEMT) Gene Polymorphisms and Risk of Spina Bifida. *Am J Med Genet A*. April 1; 140(7): 785-789 (2006). 5. Shaw, G.M., et al. Choline and Risk of Neural Tube Defects in a Folate-fortified Population. *Epidemiology*; 20:714-719 (2009). 6. Jiang X., et al. Maternal choline intake alters the epigenetic state of fetal cortisol-regulating genes in humans. *FASEB J*. Aug;26(8):3563-74 (2012). 7. Zeisel, S.H. Choline: Critical Role During Fetal Development and Dietary Requirements in Adults. *Annu Rev Nutr*; 26: 229-250 (2006). 8. Caudill, M.A., et al. Maternal choline supplementation during the third trimester of pregnancy improves infant information processing speed: a randomized, double-blind, controlled feeding study. *FASEB J* [Epub ahead of print] (2018). 9. Oyen J, Gjesdal CG, Karlsson T, et al. Dietary Choline Intake Is Directly Associated with Bone Mineral Density in the Hordaland Health Study. *The Journal of Nutrition* (Norway) 2017;147:572-8. 10. Gao X, Wang Y, Randell E, et al. Higher Dietary Choline and Betaine Intakes Are Associated with Better Body Composition in the Adult Population of Newfoundland, Canada. *PLoS One* 2016;11:e0155403. 11. Probst, Y, et al. Development of a Choline Database to Estimate Australian Population Intakes. *Nutrients* 2019, 11, 913.