



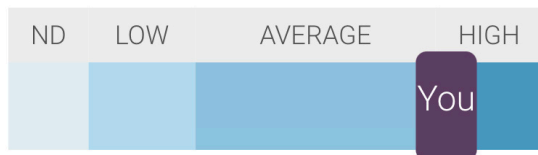
Trimethylamine

Trimethylamine (TMA) is a microbial metabolite that at high levels **can be a risk factor for metabolic disease.**



Interpretation

Trimethylamine



A high potential to produce trimethylamine is a risk factor for metabolic disease.

Clinical relevance

Cardiovascular Disease

Diabetes

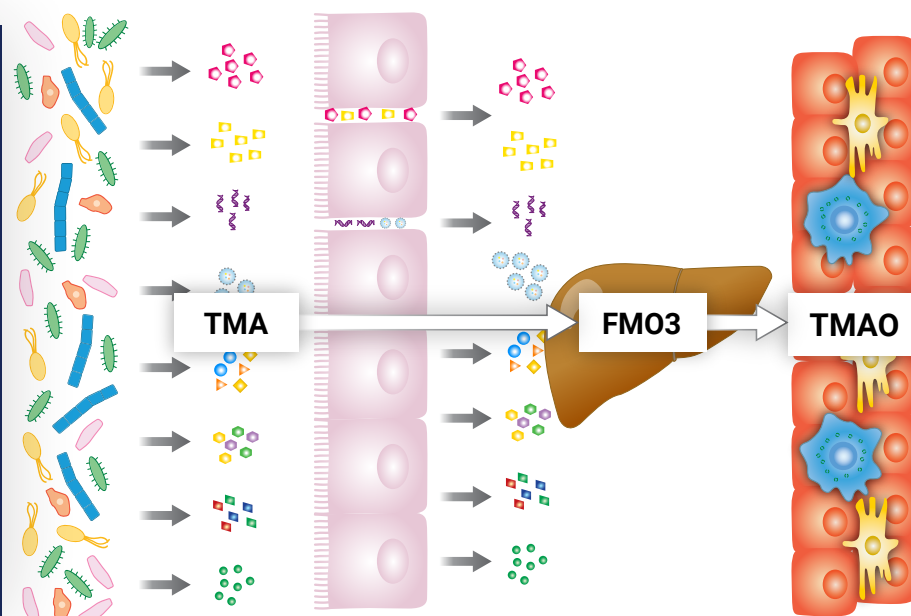
Inflammation

Hypertension

Mechanism

Trimethylamine is produced by gut microbes before it is transported to the liver and converted to trimethylamine-n-oxide (TMAO).

TMAO has been shown to be involved in atherosclerosis, blood sugar control, platelet aggregation and inflammation.



Intervention for high microbial TMA production potential

Decrease red meat intake	Increase cruciferous vegetable intake	Choose lipid soluble supplements
<p>Dietary carnitine drives microbial TMA production but response is highly individual (Wang <i>et al</i>, 2019).</p> <p>Kangaroo and beef are the richest dietary sources of carnitine (Knuttel-Gastavsen and Harmeyer 2007).</p>	<p>Cruciferous vegetables contain indoles known as I3C and DIM which have been shown to inhibit the conversion of TMA to TMAO (Cashman <i>et al</i>, 1999).</p>	<p>Free choline and carnitine supplements are associated with increased plasma TMAO levels while lipid soluble supplements do not increase TMAO levels.</p> <p>Eggs and krill oil contain lipid soluble choline, which does not increase plasma TMAO levels (Modinger <i>et al</i>, 2019).</p>

The effects of cruciferous vegetables on plasma TMAO levels

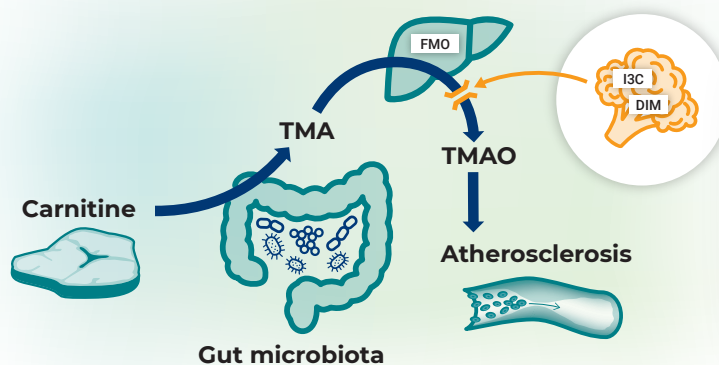
Studies show that increasing the consumption of cruciferous vegetables could help reduce plasma TMAO levels (Cashman *et al*, 1999).

Cruciferous or Brassica vegetables are rich sources of prebiotic fibres and phytochemicals such as indole-3-carbinol (I3C) and its dimer diindolylmethane (DIM).

I3C and DIM are metabolites of glucosinolates (sulphur-containing organic compounds) which can inhibit the conversion of microbially produced TMA into TMAO in the liver.

It should be noted that some cruciferous vegetables, such as brussel sprouts, cauliflower, and savoy cabbage are also rich sources of FODMAPs which can exacerbate symptoms in those with FODMAP sensitive IBS.

Some low FODMAP options include broccoli, kale, bok choy, rocket and red or green cabbage.



Cruciferous vegetables contain indoles known as I3C and DIM which inhibit the conversion of microbially produced TMA into TMAO in the liver.

The effects of choline on plasma TMAO levels

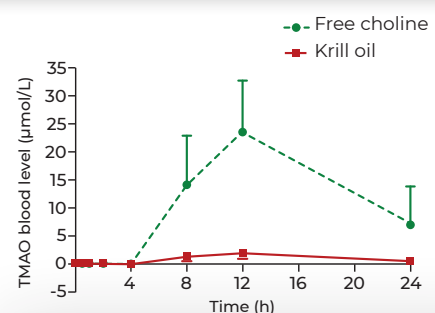
Choline in food

While microbes can also use choline to make TMA, it should be noted that most choline in food is lipid soluble which is well absorbed in the small intestine so does not reach the microbes in the large intestine.

Numerous research studies have confirmed that eggs, which are a rich source lipid soluble choline, do not increase plasma TMAO levels (Zhu *et al*, 2020).

Choline supplements

While free choline supplements are associated with an increase in plasma TMAO levels, lipid soluble choline supplements found in krill oil are not associated with an increase in plasma TMAO levels (Modinger *et al*, 2019).



Eggs do not increase plasma TMAO levels.

Cashman JR, Xiong Y, Lin J, Verhagen H, van Poppel G, van Bladeren PJ, Larsen-Su S, Williams DE. **In Vitro and In Vivo Inhibition of Human Flavin-Containing Monooxygenase Form 3 (FMO3) in the Presence of Dietary Indoles** *Biochemical Pharmacology*, Vol. 58, pp. 1047-1055, 1999.

Möding Y, Schön C, Wilhelm M, Hals PA. **Plasma Kinetics of Choline and Choline Metabolites After A Single Dose of SuperbaBoost™ Krill Oil or Choline Bitartrate in Healthy Volunteers.** *Nutrients*. 2019 Oct 22;11(10):2548. doi: 10.3390/nu1102548.

Wang Z, Bergeron N, Levison BS, Li XS, Chiu S, Jia X, Koeth RA, Li L, Wu Y, Tang WHW, Krauss RM, Hazen SL. **Impact of chronic dietary red meat, white meat, or non-meat protein on trimethylamine N-oxide metabolism and renal excretion in healthy men and women.** *Eur Heart J*. 2019 Feb 14;40(7):583-594. doi: 10.1093/eurheartj/ehy799.

Zhu C, Sawrey-Kubicek L, Bardagjy AS, Houts H, Tang X, Sacchi R, Randolph JM, Steinberg FM, Zivkovic AM. **Whole egg consumption increases plasma choline and betaine without affecting TMAO levels or gut microbiome in overweight postmenopausal women.** *Nutr Res*. 2020 Jun;78:36-41. doi: 10.1016/j.nutres.2020.04.002.

Kangaroo and beef are the richest dietary sources of carnitine.

Dietary sources of carnitine

Foods	Free Carnitine (mg/100g)	Iron (mg/100g)
MEAT		
Kangaroo steak	155	3.40
Beef steak	51.8	1.69
Lamb chop	40.5	1.75
Pork	21.2	0.84
Duck	20	1.8
Turkey	16.3	0.4
Chicken	9.1	0.55
FISH		
Salmon	5.8	1.1
Cod	1.8	0.32
Tuna	1.5	0.73
EGG		
White	0.3	0.2
Yolk	0.8	4
DAIRY		
Full fat cow's milk	2.1	0.03
Low fat cow's milk	2.4	0.01
Yoghurt	7.3	0.07
Milk powder	14.5	0.28
Cream	1.6	0
Butter	1.05	0.01
Goat's cheese	12.4	0
Feta (sheep)	3.9	0.34
Camembert	7.8	0.15
Mozzarella	0.5	0.08

Demarquoy J, Georges B, Rigault C, Royer M-C, Clairet A, Soty M, Lekounougou S, Le Borgne F. **Radioisotopic determination of L-carnitine content in foods commonly eaten in Western countries.** *Food Chemistry*. 2004 86 (1): 137-142 doi.org/10.1016/j.foodchem.2003.09.023

Food Standards Australia New Zealand, 2014. **AUSNUT2011-2013**. Canberra: FSANZ.

Knüttel-Gustavsen S and Harmeyer J. **The determination of L-carnitine in several food samples.** *Food chemistry*. 2007. 105: 793-804

N.B. The information on the carnitine content of foods is collated from published data from European countries and may not reflect the food composition of Australian foods.