Nutritional Aspects and Application of Therapeutic Carbohydrate Restriction (TCR)

Tamzyn Murphy, RD, MSc (Dist.)

Topics

- Formulating a TCR diet
- Nutrient sufficiency (micros, macros, fibre, plants vs animals)
- Problematic nutrients (PUFAs, sugar and UPF)
- Cautions, contraindications
- Assessment and monitoring

Defining and formulating a carbohydrate restricted diet

Table 1
Suggested definitions for different Forms of low-carbohydrate diets*

Very low-carbohydrate ketogenic diet (VLCKD)

- Carbohydrate, 20–50 g/d or <10% of the 2000 kcal/d diet, whether or not ketosis occurs. Derived from levels of carbohydrate required to induce ketosis in most people.
- Recommended early phase ("induction") of popular diets such as Atkins Diet or Protein Power.

Low-carbohydrate diet: <130 g/d or <26% total energy

- The ADA definition of 130 g/d as its recommended minimum.

Moderate-Carbohydrate Diet: 26%–45%

- Upper limit, approximate carbohydrate intake before the obesity epidemic (43%).

High-Carbohydrate Diet: >45%

- Recommended target on ADA websites.
- The 2010 Dietary Guidelines for Americans recommends 45%–65% carbohydrate. The average American diet is estimated to be ~49% carbohydrate.
- Carbohydrate Consumption (NHANES)†:
  - Men
    - 1971–1974: 42% (~250 g for 2450 kcal/d)
    - 1999–2000: 49% (~330 g for 2600 kcal/d)
  - Women
    - 1971–1974: 45% (~150 g for 1550 kcal/d)
    - 1999–2000: 52% (~230 g for 1900 kcal/d)

ADA, American Diabetes Association; NHANES, National Health and Nutrition Examination Survey

* Derived from Accurso et al. [3] and references therein.

† NHANES is a series of studies conducted since 1960 that monitors >5000 people.

Nutritional adequacy

Nutritional adequacy

- Provision of all essential nutrients
- CHO is not essential (Tondt et al., 2020)
- TCR for epilepsy vs. non-epileptic applications
- Dietary guidelines & RDAs
  - Expert opinions
  - Contextual
- LCHF diets are nutritionally sufficient (no deficiencies reported in clinical trials)

Nutritional adequacy: Macronutrients in TCR

- Protein: meets/exceeds DRI (46-56g/d)
- Carbohydrate: falls short of DRI (130g/d)
    - The amount of energy the brain needs (glucose vs. ketones) (Westman et al. 2003)
- Fat: Exceeds AMDR (20-35% TDEI)

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BMJ Open

Assessing the nutrient intake of a low-carbohydrate, high-fat (LCHF) diet: a hypothetical case study design

Caryn Zinn,[1] Amy Rush,[2] Rebecca Johnson[2]

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ABSTRACT

Objective The low-carbohydrate, high-fat (LCHF) diet is becoming increasingly employed in clinical dietetic practice as a means to manage many health-related conditions. Yet, it continues to remain contentious in nutrition circles due to a belief that the diet is devoid of nutrients and concern around its saturated fat content. This work aimed to assess the micronutrient intake of the LCHF diet under two conditions of saturated fat thresholds.
Design In this descriptive study, two LCHF meal plans were designed for two hypothetical cases representing the average Australian male and female weight-stable adult. National documented heights, a body mass index of 22.5 to establish weight and a 1.6 activity factor were used to estimate total energy intake using the Schofield equation. Carbohydrate was limited to <130 g, protein was set at 15%–25% of total energy and fat supplied the remaining

Strengths and limitations of this study

- A strength of this study is that we used an accurate, professional and local food composition database for dietary analysis.
- A strength of this study is that specialty foods, fortified foods and generally unpopular tasting food (ie, liver and mussels) were specifically excluded from the food selection to avoid bias towards nutrient density.
- A limitation of the study is that these results are specific to the two case studies selected, and inference to population groups cannot be made.

on metabolic health.[4–8] However, LCHF

BMJ Open

Assessing the nutrient intake of a low-carbohydrate, high-fat (LCHF) diet: a

Results All of the meal plans exceeded the minimum NRV thresholds, apart from iron in the female meal plans, which achieved 86%–98% of the threshold. Saturated fat intake was logistically unable to be reduced below the 10% threshold for the male plan but exceeded the threshold by 2 g (0.6%).

Conclusion Despite macronutrient proportions not aligning with current national dietary guidelines, a well-planned LCHF meal plan can be considered micronutrient replete. This is an important finding for health professionals, consumers and critics of LCHF nutrition, as it dispels the myth that these diets are suboptimal in their micronutrient supply. As with any diet, for optimal nutrient achievement, meals need to be well formulated.

To cite: Zinn
Johnson R. A
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Formulating Nutritionally Adequate Low-Carbohydrate Diets: An Analysis of the Australian Food Composition Database

Jessica L Turton[1]*, Rowena J Field[1], Noor A Struik[2], Helen M Parker[1] and Kieron Rooney[1]

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Keywords: Diet Therapy; Diet; Carbohydrate-Restricted; Micronutrients; Nutrients; Nutritionists

Abbreviations: LC: Low-Carbohydrate; VLC: Very Low-Carbohydrate; ADGs: Australian Dietary Guidelines; AGHE: Australian Guide to Healthy Eating; TEI: Total Energy Intake; NRVs: Nutrient Reference Values; RDI: Recommended Dietary Intakes; AI: Adequate Intakes; FSANZ: Food Standards Australia New Zealand; SDT: Suggested Dietary Target

ABSTRACT

Background: There is a lack of evidence-based resources available to guide the formulation of nutritionally adequate low-carbohydrate (LC) diets.

Methods: We searched the FSANZ Australian Food Composition Database to identify the top 10 LC food sources for each of the 27 essential micronutrients (vitamins, minerals, and fatty acids). To be included, foods had to contain ≤5.0g total digestible carbohydrates per serve (serving), contain at least 20% of the highest available Nutrient Reference Value (NRV) per serve, and be classified as a minimally processed food. We then categorized the foods into practical food groups and developed a sample meal plan suitable for a very LC diet (<30g/day) using these resources.

Results: Twelve (12/27) nutrients had 10 LC foods containing ≥20% NRV of that nutrient per serve for both men and women. Nine (9/27) nutrients had 10 LC foods containing ≥20% NRV for women but not for men, and six (6/27) nutrients had <10LC food sources for both women and men. Vitamin A, vitamin B12 and zinc had entirely animal food sources, and 16/27 nutrients had >80% animal food sources. Vitamin C had entirely plant food sources, and two additional nutrients (vitamin B7 and magnesium) had more than 80% plant food sources. The top 10 LC foods across all 27 nutrients were categorised into 18LC food groups. The group representing the highest number of nutrients was oily fish followed by seafood, offal, white fish, nuts, legumes, seeds, eggs, poultry, non-cruciferous vegetables, pork, ruminant animals, game meat, cruciferous vegetables, dairy, fruit, fungi, then grains. The sample meal plan met or exceeded the highest NRVs by ≥90% for 24/27 and 25/27 nutrients, for men and women respectively.

Conclusion: This study presents practical information to support healthcare practitioners and future researchers in formulating nutritionally adequate LC dietary plans.

Formulating Nutritionally Adequate Low-Carbohydrate Diets: An Analysis of the Australian Food Composition Database

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Reference Values; RDI: Recommended Dietary Intakes; AI: Adequate Intakes; FSANZ: Food Standards Australia New Zealand; SDT: Suggested Dietary Target

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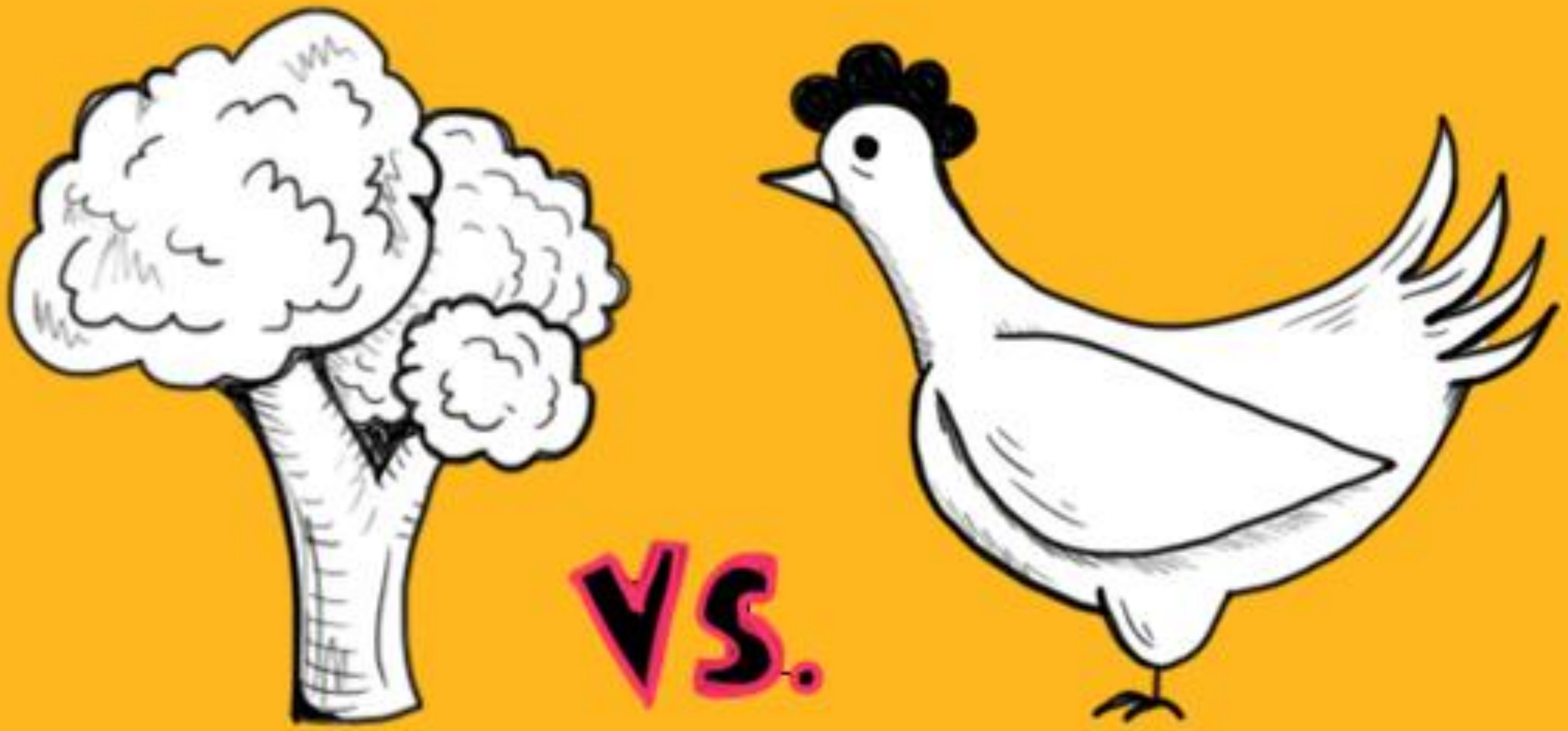
Patient tips to ensure nutritional sufficiency

- Eat an animal-based diet:
  - Mainly ruminants
  - Include organ meats
  - Bone broth

- Eat fatty fish (salmon, trout, mackerel, sardine, pilchards) or bone marrow at least twice weekly.
  - If you don’t eat this then supplement with Fish Oil (2g daily) or krill or algae oil.
- Eat free range or organic liver twice weekly (100-300g/week).
- Eat fermented foods.
- See at least 20 minutes of midday sun daily or supplement with Vitamin D3 *(based on recommendations, and bloods).*
- If magnesium is a concern eat 1-2 handfuls of nuts daily (except cashews, which are high in carbohydrate) and add cacao to the diet.

Nutritional adequacy:
Plants vs. Animals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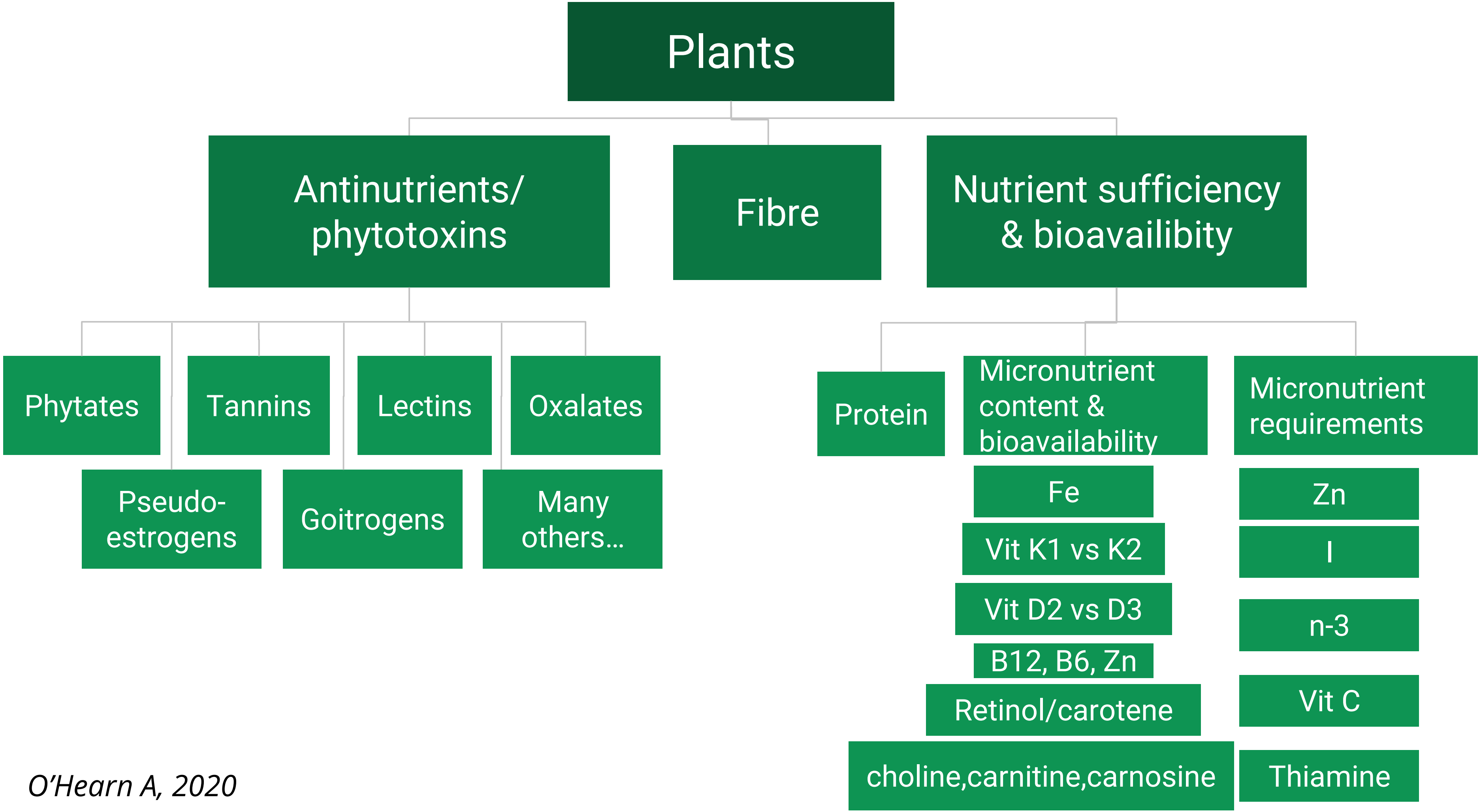

O'Hearn A, 2020

Plants

- Antinutrients/ phytotoxins
  - Phytates
  - Tannins
  - Lectins
  - Oxalates
  - Pseudo-estrogens
  - Goitrogens
  - Many others…
- Fibre
- Nutrient sufficiency & bioavailibity
  - Protein
  - Micronutrient content & bioavailability
    - Fe
    - Vit K1 vs K2
    - Vit D2 vs D3
    - B12, B6, Zn
    - Retinol/carotene
    - choline,carnitine,carnosine
  - Micronutrient requirements
    - Zn
    - I
    - n-3
    - Vit C
    - Thiamine

(All per 100g)	Liver	Steak	Chicken breast	Sardines	Eggs	Whole milk	Broccoli	Carrot	Apple	Brown rice
Calories	116	154	110	208	143	60	34	41	52	**370**
A Retinol (900mcg)	**3,323**	0	6	32	146	31	0	0	0	0
B1 (1.2mg)	0.3	0.1	0.1	0.1	0.1	0	0.1	0.1	0	**0.4**
B2 (1.3mg)	**1.8**	0.1	0.1	0.2	0.5	0.2	0.1	0.1	0	0.1
B3 (16mg)	9.7	7.2	**11**	5.2	0.1	0.1	0.6	1	0.1	5.1
B5 (5mg)	**6.2**	0.6	0.8	0.6	1.4	0.4	0.6	0.3	0.1	1.5
B6 (1.7mg)	**0.9**	0.6	0.5	0.2	0.1	0	0.2	0.1	0	0.5
Folate 400mcg	**588**	13	4	12	47	5	63	19	3	20
B12 (2.4mcg)	**17**	1.2	0.4	8.9	1.3	0.4	0	0	0	0
C (90mg)	18	0	1.2	0	0	0	**89**	5.9	4.6	0
D (15mcg)	0	0	0	**6.8**	0.9	1	0	0	0	0
E (15mg)	0.7	0.3	0.1	**2**	1	0.1	0.8	0.7	0.2	1.2
Calcium (1000mg)	8	27	11	**382**	53	123	47	33	6	23
Magnesium (420mg)	19	22	28	39	12	10	21	12	5	**143**
Phosphorus (700mg)	297	193	196	**490**	191	91	66	35	11	333
Copper (0.9mg)	**0.5**	0.1	0	0.2	0.1	0	0	0	0	0.3
Iron (18mg)	**9.0**	1.5	0.7	2.9	1.8	0	0.7	0.3	0.1	1.5
Zinc (11mg)	2.7	**3.9**	0.8	1.3	1.1	0.4	0.4	0.2	0	2

Harcombe Z. National Food Strategy – call for evidence. 28 Oct 2019

Data extracted from: United States Department of Agriculture all-foods database

(All per 100 calories)	Liver	Steak	Chicken breast	Sardines	Eggs	Whole milk	Broccoli	Carrot	Apple	Brown rice
A Retinol (900mcg)	**2,865**	0	5.7	16	102	51	0	0	0	0
B1 (1.2mg)	**0.3**	0.1	0.1	0	0.1	0	0.3	0.2	0	0.1
B2 (1.3mg)	**1.6**	0.1	0.1	0.1	0.3	0.3	0.3	0.2	0	0
B3 (16mg)	8.4	4.7	**10**	2.5	0.1	0.2	1.8	2.4	0.2	1.4
B5 (5mg)	**5.3**	0.4	0.7	0.3	1.0	0.7	1.8	0.7	0.2	0.4
B6 (1.7mg)	**0.8**	0.4	0.5	0.1	0.1	0	0.6	0.2	0	0.1
Folate 400mcg	**507**	8.4	3.6	5.8	33	8.3	185	46	5.8	5.4
B12 (2.4mcg)	**14**	0.8	0.4	4.3	0.9	0.7	0	0	0	0
C (90mg)	15	0	1.1	0	0	0	**262**	14	8.8	0
D (15mcg)	0	0	0	**3.3**	0.6	1.7	0	0	0	0
E (15mg)	0.6	0.2	0.1	1.0	0.7	0.2	**2.4**	1.7	0.4	0.3
Calcium (1000mg)	6.9	18	10	184	37	**205**	138	80	11	6.2
Magnesium (420mg)	16	14	26	19	8.4	17	**62**	29	9.6	39
Phosphorus (700mg)	**256**	125	178	236	134	152	194	85	21	90
Copper (0.9mg)	**0.4**	0.1	0	0.1	0.1	0	0	0	0	0.1
Iron (18mg)	**7.8**	1.0	0.6	1.4	1.3	0	2.1	0.7	0.2	0.4
Zinc (11mg)	2.3	**2.5**	0.7	0.6	0.8	0.7	1.2	0.5	0	0.5

Harcombe Z. National Food Strategy – call for evidence. 28 Oct 2019

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What should we eat?

Guidelines vs. Evidence

In the right form	EFAs	Protein	Vits A/D/E/K	Other vits	Minerals
EAT – Veg	X	X	E/K1	Not B12	✔
EAT – Fruit	X	X	E/K1	Not B12	✔
EAT – Grains	X	X	E/K1	Not B12	✔
EAT – Legumes	X	X	E/K1	Not B12	✔
EAT – Oils	X	X	E/K1	X	X
Eggs	✔	✔	✔	Not C	✔
Dairy (Full fat)	✔	✔	✔	Not C	✔
Meat	✔	✔	✔	✔	✔
Fish	✔	✔	✔	Not C	✔

Harcombe Z. National Food Strategy – call for evidence. 28 Oct 2019

Plants

- Antinutrients/ phytotoxins
  - Phytates
  - Tannins
  - Lectins
  - Oxalates
  - Pseudo-estrogens
  - Goitrogens
  - Many others…
- Fibre
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    - n-3
    - Vit C
    - Thiamine

Plants and Protein

Most plant based proteins aren't complete - need to complement

Food	Limited Amino Acid	Complement
Beans (7g prot/ ½ cup)	Methionine	Grains, nuts, seeds
Grains* (3 g prot/ ½ cup)	Lysine, threonine	Legumes
Nuts/seeds (7 g prot/ 30 g)	Lysine	Legumes
Vegetables* (2 g prot/ ½-1 cup)	Methionine	Grains, nuts, seeds
Corn	Tryptophan, lysine	Legumes

Plants and Protein

Complete plant proteins

- Quinoa. (1 cup cooked = 8 g protein)
- Soy (1 cup cooked = 29 g protein)
- Buckwheat. (1 cup cooked = 6 g protein)
- Hemp (1/4 cup = 15 g protein)
- Chia seeds (100 g seeds = 17 g protein)
- Spirulina.
- Tempeh. (1 cup cooked = 30 g)
- Amaranth. (1 cup cooked = 9 g protein)

But not as high quality nor as compact as animal protein

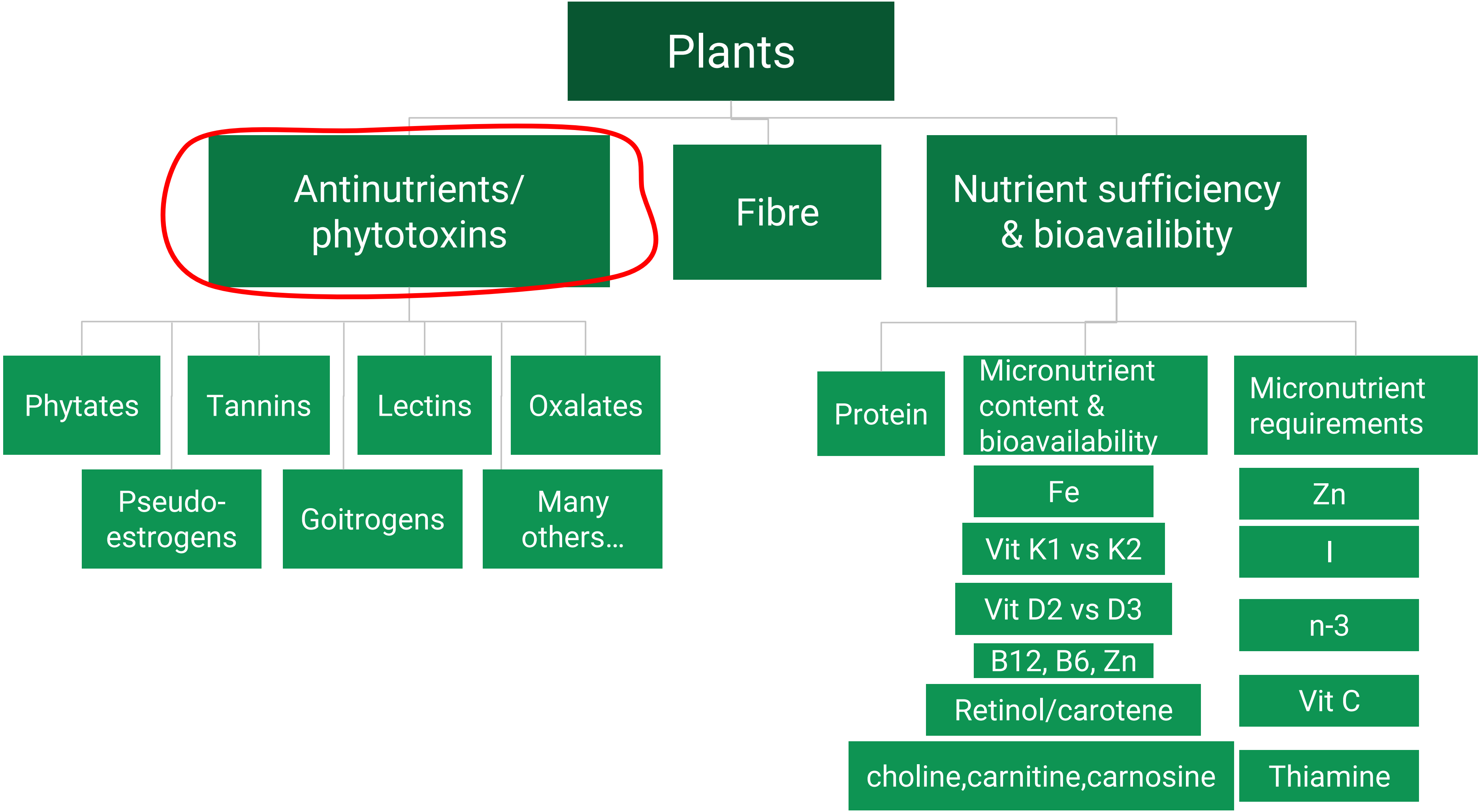
Plants and Protein

To meet 1g/kg BW requirement of a 70kg person:

- 3 handfuls (9 g) nuts & seeds
- 1.5 cups of legumes
- 3 cups of grains
- 3 cups of veg

(OR approx. 2 L or 1.5 kg plant foods)

Vs. 300 g steak.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n-3
Vit C
Thiamine

"*99% of pesticides consumed by people are made by plants*" (and many are carcinogenic)

~ Bruce Ames, Dietary pesticides 99.9% all natural

Table 1. Plant Compounds, Food Sources, and Their Suggested Clinical Implications.

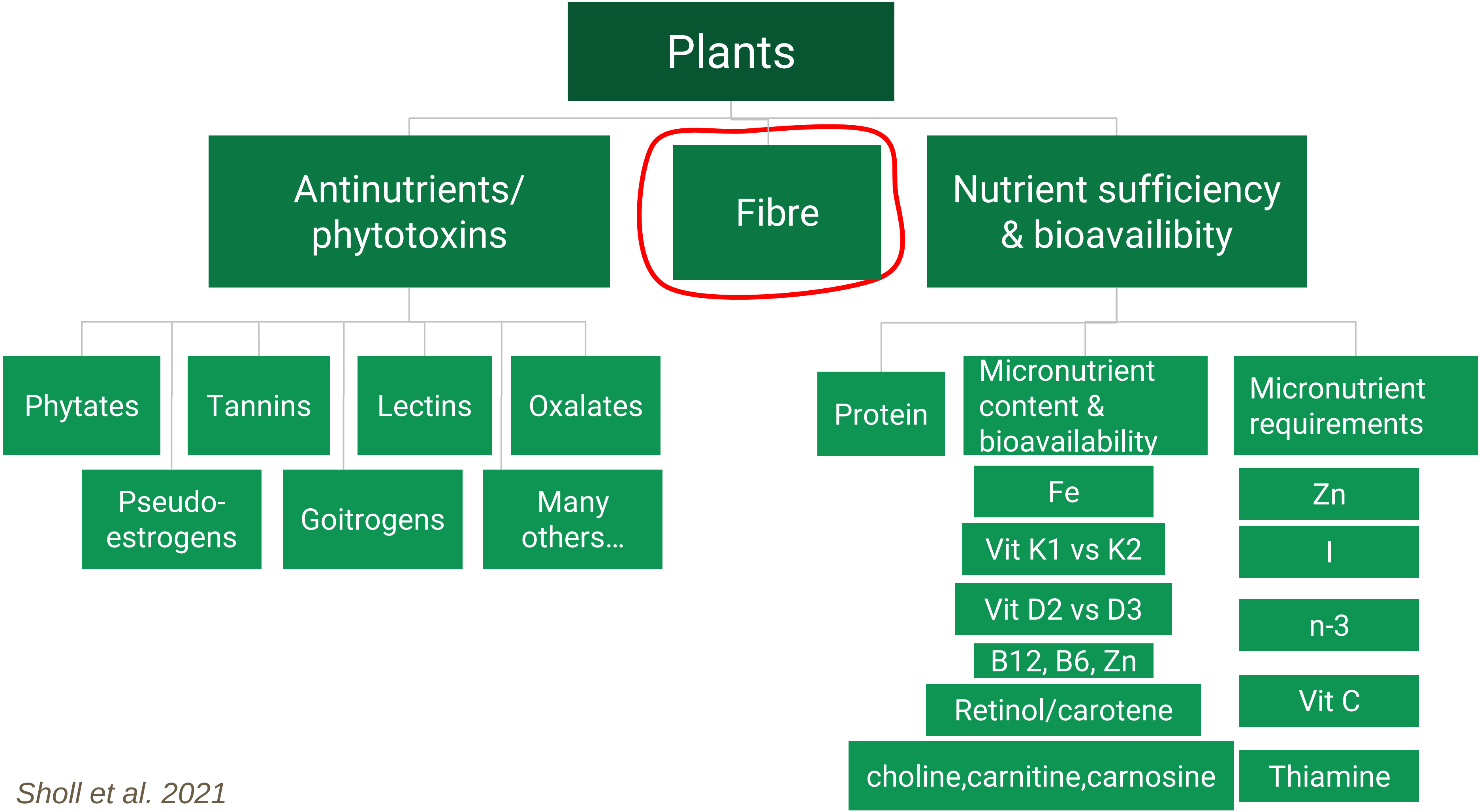
'Anti-nutrient'	Food Sources	Suggested Clinical Implications
Lectins	Legumes, cereal grains, seeds, nuts, fruits, vegetables	Altered gut function; inflammation
Oxalates	Spinach, Swiss chard, sorrel, beet greens, beet root, rhubarb, nuts, legumes, cereal grains, sweet potatoes, potatoes	May inhibit calcium absorption; May increase calcium kidney stone formation
Phytate (IP6)	Legumes, cereal grains, pseudocereals (amaranth, quinoa, millet), nuts, seeds	May inhibit absorption of iron, zinc and calcium; Acts as an antioxidant; Antineoplastic effects
Goitrogens	*Brassica* vegetables (kale, Brussels sprouts, cabbage, turnip greens, Chinese cabbage, broccoli), millet, cassava	Hypothyroidism and/or goiter; Inhibit iodine uptake
Phytoestrogens	Soy and soy products, flaxseeds, nuts (negligible amounts), fruits and vegetables (negligible amounts)	Endocrine disruption; Increased risk of estrogen-sensitive cancers
Tannins	Tea, cocoa, grapes, berries, apples, stone fruits, nuts, beans, whole grains	Inhibit iron absorption; Negatively impact iron stores

Petroski W et al., 2020

Table 2. Preparation tips for reducing 'anti-nutrients'.

'Anti-nutrient'	Food Preparation that Reduces	Food Preparation that Increase
Lectins	Soaking, boiling, autoclaving, germination, fermentation	Roasting, baking
Oxalate	Soaking, boiling, steaming, pairing with high calcium foods	Roasting, grilling, baking, low-calcium diet
Phytates	Soaking, boiling, germination, fermentation	*n*/a
Tannins	Cooking, peeling skins of fruits and nuts	*n*/a
Phytoestrogens	*n/a*	Boiling, steaming, fermenting (increases aglycone content)
Goitrogens	Steaming, boiling	

Petroski W et al., 2020



Sholl et al. 2021

Reframing Nutritional Microbiota Studies To Reflect an Inherent Metabolic Flexibility of the Human Gut: a Narrative Review Focusing on High-Fat Diets

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Jonathan Sholl and Lucy J. Mailing contributed equally. Author order was based on relative contributions to drafting and editing the manuscript.

ABSTRACT There is a broad consensus in nutritional-microbiota research that high-fat (HF) diets are harmful to human health, at least in part through their modulation of the gut microbiota. However, various studies also support the inherent flexibility of the human gut and our microbiota's ability to adapt to a variety of food sources, suggesting a more nuanced picture. In this article, we first discuss some problems facing basic translational research and provide a different framework for thinking about diet and gut health in terms of metabolic flexibility. We then offer evidence that well-formulated HF diets, such as ketogenic diets, may provide healthful alternative fuel sources for the human gut. We place this in the context of cancer research, where this concern over HF diets is also expressed, and consider various potential objections concerning the effects of lipopolysaccharides, trimethylamine-*N*-oxide, and secondary bile acids on human gut health. We end by providing some general suggestions for how to improve research and clinical practice with respect to the gut microbiota when considering the framework of metabolic flexibility.

Nature. 2014 January 23; 505(7484): 559–563. doi:10.1038/nature12820.

Diet rapidly and reproducibly alters the human gut microbiome

Lawrence A. David[1,2,#], Corinne F. Maurice[1], Rachel N. Carmody[1], David B. Gootenberg[1], Julie E. Button[1], Benjamin E. Wolfe[1], Alisha V. Ling[3], A. Sloan Devlin[4], Yug Varma[4], Michael A. Fischbach[4], Sudha B. Biddinger[3], Rachel J. Dutton[1], and Peter J. Turnbaugh[1,*]

Our findings that the human gut microbiome can rapidly switch between herbivorous and carnivorous functional profiles may reflect past selective pressures during human evolution. Consumption of animal foods by our ancestors was likely volatile, depending on season and stochastic foraging success, with readily available plant foods offering a fallback source of calories and nutrients[21]. Microbial communities that could quickly, and appropriately, shift their functional repertoire in response to diet change would have subsequently enhanced human dietary flexibility. Examples of this flexibility may persist today in the form of the wide diversity of modern human diets[11].

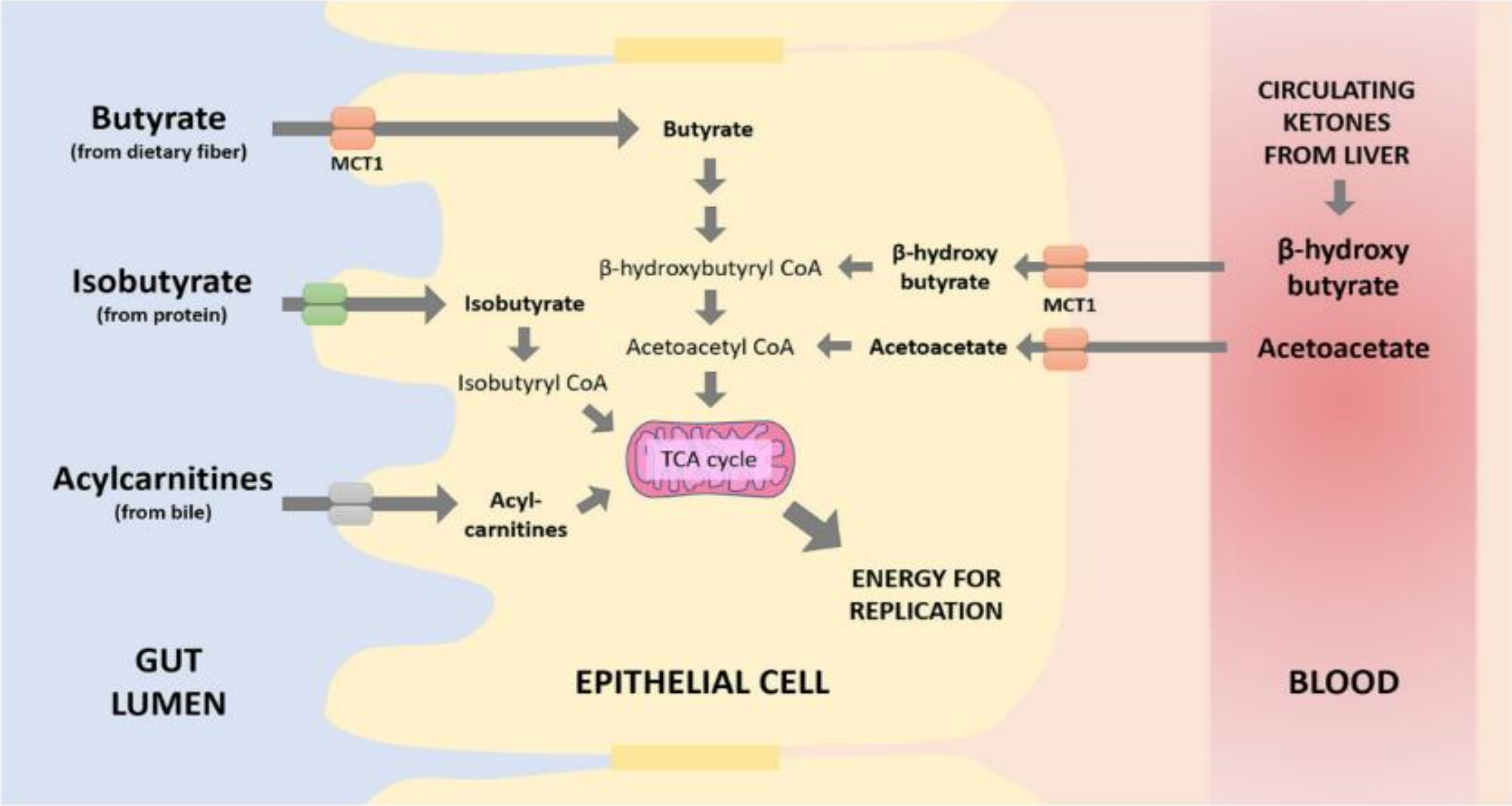


FIG 2 The many substrates and pathways that contribute to energy production in the intestinal epithelium. TCA, tricarboxylic acid.

Sholl et al. (2021)

World J Gastroenterol. 2012 Sep 7; 18(33): 4593–4596.
Published online 2012 Sep 7. doi: 10.3748/wjg.v18.i33.4593

PMCID: PMC3435786
PMID: 22969234

Stopping or reducing dietary fiber intake reduces constipation and its associated symptoms

Kok-Sun Ho, Charmaine You Mei Tan, Muhd Ashik Mohd Daud, and Francis Seow-Choen

Abstract

Go to: ▸

AIM: To investigate the effect of reducing dietary fiber on patients with idiopathic constipation.

METHODS: Sixty-three cases of idiopathic constipation presenting between May 2008 and May 2010 were enrolled into the study after colonoscopy excluded an organic cause of the constipation. Patients with previous colon surgery or a medical cause of their constipation were excluded. All patients were given an explanation on the role of fiber in the gastrointestinal tract. They were then asked to go on a no fiber diet for 2 wk. Thereafter, they were asked to reduce the amount of dietary fiber intake to a level that they found acceptable. Dietary fiber intake, symptoms of constipation, difficulty in evacuation of stools, anal bleeding, abdominal bloating or abdominal pain were recorded at 1 and 6 mo.

RESULTS: The median age of the patients (16 male, 47 female) was 47 years (range, 20-80 years). At 6 mo, 41 patients remained on a no fiber diet, 16 on a reduced fiber diet, and 6 resumed their high fiber diet for religious or personal reasons. Patients who stopped or reduced dietary fiber had significant improvement in their symptoms while those who continued on a high fiber diet had no change. Of those who stopped fiber completely, the bowel frequency increased from one motion in 3.75 d (± 1.59 d) to one motion in 1.0 d (± 0.0 d) ($P < 0.001$); those with reduced fiber intake had increased bowel frequency from a mean of one motion per 4.19 d (± 2.09 d) to one motion per 1.9 d (± 1.21 d) on a reduced fiber diet ($P < 0.001$); those who remained on a high fiber diet continued to have a mean of one motion per 6.83 d (± 1.03 d) before and after consultation. For no fiber, reduced fiber and high fiber groups, respectively, symptoms of bloating were present in 0%, 31.3% and 100% ($P < 0.001$) and straining to pass stools occurred in 0%, 43.8% and 100% ($P < 0.001$).

CONCLUSION: Idiopathic constipation and its associated symptoms can be effectively reduced by stopping or even lowering the intake of dietary fiber.

Summary of plants vs animals

- Micronutrients from plants are less potent and bioavailable
- Micronutrient needs are contextual
- Protein from plants is generally not complete or concentrated
- Fats from plants may be healthy when packaged in whole food BUT processed seed and vegetable oils are toxic
- Plants contain anti nutrients that may be problematic for some people
- Fibre may be less important in the context of a KD

Ultra Processed food (UPF) and nutrients of concern

UPF: Refined carbs and High GI/GL diets

February 1968

Diabetes, Coronary Thrombosis and the Saccharine Disease.

Lester R. Tuchman, MD

» Author Affiliations

Arch Intern Med. 1968;121(2):197-198. doi:10.1001/archinte.1968.03640020085027

Abstract

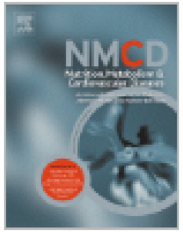
This small book of 146 pages attempts nothing less than the elaboration of a concept which would provide a common causation for diabetes mellitus, dental caries, pyorrhea, peptic ulcer, obesity, colonic stasis, varicose veins, hemorrhoids, coronary artery disease, and *Escherichia coli* infections! Surgeon-Captain T. L. Cleave and Dr. G. D. Campbell have coined the designation "The Saccharine Disease" to describe the train of ills following upon the ingestion by man of "refined sugars," particularly cane or beet sugar, white flour, and—in rice eating countries —milled rice.

The authors state (as an axiom) that primitive man for half a million years did not ingest refined carbohydrates, that for a brief 5,000 years he has had to cope with "refined carbohydrates" for which the human body was not adapted. This, the argument goes, leads to over-consumption. Dietary fat and protein are unchanged, the authors state; hence we do not overeat in these areas.

ELSEVIER

Nutrition, Metabolism and Cardiovascular Diseases

Volume 23, Issue 8, August 2013, Pages 699-706



Systematic review

Long-term effects of low glycemic index/load vs. high glycemic index/load diets on parameters of obesity and obesity-associated risks: A systematic review and meta-analysis

L. Schwingshackl, G. Hoffmann

ELSEVIER

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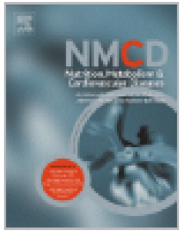


"Conclusions

The present systematic review provides evidence for beneficial effects of long-term interventions administering a low glycemic index/load diet with respect to fasting insulin and pro-inflammatory markers such as C-reactive protein which might prove to be helpful in the primary prevention of obesity-associated diseases."

L. Schwingshackl, G. Hoffmann

UPF: Sugar

Sugar

- Overweight/obesity
- IR and T2D
- MetS
- Dyslipidemia
- Hypertension
- Inflammation
- NAFLD
- Gout
- Dysbiosis
- Atherosclerosis
- Oxidative stress
- Addictive

Lustig R, 2010; Cheng WL et al., 2021

THE 56 NAMES OF

SUGAR

Buttered syrup
Cane sugar
Dextrose
Caramel
Brown sugar
Corn syrup
Cane juice
Corn syrup solids
Beet sugar
Confectioners' sugar
Dehydrated cane juice
Galactose
Agave nectar
Demerara sugar
Fruit juice concentrate
Maltodextrin
Diastatic malt
Diatase
Maltose
Fructose
Malt sugar
Mannitol
Florida crystals
Molasses
Sorbitol
Yellow sugar
Sucrose
Sorghum syrup
Treacle
Carob syrup
Lactose
Panocha
Raw sugar
Rice syrup
Muscovado
Castor sugar
HFCS (High Frustose Corn Syrup)
Golden sugar
Glucose solids
Barbados sugar
Grape sugar
Maple syrup
Honey
Barley malt
Refiner's Syrup
Sugar (granulated)
Turbinado sugar
Golden syrup
Fruit juice
Icing sugar
Glucose
Date sugar
Ethyl maltol
Dextran

Photo from *The Family Cooks* by Laurie David

Help bring **FED UP** to Schools! HTTP://BIT.LY/FEDUPINSCHOOLS

UPF: Linoleic Acid PUFA
(primarily from processed seed/vegetable oil)

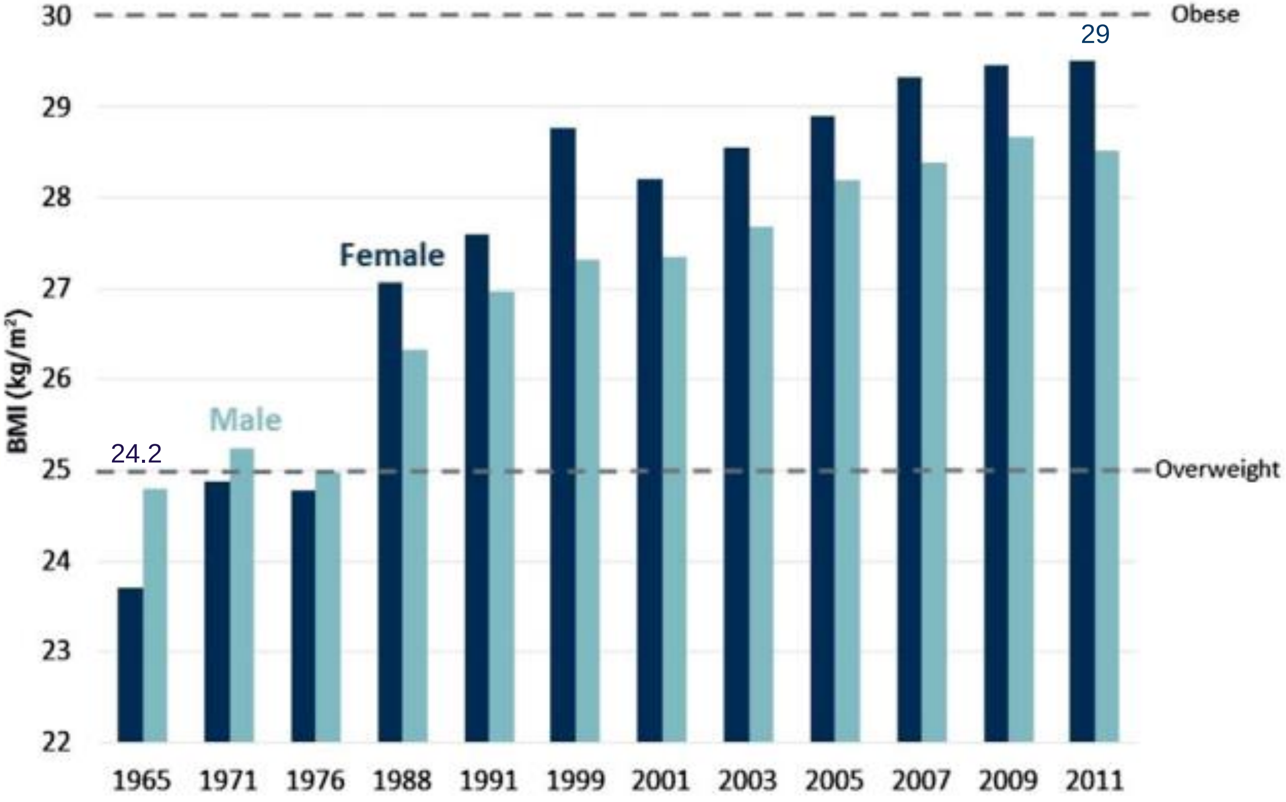
N-6 PUFA composition of common foods

Name	% LA
Safflower oil	74.62%
Evening Primrose oil	65-80%
Grape seed oil	69.60%
Sunflower oil	65.70%
Corn oil	59%
Wheat germ oil	55%
Soybean oil	51%
Sesame oil	45%
Peanut oil	32%
Almonds	24%
Canola oil	21%
Chicken fat	18-23%

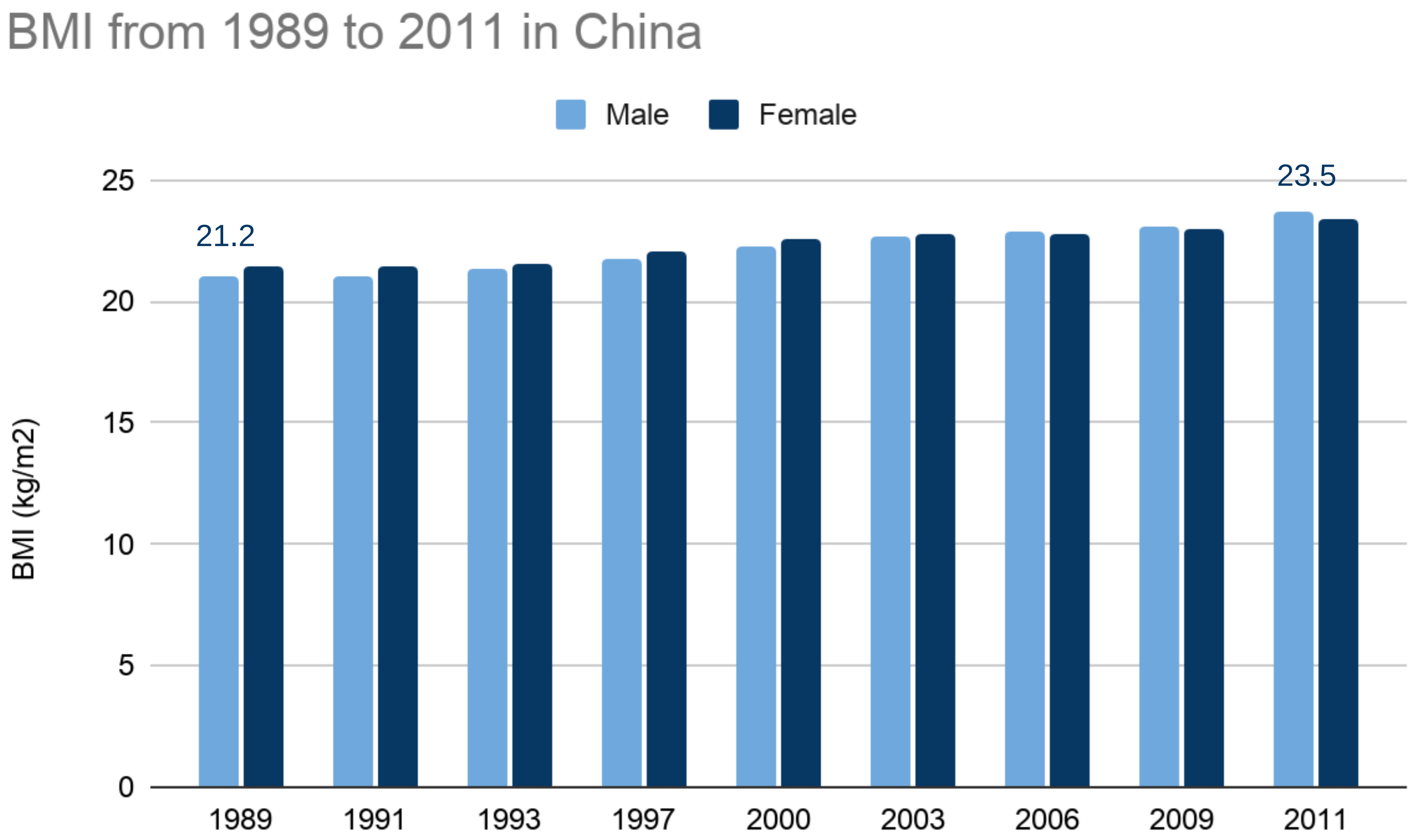
Name	% LA
Egg yolk	16%
Linseed oil (flax)	15%
Pork	12%
Lard	10%
Olive oil	10% (3.5 - 21%)
Palm oil	10%
Cocoa butter	3%
Macadamia oil	2%
Butter	2%
Coconut oil	2%
Ruminants (beef/lamb)	1-2 %

Populations getting fat and sick on different macros?

BMI from 1965 to 2011 in the U.S.

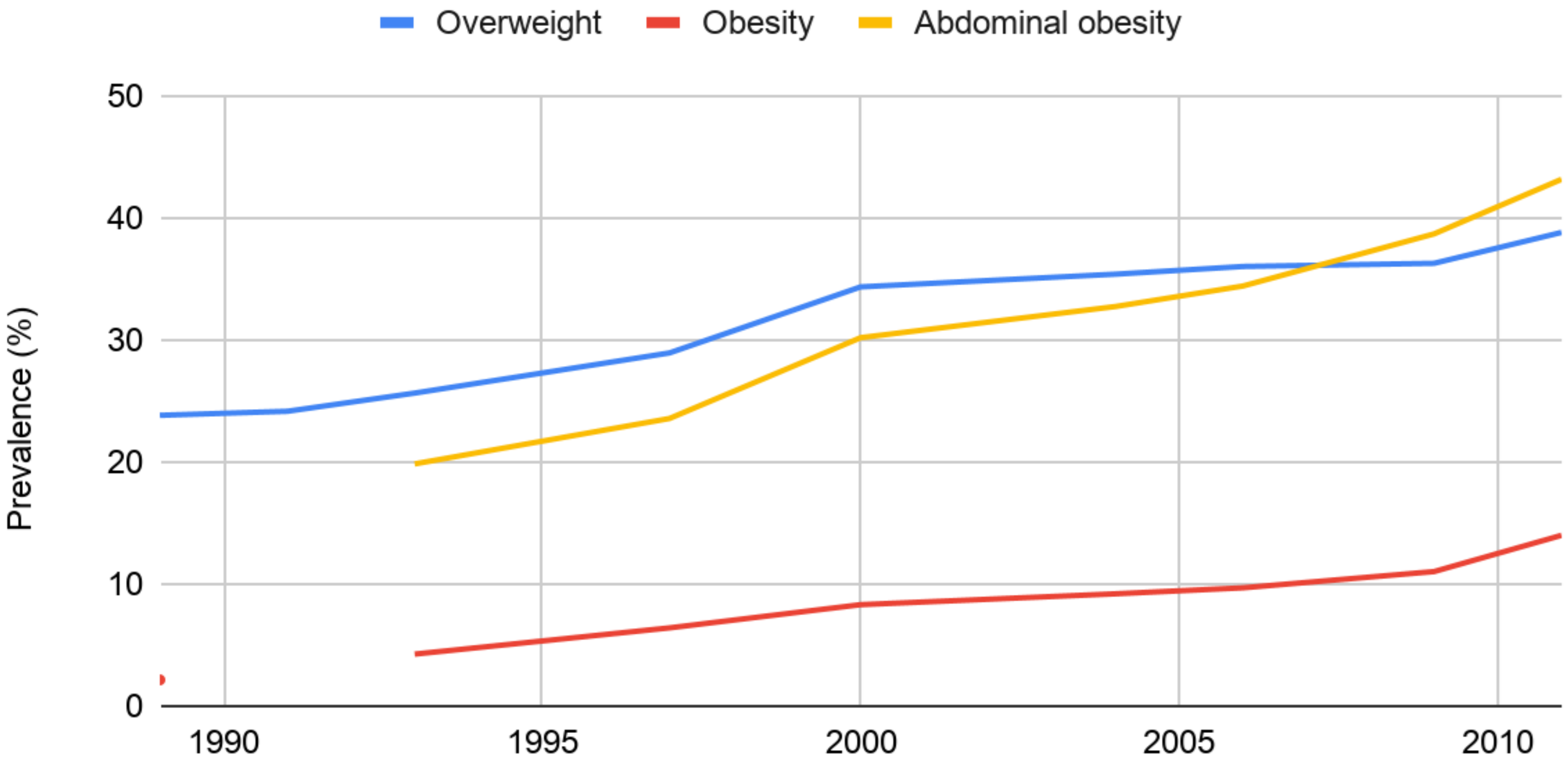


Cohen E et al. Statistical review of US macronutrient consumption data, 1965–2011: ***Americans have been following dietary guidelines, coincident with the rise in obesity****. 2015.*



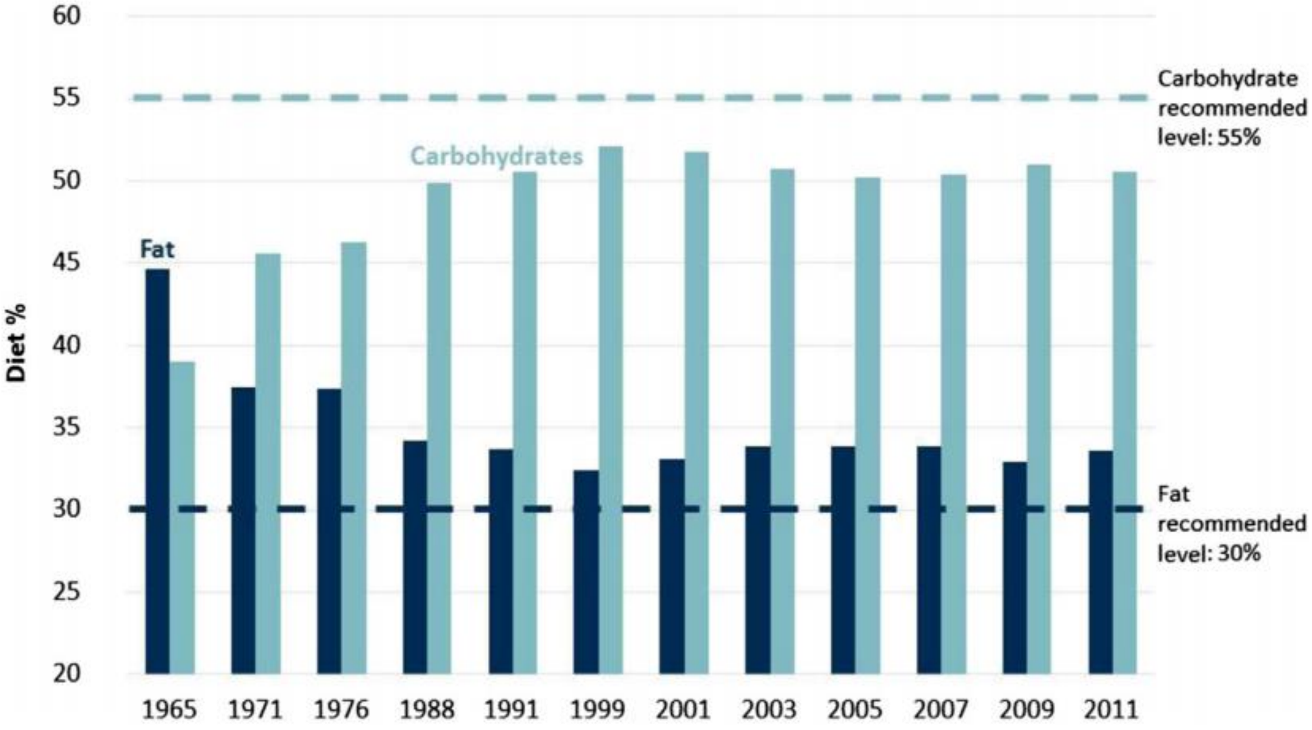
Graph created using data from Chen, Y., Peng, Q., Yang, Y. *et al.* The prevalence and increasing trends of overweight, general obesity, and abdominal obesity among Chinese adults: a repeated cross-sectional study. *BMC Public Health* 19, 1293 (2019). https://doi.org/10.1186/s12889-019-7633-0

Prevalence of overweight, obesity and abdominal obesity between 1989 and 2011 in China



Graph created using data from Chen, Y., Peng, Q., Yang, Y. *et al.* The prevalence and increasing trends of overweight, general obesity, and abdominal obesity among Chinese adults: a repeated cross-sectional study. *BMC Public Health* 19, 1293 (2019). https://doi.org/10.1186/s12889-019-7633-0

Energy contribution (%) from fat and carbohydrates between 1965 and 2011 in the U.S.



Cohen E et al. Statistical review of US macronutrient consumption data, 1965–2011: Americans have been following dietary guidelines, coincident with the rise in obesity. 2015.

Changes in dietary fat in the U.S. from 1965 to 2011

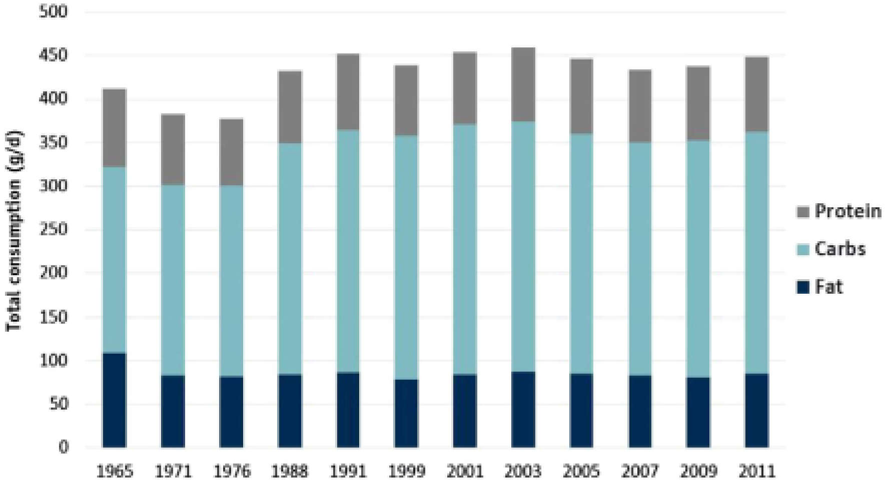


Fig. 6. Total daily consumption y adults. Source: Authors' analysis of the NHANES data. Horizontal axis indicates the start year of each survey.

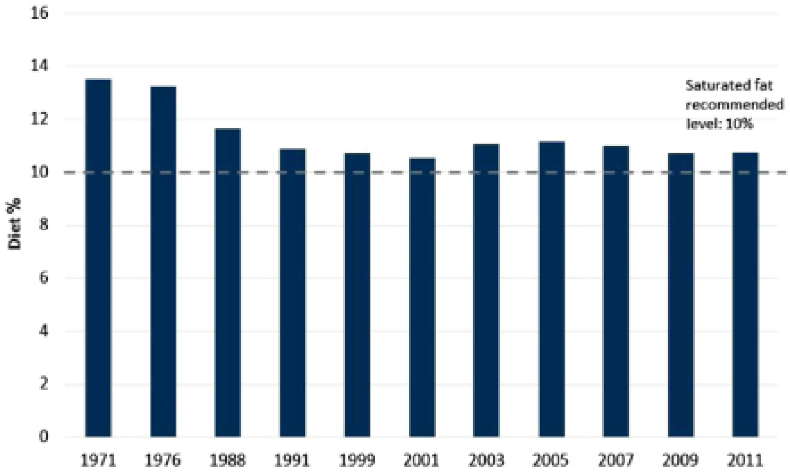
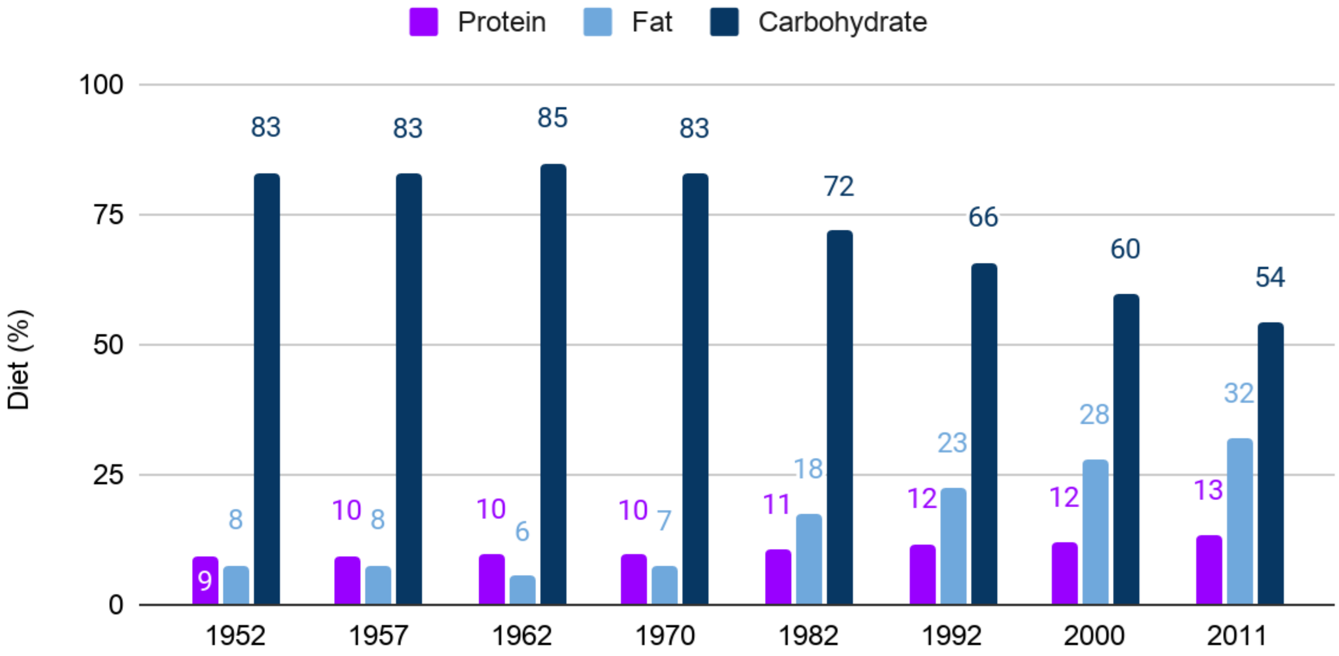


Fig. 4. Saturated fat consumed by adults as a portion of diet. Source: Authors' analysis of the NHANES data. Horizontal axis indicates the start year of each survey. Saturated fat consumption data not available for 1965.

Cohen E et al. Statistical review of US macronutrient consumption data, 1965–2011: Americans have been following dietary guidelines, coincident with the rise in obesity. 2015.

Energy contribution (%) from protein, fat and carbohydrates between 1952 and 2011 in China



Zhai FY, Du SF, Wang ZH, Zhang JG, Du WW, Popkin MB. Dynamics of the Chinese diet and the role of urbanicity, 1991–2011. Obesity Reviews. 17 December 2013. https://doi.org/10.1111/obr.12124

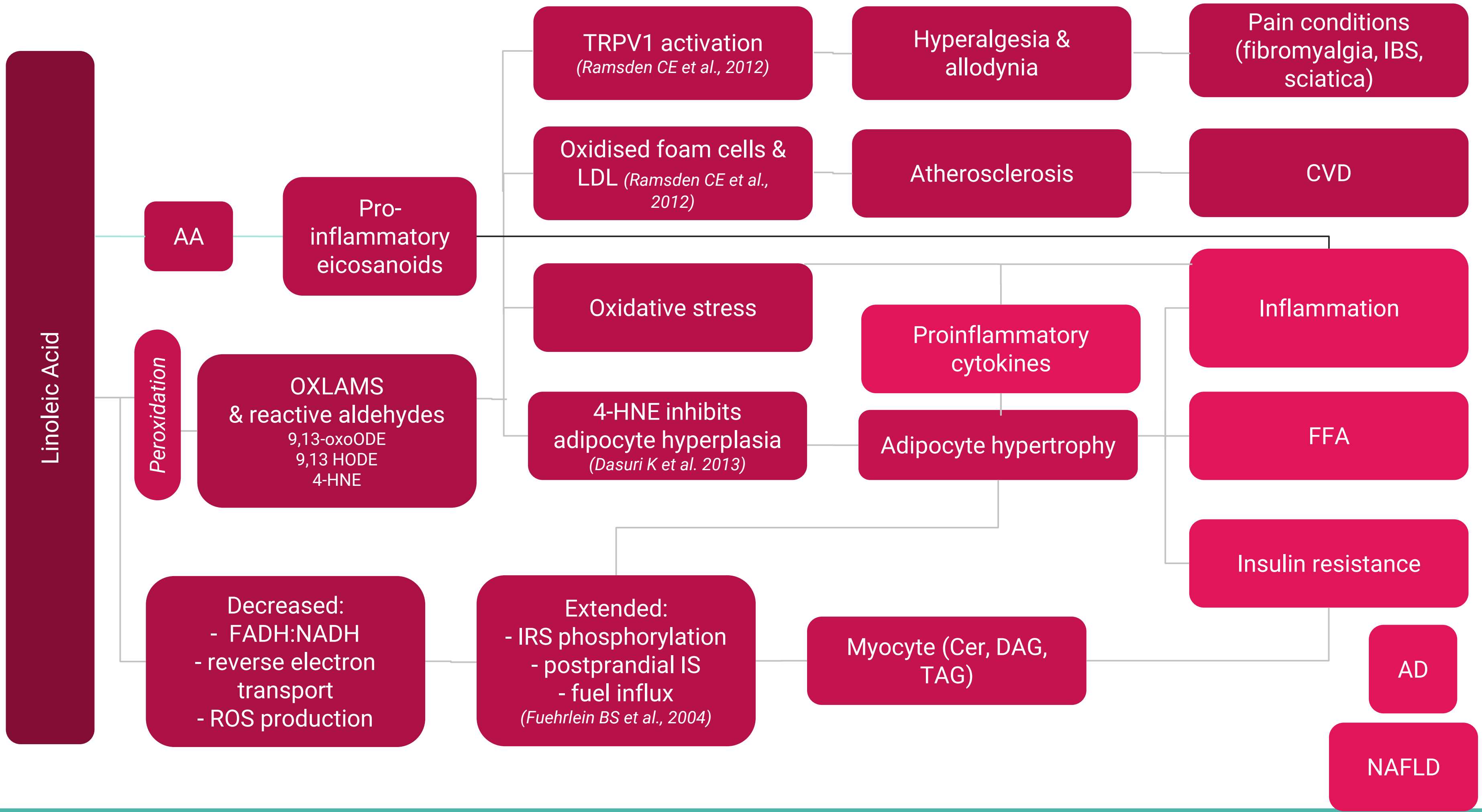
Du SF, Wang HJ, Zhang B, Zhai ZY, Popkin BM. China in the period of transition from scarcity and extensive undernutrition to emerging nutrition-related non-communicable diseases, 1949–1992. Obesity Reviews. 17 December 2013 https://doi.org/10.1111/obr.12122

The following foods have increased over this time in both populations:

- Refined seed/vegetable oils
- Pork and poultry
- Refined ultra-processed grains and sugars
  - though not the absolute or relative amount of carbohydrate for both cases

Cohen E et al. Statistical review of US macronutrient consumption data, 1965–2011: Americans have been following dietary guidelines, coincident with the rise in obesity. 2015.

Du SF, Wang HJ, Zhang B, Zhai ZY, Popkin BM. China in the period of transition from scarcity and extensive undernutrition to emerging nutrition-related non-communicable diseases, 1949–1992. Obesity Reviews. 17 December 2013 https://doi.org/10.1111/obr.12122


Linoleic Acid
AA
Pro-inflammatory eicosanoids
Peroxidation
OXLAMS
& reactive aldehydes
9,13-oxoODE
9,13 HODE
4-HNE
TRPV1 activation
(Ramsden CE et al., 2012)
Oxidised foam cells & LDL (Ramsden CE et al., 2012)
Oxidative stress
4-HNE inhibits adipocyte hyperplasia
(Dasuri K et al. 2013)
Hyperalgesia & allodynia
Atherosclerosis
Proinflammatory cytokines
Adipocyte hypertrophy
Pain conditions (fibromyalgia, IBS, sciatica)
CVD
Inflammation
FFA
Insulin resistance
AD
NAFLD
Decreased:
- FADH:NADH
- reverse electron transport
- ROS production
Extended:
- IRS phosphorylation
- postprandial IS
- fuel influx
(Fuehrlein BS et al., 2004)
Myocyte (Cer, DAG, TAG)

UPF: Other ingredients of concern

UPF: Other ingredients of concern

- To improve…
    - flavour
    - texture
    - appearance
    - shelf-life

- **Artificial flavouring**
- **Artificial colourants**
- **MSG** – monosodium glutamate
- **Sodium benzoate** (acidic foods/drinks – e.g. sodas, orange juice)
- **Carrageenan**

https://www.healthline.com/nutrition/common-food-additives#section13

Clinical aspects of TCR

Cautions and Contraindications

Contraindications

Contraindication	Complications
Carnitine deficiency and carnitine associated enzyme deficiency	Defective ketogenesis - fatal hypoglycemia
Mitochondrial fatty acid B-oxidation disorders	Defective ketogenesis - fatal hypoglycemia
Pyruvate carboxylase deficiency	Defective ketogenesis - fatal hypoglycemia
Acute intermittent porphyria	Carbohydrate restriction induces relapse of the condition

Cautions

Caution	Symptoms	Cause	Treatment
Dehydration and loss of sodium, potassium and magnesium	Keto-flu: dehydration, fatigue, hypotension, lightheadedness, headaches, difficulty concentrating and muscle cramps Usually in first week.	Increased glycogen use (glycogen is stored with water, and water is released during glycogenolysis). Lower insulin concentrations (insulin signals the kidneys to retain water and sodium).	5 g sodium/ d + fluid to thirst
Medication (diabetic and hpt)	Hypoglycaemia Ketoacidosis Keto-flu/dehydration	Insulin, oral hypoglycaemics Sulfonylureas Anti-hypertensives	Deprescription under supervision of knowledgeable MD
Raised total and LDL cholesterol	None	Increase dietary saturated fat (May be offset by lower insulin's effect on inhibiting HMG-CoA reductase)	Evaluate in context of: Atherosclerosis Cardiovascular Disease (ASCVD) risk and CAC scores, TG and HDL

Mild side-effects and troubleshooting

Problem	Cause	Action
Fatigue & constipation	'keto-flu' or excessive protein.	5 g sodium/ d + fluid to thirst < 2 g /kg IBW / d protein Laxative (e.g. magnesium oxide, other)
Muscle spasm, aches or loss (with/without anxiety or insomnia)	Natriuresis of fasting-induced magnesium or potassium wasting.	Magnesium chelate supplement for 20 days, supplying 200 - 400mg elemental magnesium daily.
Keto-rash	Prurigo pigmentosa. Unknown cause - possibly insufficient protein or nutrients.	Check and correct nutrient or protein insufficiencies. This rash usually goes away within a few days.
Weight loss plateau	Possibly too much carbohydrate or fat, frequent meals/snacks, alcohol, portions size or eating past satiety.	Check and amend CHO, fat, portion size, energy intake, or consider implementing IF.
Cravings and addictions	Psychological, carbohydrate.	Psychologist, LCHF.
Social situations	Lack of control over food, or peer pressure/ criticism	Ideas for travelling and eating out. Coping strategies.

Patient tips to prevent side effects

To combat common side effects associated with TCR (particularly in the first week of the diet) - such as constipation, fatigue, lightheadedness and muscle aches:

- Drink plenty of fluids (to thirst)
- Add salt to your food
- Drink a cup of bone broth every day (providing 1-2 g additional sodium or ½ - 1 tsp additional salt daily)

Murphy TE & Surtees B (Real Food Dietitians), 2018

Assessment and monitoring

Pre-assessment

- Complete medical history
- Physical examination (including weight, waist circumference, neck circumference (for sleep apnea risk), blood pressure, pulse and body composition measurement if available.)
- Diet history (24HR, food diary and FFQ)
- Complete blood count, serum electrolytes/renal function/glucose, liver function tests, fasting serum lipid profile
- Serum thyroid function tests (TSH, free T4)
- Electrocardiogram if symptoms for heart disease
- HgbA1c, insulin (screen for pre-diabetes, diabetes, especially if metabolic syndrome is present)

Westman & Yancy. Ketogenic. 2023

Follow-up

- Focused history (adverse effect symptoms, hunger level)
- Physical exam (heart, lungs, waist/anthropometry, peripheral edema)
- Diet evaluation (24HR, food diary, FFQ)
- Vital signs (blood pressure, pulse)
- Serum chemistry panel (electrolytes, renal function, glucose, liver function)
- Fasting serum lipid profile
- HbA1c, insulin
- Review of medications, especially diabetes and hypertension medications

Westman & Yancy. Ketogenic. 2023

Summary

- An LCHF diet is <130g cho, VLCHF/KD is <50g cho, moderate protein, > 60% fat
- TCR can be nutritionally sufficient
- Animal based diets are superior to plant based diets:
    - Micronutrient provision
    - Avoidance of antinutrients
    - High quality protein
    - Avoidance of excessive LA intake
- Nutritional requirements and benefits (e.g. micronutrients and fibre) are contextual

Thank you

nutrition network

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