Plant-Based Alternatives as Transition and Maintenance Foods

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Director of Nutrition Science and Research
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Disclosures/Conflicts of Interest

Receives funding from soybean farmers via the national soybean checkoff program and via membership dues from companies that are involved in producing, manufacturing and/or selling soy protein, soy supplements and/or soyfoods.

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Food Forum

Alternative Protein Sources: Balancing Food Innovation, Sustainability, Nutrition, and Health

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World Population to Reach 9.9 Billion by 2050

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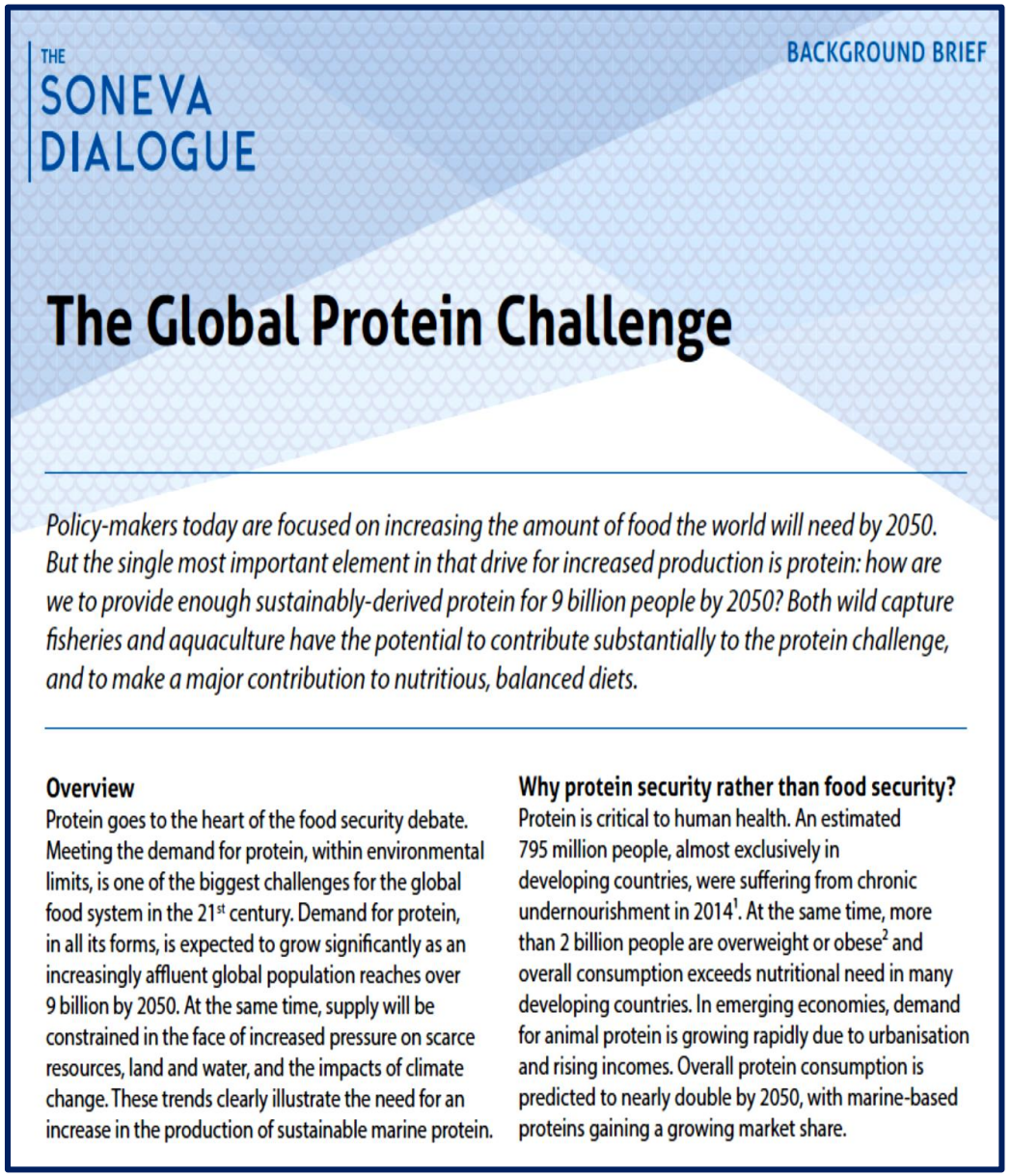

THE SONEVA DIALOGUE

BACKGROUND BRIEF

The Global Protein Challenge

Policy-makers today are focused on increasing the amount of food the world will need by 2050. But the single most important element in that drive for increased production is protein: how are we to provide enough sustainably-derived protein for 9 billion people by 2050? Both wild capture fisheries and aquaculture have the potential to contribute substantially to the protein challenge, and to make a major contribution to nutritious, balanced diets.

Overview

Protein goes to the heart of the food security debate. Meeting the demand for protein, within environmental limits, is one of the biggest challenges for the global food system in the 21st century. Demand for protein, in all its forms, is expected to grow significantly as an increasingly affluent global population reaches over 9 billion by 2050. At the same time, supply will be constrained in the face of increased pressure on scarce resources, land and water, and the impacts of climate change. These trends clearly illustrate the need for an increase in the production of sustainable marine protein.

Why protein security rather than food security?

Protein is critical to human health. An estimated 795 million people, almost exclusively in developing countries, were suffering from chronic undernourishment in 2014[1]. At the same time, more than 2 billion people are overweight or obese[2] and overall consumption exceeds nutritional need in many developing countries. In emerging economies, demand for animal protein is growing rapidly due to urbanisation and rising incomes. Overall protein consumption is predicted to nearly double by 2050, with marine-based proteins gaining a growing market share.

"Meeting the demand for protein, within environmental limits, is one of the biggest challenges for the global food system in the 21st century."

Stockholm Resilience Centre | Stockholm University

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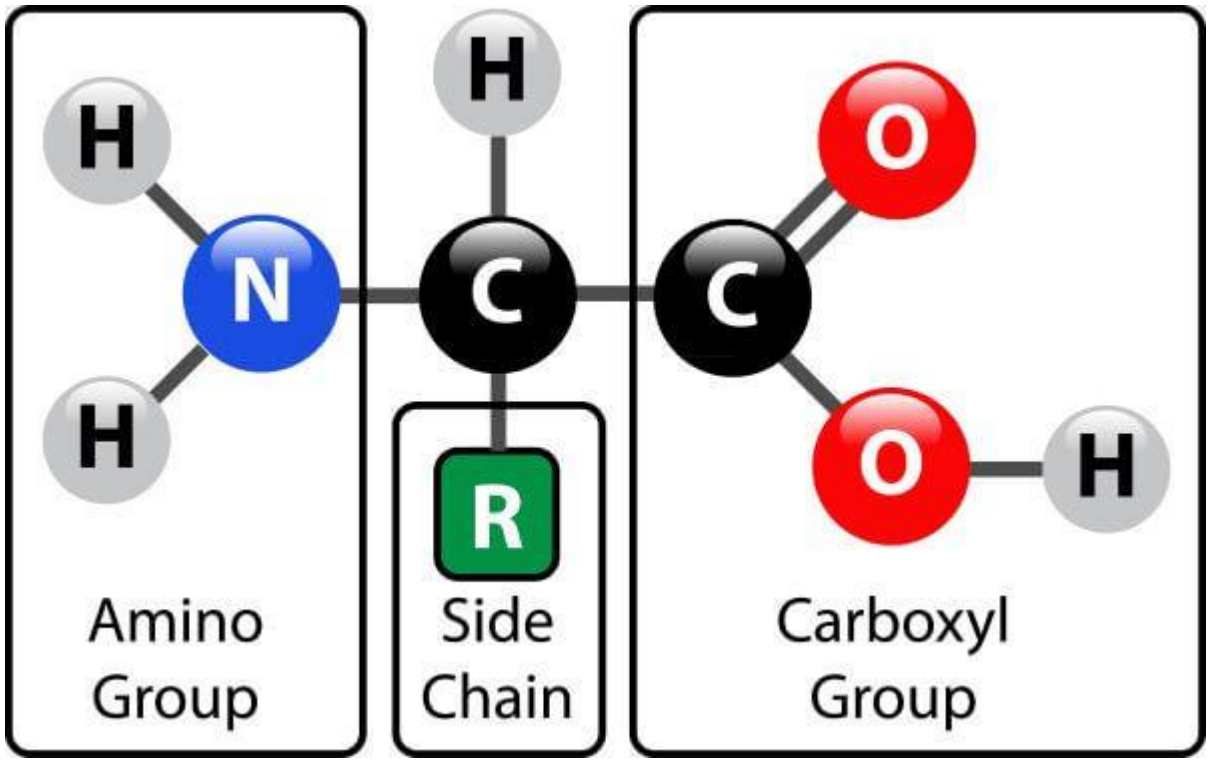

How much protein will the world need?

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Review

Future Protein Supply and Demand: Strategies and Factors Influencing a Sustainable Equilibrium

Maeve Henchion [1,*], Maria Hayes [2], Anne Maria Mullen [3], Mark Fenelon [4] and Brijesh Tiwari [5]

1 Department Agri-Food Business and Spatial Analysis, Rural Economy and Development Programme, Teagasc Food Research Centre, Ashtown, Dublin D15 KN3K, Ireland
2 Food BioSciences Department, Teagasc Food Research Centre, Ashtown, Dublin D15 KN3K, Ireland; Maria.Hayes@teagasc.ie
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4 Teagasc Food Research Programme, Teagasc Food Research Centres, Ashtown and Moorepark, Fermoy, Co. Cork P61 C996, Ireland; Mark.Fenelon@teagasc.ie
5 Food Chemistry and Technology Department, Teagasc Food Research Centre, Ashtown, Dublin D15 KN3K, Ireland; Brijesh.Tiwari@teagasc.ie
* Correspondence: Maeve.Henchion@teagasc.ie; Tel.: +353-1-805-9515

Received: 28 June 2017; Accepted: 13 July 2017; Published: 20 July 2017

Abstract: A growing global population, combined with factors such as changing socio-demographics, will place increased pressure on the world's resources to provide not only more but also different types of food. Increased consumption is expected to have a negative environmental impact, requiring more water and more land. Addressing this challenge will require optimisation of existing sources of protein as well as alternative sources for direct human consumption. This paper outlines some potential demand scenarios and provides an overview of selected existing and novel protein sources in terms of their potential to sustainably deliver protein for the future, considering drivers and challenges relating to nutritional, environmental, and technological and market/consumer domains. It concludes that different factors influence the potential of existing and novel sources. Existing protein sources are primarily hindered by their negative environmental impacts with some concerns around health. However, they offer social and economic benefits, and have a high level of consumer acceptance. Furthermore, recent research emphasizes the role of livestock as part of the solution to greenhouse gas emissions, and indicates that animal-based protein has an important role as part of a sustainable diet and as a contributor to food security. Novel proteins require the development of new value chains, and attention to issues such as production costs, food safety, scalability and consumer acceptance. Furthermore, positive environmental impacts cannot be assumed with novel protein sources and care must be taken to ensure that comparisons between novel and existing protein sources are valid. Greater alignment of political forces, and the involvement of wider stakeholders in a governance role, as well as development/commercialization role, is required to address both sources of protein and ensure food security.

Keywords: protein; novel protein; protein demand; in vitro meat; algae; insect; dairy; meat; vegetal; consumer

Foods 2017, 6, 53

1. Introduction

UN figures projecting global population growth of almost 50% since 2000 to 9.5 billion by 2050 [1] seem to be generally accepted. In addition to giving rise to an increased demand for food as a result of more mouths to feed, other changes, such as increased incomes and urbanization, will result in changes

Impact of Different Consumption Scenarios on Annual Global Protein Demand at Year 2050[1]

Proposed protein intake scenario	Change
Entire pop. at level needed for sedentary adult[2]	↓ 13%
Existing pop. at current intake levels, ↑ pop. at average for developing world	↑ 32%
Existing pop. at current intake levels, ↑ pop. at average intake for world	↑ 33%
Existing pop. at current intake levels, ↑ pop. at average for developed world	↑ 43%
Entire pop. at current maximum intake levels[3]	↑ 78%

[1]Assuming a population of 9.6 billion
[2]50 g/d [3]103 g/d

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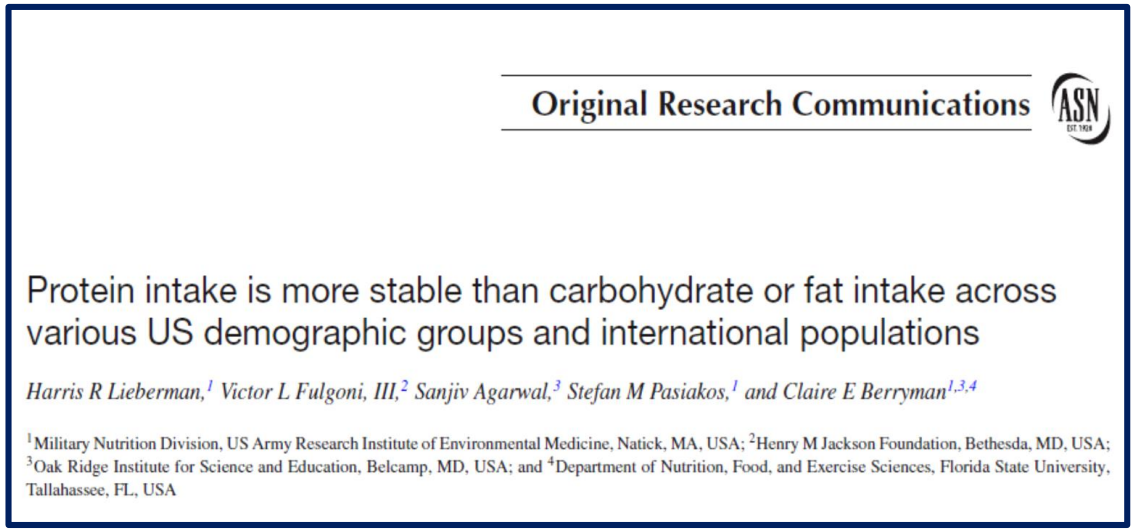


Original Research Communications

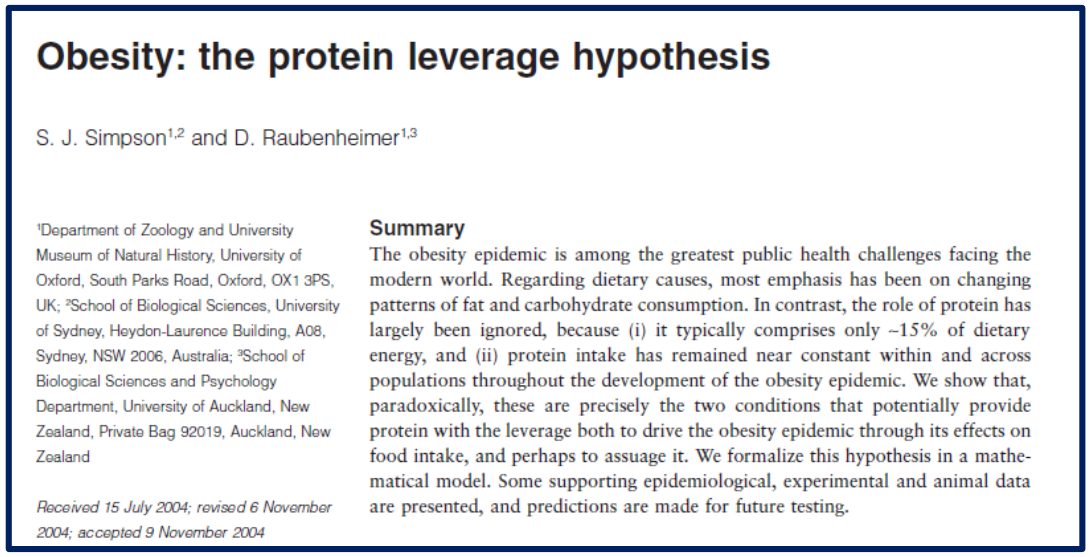
Protein intake is more stable than carbohydrate or fat intake across various US demographic groups and international populations

Harris R Lieberman,[1] Victor L Fulgoni, III,[2] Sanjiv Agarwal,[3] Stefan M Pasiakos,[1] and Claire E Berryman[1,3,4]

[1]Military Nutrition Division, US Army Research Institute of Environmental Medicine, Natick, MA, USA; [2]Henry M Jackson Foundation, Bethesda, MD, USA; [3]Oak Ridge Institute for Science and Education, Belcamp, MD, USA; and [4]Department of Nutrition, Food, and Exercise Sciences, Florida State University, Tallahassee, FL, USA

AJCN 112:180, 2020

"Protein intake … regardless of demographic and lifestyle factors, was consistently ~16% of total energy, suggesting biological control mechanism(s) tightly regulate protein intake and, consequently, influence intake of other macronutrients and food constituents."



Obesity: the protein leverage hypothesis

S. J. Simpson[1,2] and D. Raubenheimer[1,3]

[1]Department of Zoology and University Museum of Natural History, University of Oxford, South Parks Road, Oxford, OX1 3PS, UK; [2]School of Biological Sciences, University of Sydney, Heydon-Laurence Building, A08, Sydney, NSW 2006, Australia; [3]School of Biological Sciences and Psychology Department, University of Auckland, New Zealand, Private Bag 92019, Auckland, New Zealand

Received 15 July 2004; revised 6 November 2004; accepted 9 November 2004

Summary

The obesity epidemic is among the greatest public health challenges facing the modern world. Regarding dietary causes, most emphasis has been on changing patterns of fat and carbohydrate consumption. In contrast, the role of protein has largely been ignored, because (i) it typically comprises only ~15% of dietary energy, and (ii) protein intake has remained near constant within and across populations throughout the development of the obesity epidemic. We show that, paradoxically, these are precisely the two conditions that potentially provide protein with the leverage both to drive the obesity epidemic through its effects on food intake, and perhaps to assuage it. We formalize this hypothesis in a mathematical model. Some supporting epidemiological, experimental and animal data are presented, and predictions are made for future testing.

Obesity Reviews 6:133, 2005

" … when humans are forced to trade-off protein intake against that of carbohydrate and fat on nutritionally unbalanced diets, physiological regulatory mechanisms prioritize protein."

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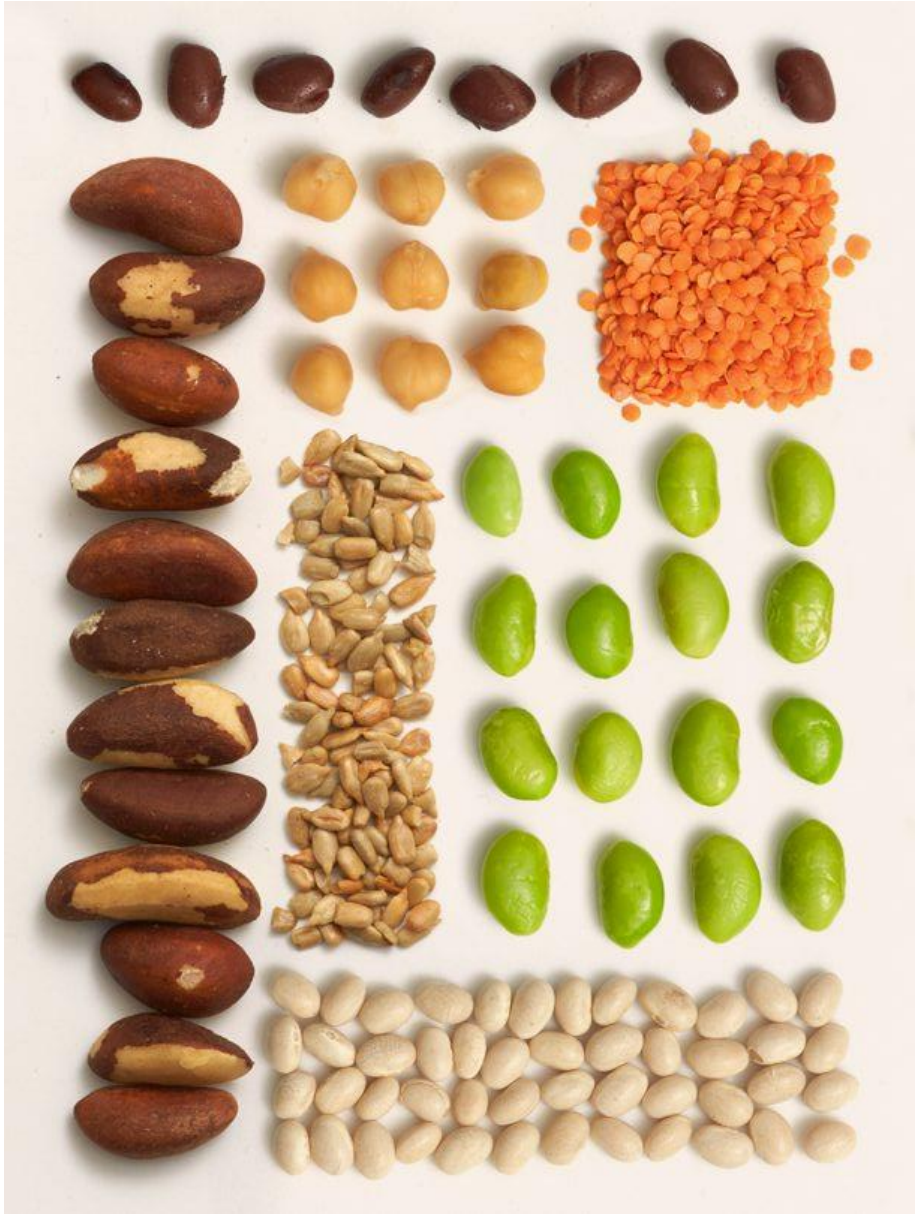

Premise

Populations will shift in the direction of a plant-based diet

Motivation

- **Environmental**
- **Health • Ethical**

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How best to produce the calories and plant protein the world needs?

HOW TO FEED THE WORLD 2050

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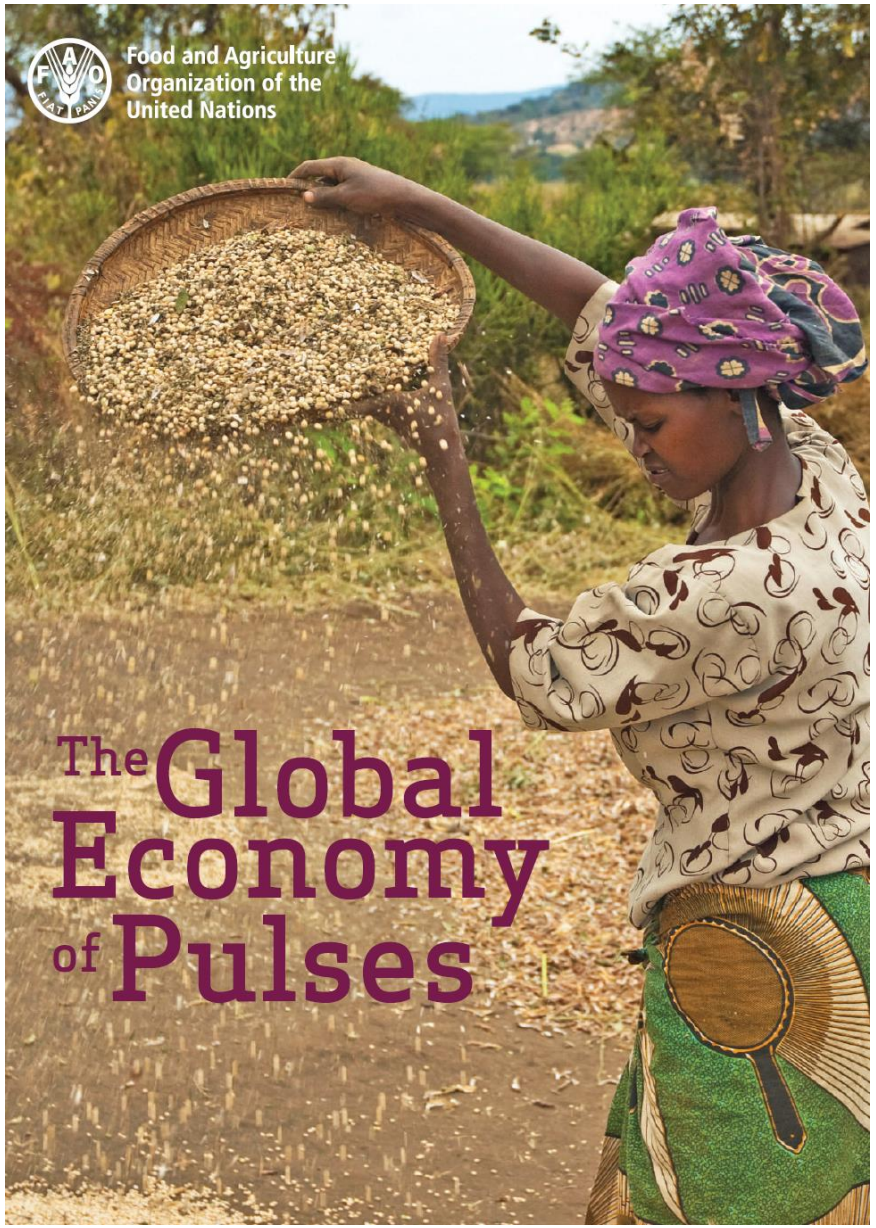

Legumes, pulses, beans

- Low environmental footprint
- Good sources of protein and fiber
- Affordable

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9 Major Legumes

Non-oilseed legumes — Lower fat, higher fiber

Oilseed legumes — Higher fat, lower fiber

Peanuts

Soybeans

Undried legumes

Snap bean

Snap pea

Dried, mature seeds — **Pulses**

5 most common

Chickpeas

Cowpea

Lentils

Dry pea

Dry bean

Underutilized sources of nutrition

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Region	grams per day	% total intake	
		Protein	Energy
Oceania	12	2	1
East Asia	4	1	0
Southeast Asia	9	3	1
South Asia	33	11	5
West Asia	19	6	3
Caucasus & Central Asia	1	0	0
Europe	7	2	1
North Africa	19	5	2
Sub-Saharan Africa	33	12	5
Latin America & Caribbean	34	9	4
North America	11	2	1
World	21	6	3

Average per capita daily consumption of pulses, and its contribution to protein and calorie intake, by region, 2011–13

Rawal, V. & Navarro, D. K., eds. 2019. The Global Economy of Pulses. Rome, FAO

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Optimal animal to plant protein ratio?

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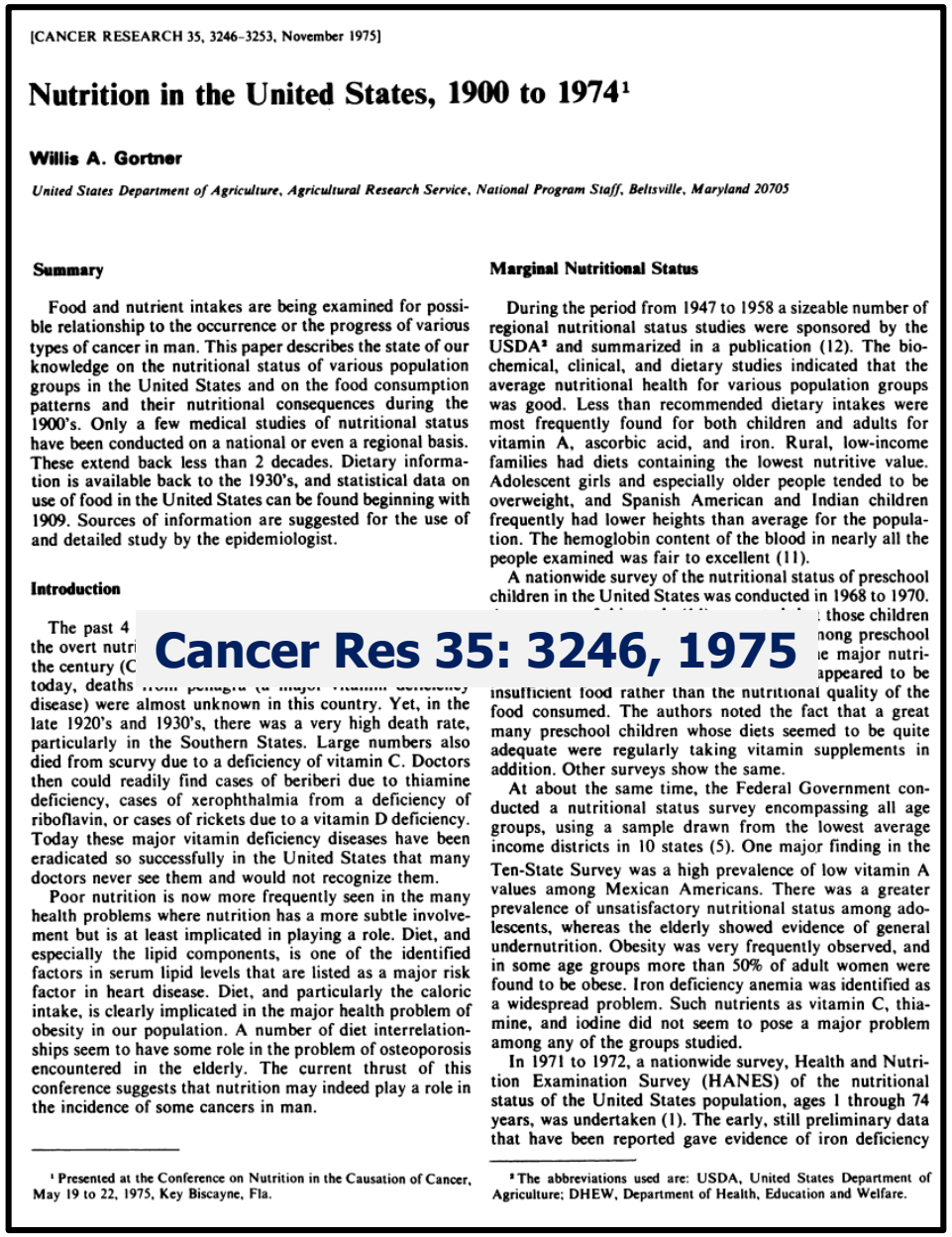
Dutch Food-Based Dietary Guidelines recommend an animal to plant protein ratio of 1:1



[CANCER RESEARCH 35, 3246–3253, November 1975]

Nutrition in the United States, 1900 to 1974[1]

Willis A. Gortner

United States Department of Agriculture, Agricultural Research Service, National Program Staff, Beltsville, Maryland 20705

Summary

Food and nutrient intakes are being examined for possible relationship to the occurrence or the progress of various types of cancer in man. This paper describes the state of our knowledge on the nutritional status of various population groups in the United States and on the food consumption patterns and their nutritional consequences during the 1900's. Only a few medical studies of nutritional status have been conducted on a national or even a regional basis. These extend back less than 2 decades. Dietary information is available back to the 1930's, and statistical data on use of food in the United States can be found beginning with 1909. Sources of information are suggested for the use of and detailed study by the epidemiologist.

Introduction

The past 4
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disease) were almost unknown in this country. Yet, in the late 1920's and 1930's, there was a very high death rate, particularly in the Southern States. Large numbers also died from scurvy due to a deficiency of vitamin C. Doctors then could readily find cases of beriberi due to thiamine deficiency, cases of xerophthalmia from a deficiency of riboflavin, or cases of rickets due to a vitamin D deficiency. Today these major vitamin deficiency diseases have been eradicated so successfully in the United States that many doctors never see them and would not recognize them.

Poor nutrition is now more frequently seen in the many health problems where nutrition has a more subtle involvement but is at least implicated in playing a role. Diet, and especially the lipid components, is one of the identified factors in serum lipid levels that are listed as a major risk factor in heart disease. Diet, and particularly the caloric intake, is clearly implicated in the major health problem of obesity in our population. A number of diet interrelationships seem to have some role in the problem of osteoporosis encountered in the elderly. The current thrust of this conference suggests that nutrition may indeed play a role in the incidence of some cancers in man.

Marginal Nutritional Status

During the period from 1947 to 1958 a sizeable number of regional nutritional status studies were sponsored by the USDA[2] and summarized in a publication (12). The biochemical, clinical, and dietary studies indicated that the average nutritional health for various population groups was good. Less than recommended dietary intakes were most frequently found for both children and adults for vitamin A, ascorbic acid, and iron. Rural, low-income families had diets containing the lowest nutritive value. Adolescent girls and especially older people tended to be overweight, and Spanish American and Indian children frequently had lower heights than average for the population. The hemoglobin content of the blood in nearly all the people examined was fair to excellent (11).

A nationwide survey of the nutritional status of preschool children in the United States was conducted in 1968 to 1970.
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At about the same time, the Federal Government conducted a nutritional status survey encompassing all age groups, using a sample drawn from the lowest average income districts in 10 states (5). One major finding in the Ten-State Survey was a high prevalence of low vitamin A values among Mexican Americans. There was a greater prevalence of unsatisfactory nutritional status among adolescents, whereas the elderly showed evidence of general undernutrition. Obesity was very frequently observed, and in some age groups more than 50% of adult women were found to be obese. Iron deficiency anemia was identified as a widespread problem. Such nutrients as vitamin C, thiamine, and iodine did not seem to pose a major problem among any of the groups studied.

In 1971 to 1972, a nationwide survey, Health and Nutrition Examination Survey (HANES) of the nutritional status of the United States population, ages 1 through 74 years, was undertaken (1). The early, still preliminary data that have been reported gave evidence of iron deficiency

[1] Presented at the Conference on Nutrition in the Causation of Cancer, May 19 to 22, 1975, Key Biscayne, Fla.

[2] The abbreviations used are: USDA, United States Department of Agriculture; DHEW, Department of Health, Education and Welfare.

Cancer Res 35: 3246, 1975

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Year	Protein (g/d)		Animal: Plant
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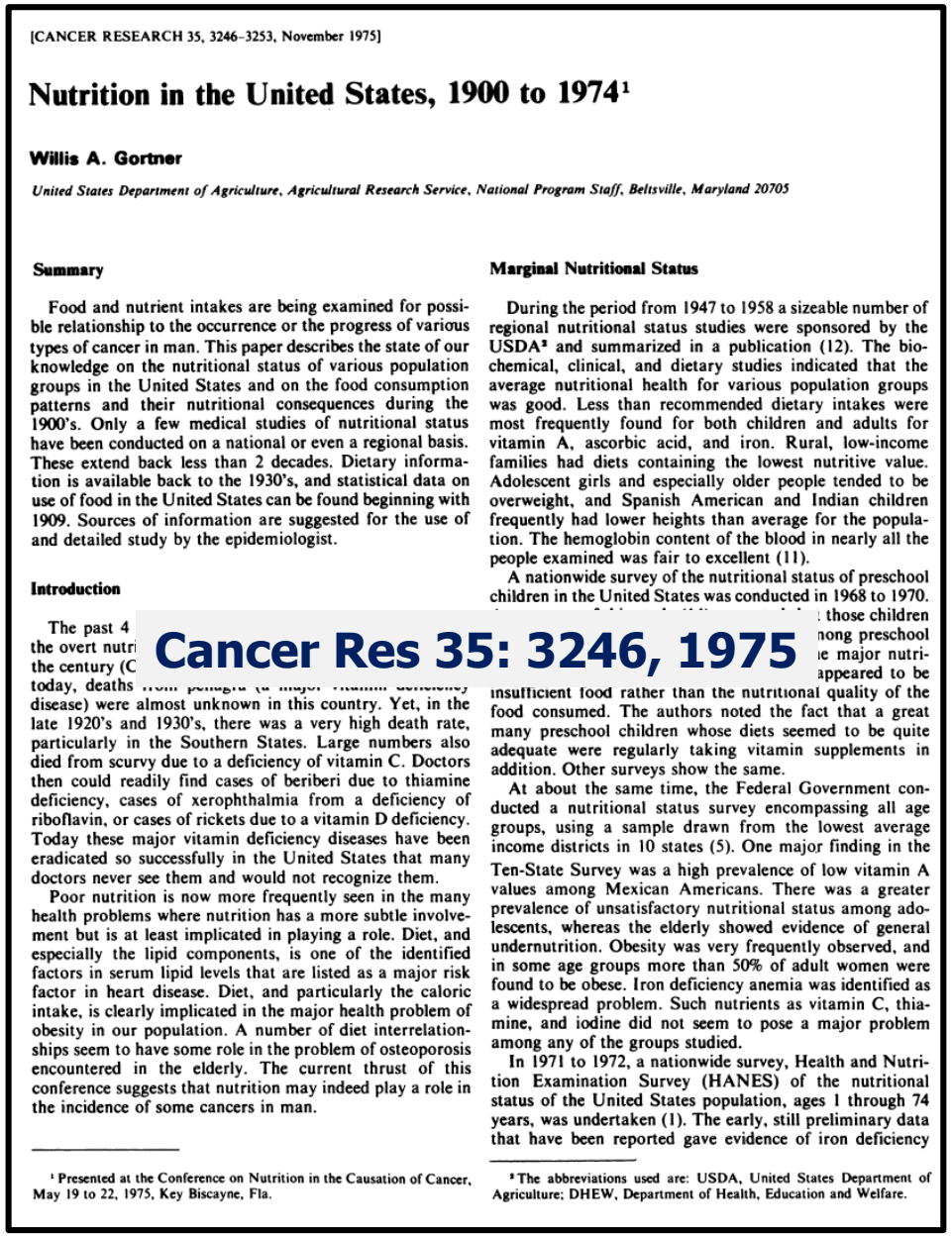

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1969	69	31	2.2
2015-16*	51.1	30.2	1.84

*NHANES JAMA 2019;322:1178

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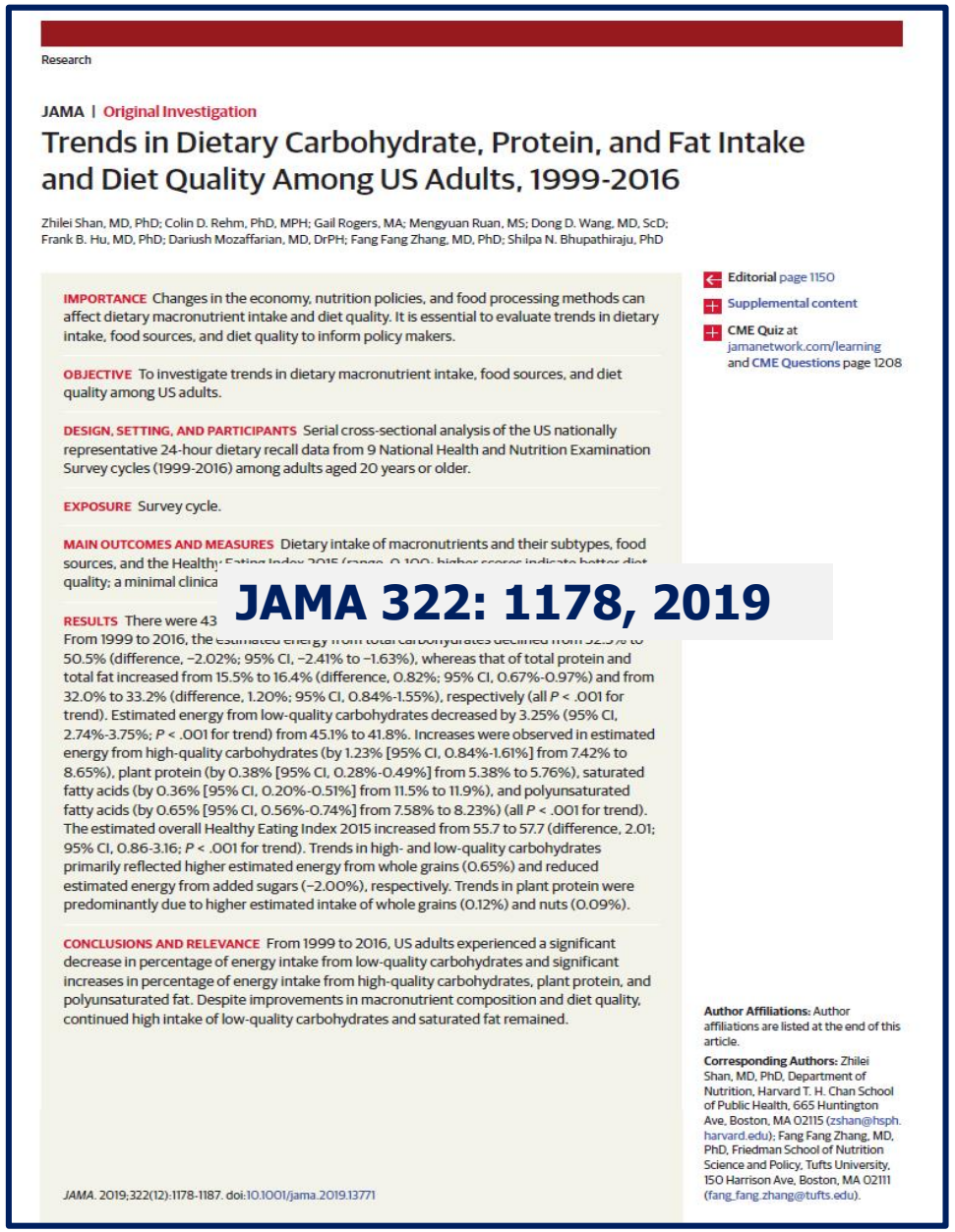

Research

JAMA | Original Investigation

Trends in Dietary Carbohydrate, Protein, and Fat Intake and Diet Quality Among US Adults, 1999-2016

Zhilei Shan, MD, PhD; Colin D. Rehm, PhD, MPH; Gail Rogers, MA; Mengyuan Ruan, MS; Dong D. Wang, MD, ScD; Frank B. Hu, MD, PhD; Dariush Mozaffarian, MD, DrPH; Fang Fang Zhang, MD, PhD; Shilpa N. Bhupathiraju, PhD

Editorial page 1150
Supplemental content
CME Quiz at jamanetwork.com/learning and CME Questions page 1208

IMPORTANCE Changes in the economy, nutrition policies, and food processing methods can affect dietary macronutrient intake and diet quality. It is essential to evaluate trends in dietary intake, food sources, and diet quality to inform policy makers.

OBJECTIVE To investigate trends in dietary macronutrient intake, food sources, and diet quality among US adults.

DESIGN, SETTING, AND PARTICIPANTS Serial cross-sectional analysis of the US nationally representative 24-hour dietary recall data from 9 National Health and Nutrition Examination Survey cycles (1999-2016) among adults aged 20 years or older.

EXPOSURE Survey cycle.

MAIN OUTCOMES AND MEASURES Dietary intake of macronutrients and their subtypes, food sources, and the Healthy Eating Index 2015 (range, 0-100; higher scores indicate better diet quality; a minimal clinica

RESULTS There were 43

From 1999 to 2016, the estimated energy from total carbohydrates declined from 52.5% to 50.5% (difference, −2.02%; 95% CI, −2.41% to −1.63%), whereas that of total protein and total fat increased from 15.5% to 16.4% (difference, 0.82%; 95% CI, 0.67%-0.97%) and from 32.0% to 33.2% (difference, 1.20%; 95% CI, 0.84%-1.55%), respectively (all $P < .001$ for trend). Estimated energy from low-quality carbohydrates decreased by 3.25% (95% CI, 2.74%-3.75%; $P < .001$ for trend) from 45.1% to 41.8%. Increases were observed in estimated energy from high-quality carbohydrates (by 1.23% [95% CI, 0.84%-1.61%] from 7.42% to 8.65%), plant protein (by 0.38% [95% CI, 0.28%-0.49%] from 5.38% to 5.76%), saturated fatty acids (by 0.36% [95% CI, 0.20%-0.51%] from 11.5% to 11.9%), and polyunsaturated fatty acids (by 0.65% [95% CI, 0.56%-0.74%] from 7.58% to 8.23%) (all $P < .001$ for trend). The estimated overall Healthy Eating Index 2015 increased from 55.7 to 57.7 (difference, 2.01; 95% CI, 0.86-3.16; $P < .001$ for trend). Trends in high- and low-quality carbohydrates primarily reflected higher estimated energy from whole grains (0.65%) and reduced estimated energy from added sugars (−2.00%), respectively. Trends in plant protein were predominantly due to higher estimated intake of whole grains (0.12%) and nuts (0.09%).

CONCLUSIONS AND RELEVANCE From 1999 to 2016, US adults experienced a significant decrease in percentage of energy intake from low-quality carbohydrates and significant increases in percentage of energy intake from high-quality carbohydrates, plant protein, and polyunsaturated fat. Despite improvements in macronutrient composition and diet quality, continued high intake of low-quality carbohydrates and saturated fat remained.

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JAMA. 2019;322(12):1178-1187. doi:10.1001/jama.2019.13771

JAMA 322: 1178, 2019

46% of plant protein intake from refined grains

2015-16

nhanes

National Health and Nutrition Examination Survey

US SOY

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Impact of Consuming the Recommended Bean Intake (1½ cups, 3 servings per week) on the US Animal to Plant Protein Ratio

US SOY

SNI SOY NUTRITION INSTITUTE GLOBAL

Impact of Adhering to the Recommended Bean Intake on the US Animal to Plant Protein Ratio

1½ cups/week

1.84 → **1.43**

3.3 g/day protein

NHANES 2015-16. 23.2 g (1.5 C)/7 = 3.3 g/d; 51.1 g animal protein; 30.2 g plant protein. Assuming bean protein replaces animal protein. JAMA 2019;322:1178

US SOY

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Impact of Consuming One Serving (½ C) Daily on the US Animal to Plant Protein Ratio if Replacing Animal Protein

1 serving/day

1.84 → **1.14**

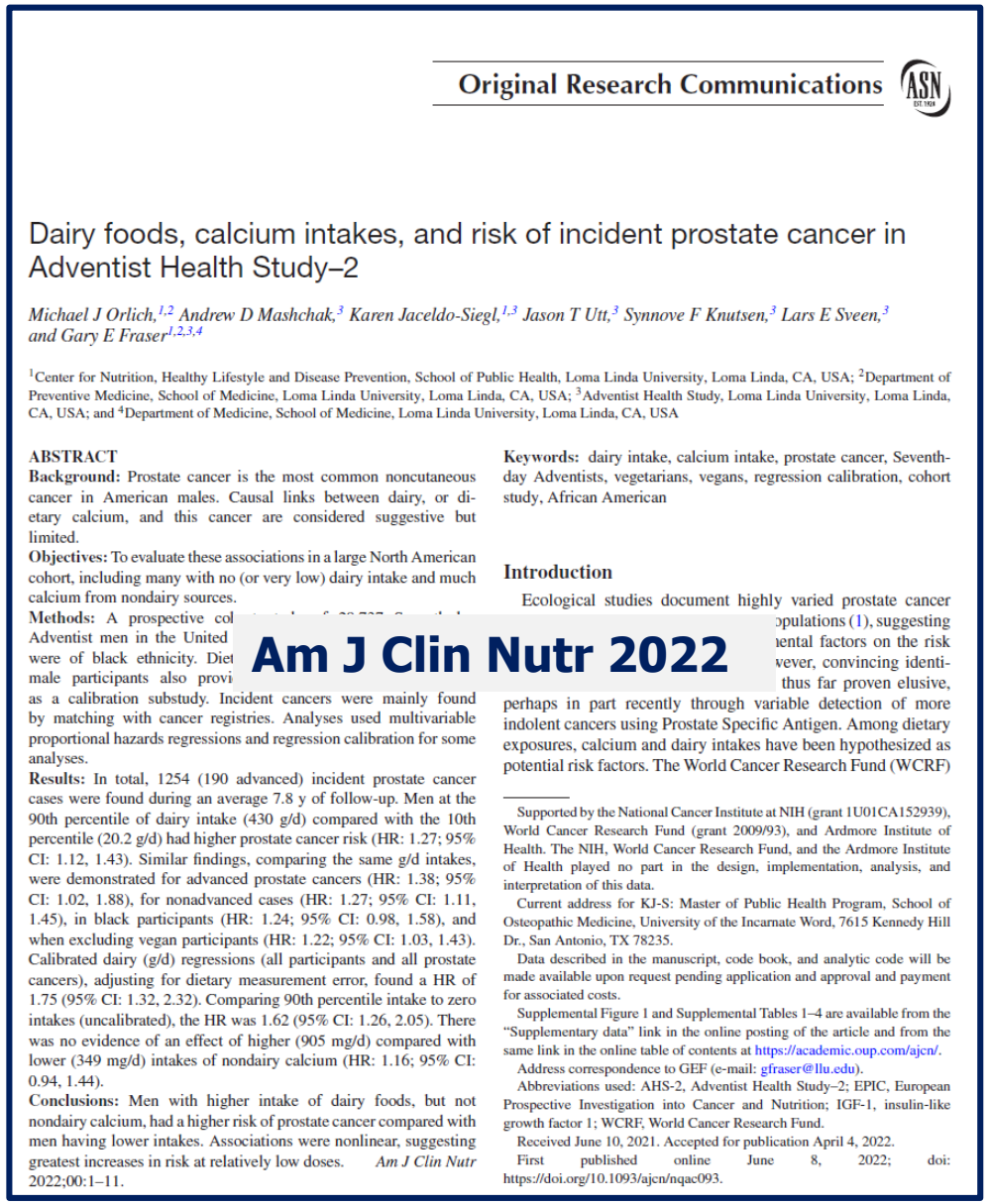
7.8 g/day protein

NHANES 2015-16. 23.2 g (1.5 C)/7 = 3.3 g/d; 51.1 g animal protein; 30.2 g plant protein. Assuming bean protein replaces animal protein. JAMA 2019;322:1178

US SOY

SNI SOY NUTRITION INSTITUTE GLOBAL

How likely is it that we will consume 1 serving of beans daily?



Original Research Communications

Dairy foods, calcium intakes, and risk of incident prostate cancer in Adventist Health Study–2

Michael J Orlich,[1,2] Andrew D Mashchak,[3] Karen Jaceldo-Siegl,[1,3] Jason T Utt,[3] Synnove F Knutsen,[3] Lars E Sveen,[3] and Gary E Fraser[1,2,3,4]

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ABSTRACT

Background: Prostate cancer is the most common noncutaneous cancer in American males. Causal links between dairy, or dietary calcium, and this cancer are considered suggestive but limited.

Objectives: To evaluate these associations in a large North American cohort, including many with no (or very low) dairy intake and much calcium from nondairy sources.

Methods: A prospective col… Adventist men in the United … were of black ethnicity. Diet… male participants also provi… as a calibration substudy. Incident cancers were mainly found by matching with cancer registries. Analyses used multivariable proportional hazards regressions and regression calibration for some analyses.

Results: In total, 1254 (190 advanced) incident prostate cancer cases were found during an average 7.8 y of follow-up. Men at the 90th percentile of dairy intake (430 g/d) compared with the 10th percentile (20.2 g/d) had higher prostate cancer risk (HR: 1.27; 95% CI: 1.12, 1.43). Similar findings, comparing the same g/d intakes, were demonstrated for advanced prostate cancers (HR: 1.38; 95% CI: 1.02, 1.88), for nonadvanced cases (HR: 1.27; 95% CI: 1.11, 1.45), in black participants (HR: 1.24; 95% CI: 0.98, 1.58), and when excluding vegan participants (HR: 1.22; 95% CI: 1.03, 1.43). Calibrated dairy (g/d) regressions (all participants and all prostate cancers), adjusting for dietary measurement error, found a HR of 1.75 (95% CI: 1.32, 2.32). Comparing 90th percentile intake to zero intakes (uncalibrated), the HR was 1.62 (95% CI: 1.26, 2.05). There was no evidence of an effect of higher (905 mg/d) compared with lower (349 mg/d) intakes of nondairy calcium (HR: 1.16; 95% CI: 0.94, 1.44).

Conclusions: Men with higher intake of dairy foods, but not nondairy calcium, had a higher risk of prostate cancer compared with men having lower intakes. Associations were nonlinear, suggesting greatest increases in risk at relatively low doses. *Am J Clin Nutr* 2022;00:1–11.

Keywords: dairy intake, calcium intake, prostate cancer, Seventh-day Adventists, vegetarians, vegans, regression calibration, cohort study, African American

Introduction

Ecological studies document highly varied prostate cancer …opulations (1), suggesting …ental factors on the risk …wever, convincing identi- … thus far proven elusive, perhaps in part recently through variable detection of more indolent cancers using Prostate Specific Antigen. Among dietary exposures, calcium and dairy intakes have been hypothesized as potential risk factors. The World Cancer Research Fund (WCRF)

Supported by the National Cancer Institute at NIH (grant 1U01CA152939), World Cancer Research Fund (grant 2009/93), and Ardmore Institute of Health. The NIH, World Cancer Research Fund, and the Ardmore Institute of Health played no part in the design, implementation, analysis, and interpretation of this data.

Current address for KJ-S: Master of Public Health Program, School of Osteopathic Medicine, University of the Incarnate Word, 7615 Kennedy Hill Dr., San Antonio, TX 78235.

Data described in the manuscript, code book, and analytic code will be made available upon request pending application and approval and payment for associated costs.

Supplemental Figure 1 and Supplemental Tables 1–4 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/ajcn/.

Address correspondence to GEF (e-mail: gfraser@llu.edu).

Abbreviations used: AHS-2, Adventist Health Study–2; EPIC, European Prospective Investigation into Cancer and Nutrition; IGF-1, insulin-like growth factor 1; WCRF, World Cancer Research Fund.

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First published online June 8, 2022; doi: https://doi.org/10.1093/ajcn/nqac093.

Am J Clin Nutr 2022

Adventist Health Study 2

better health for everyone!

Vegan legume intake: 64 g/day*

***~¾ USDA serving. N= 2306 men, excludes soy products**

US SOY

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If not beans, then what?

Traditional meat substitutes such as black bean burgers have not led to the desired shift in the animal to plant protein ratio

Traditional soyfoods may continue to gain in popularity but may never achieve mass appeal to the point where they substantially contribute to US and global protein intake

Plant-based meat alternatives made from concentrated sources of bean protein, such as soy and pea, that are designed to emulate the orosensory properties of meat.

May have mass appeal

US SOY

SNI SOY NUTRITION INSTITUTE GLOBAL

“Meat substitutes could replace meat successfully only if they resemble highly processed meat products in taste and texture …”

Szenderák et al. Consumer Acceptance of Plant-Based Meat Substitutes: A Narrative Review. Foods 2022, 11,1274.

scientific reports

Check for updates

OPEN

Most plant-based meat alternative buyers also buy meat: an analysis of household demographics, habit formation, and buying behavior among meat alternative buyers

Zachary T. Neuhofer✉ & Jayson L. Lusk

The promise of novel plant-based meat alternatives (PBMAs) to lessen the health and environmental impacts of meat consumption ultimately depend on market acceptance and the extent to which they displace meat in consumers' diets. We use household scanner data to provide an in-depth analysis of consumers' PBMA buying behaviors. PBMAs buyers tend to be young, single, female, college educated, employed, higher income, and non-white. About 20% of consumers purchased a PBMA at least once, and 12% purchased a PBMA on multiple occasions. About 2.79% of households only purchased PBMAs. About 86% of PBMA buyers also bought ground meat; however, PBMA buyers spent about 13% less on ground meat. Interestingly, after a household's first PBMA purchase, ground

Scientific Reports 2022 12:13062

In recent years, concerns have increased around the health and environmental impacts of meat consumption[1–8]. Encouraging dietary change toward more plant-based diets has been proposed to reduce dietary-related land-use, water use, and greenhouse gas emissions[1,2,9,10]. From a public health perspective, substitution to a plant based diet has been estimated to lower the risk of chronic diseases and mortality[11–14]. Despite encouragement for dietary change, consumer demand for meat remains high and is growing[15]. Moreover, there is little public support for policies to tax foods based on health or environmental outcomes[16]. The current dilemma faced by the industry and policymakers is between persistently high meat demand and a lack of political support for policies that would curb meat consumption. A potential solution is to invest in innovative plant-based meat alternatives (PBMA) that have the potential to induce consumers to willingly transition away from animal to plant-based diets[17–21]. Novel PBMAs use ingredients such as soy, wheat, pea, and heme to mimic the sensory characteristics and macronutrients of meat.

Interest in PMBAs also stems from potential environmental benefits. Several studies have suggested that reducing meat consumption in favor of a more plant-based diet will lead to better environmental outcomes, which include, reducing greenhouse gas (GHG) emissions, land use, and water use relative to conventional beef production[3,17,18,22,23]. However, for these environmental benefits to be realized, consumers must be willing to choose PBMAs over meat options. At this point, much remains unknown about consumer purchase behaviors surrounding PBMAs.

What is known about consumer preferences for PBMAs is primarily limited to hypothetical stated preference surveys[16,24–27], industry and interest groups reports[28,29], and analysis of retail scanner data that aggregates over thousands of consumers[30]. Analysis of household scanner data has only recently been undertaken[31]. These previous studies have estimated market shares for PBMAs that range from 30% to less than 1%. These estimates depended on how the market is defined (e.g., ground products vs. all beef vs. all meat), the data source used (e.g., stated preference survey vs. retail scanner data), and the unit of measurement (e.g., share of quantities sold or share of sales)[16,26–30,32,33]. Most estimates of retail scanner data put the dollar market share of PBMA out of all meat sales at less than 1%, a figure that grew rapidly from 2019–2021, but that appears to have stalled in 2022[28,30]. Analysis using scanner data has suggested low repeat purchases of PBMAs and that PBMAs are not a substitute for beef or pork[31].

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Results of US Household Scanner Data (November 2018 – November 2020)

Category	N	Percent
PBMA buyers	7,761	100
PBMA and ground beef buyers	6,672	86
PBMA buyers only	1,089	14

PBMA, plant-based meat alternatives. Of 38,966 HHs, 7,761 (19.9%) purchased PBMA at least once

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Transition and Maintenance Foods

Plant-based meat alternatives make the transition to a plant-based diet easier and make it easier to maintain one.

Journal Pre-proof

The rise of processed meat alternatives: A narrative review of the manufacturing, composition, nutritional profile and health effects of newer sources of protein, and their place in healthier diets

Annalisa Gastaldello, Francesca Giampieri, Rachele de Giuseppe, Giuseppe Grosso, Luciana Baroni, Maurizio Battino

PII: S0924-2244(22)00222-9

DOI: https://doi.org/10.1016/j.tifs.2022.07.005

Reference: TIFS 3840

To appear in: *Trends in Food Science & Technology*

Received Date: 15 March 2022

Revised D

Accepted

Trends Food Sci Technol 2022

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" … processed meat alternatives could be seen as a strategy for making transitioning to healthier eating patterns a more reachable goal."

US SOY

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Easier

Harder

Österreich Z Soziol (2021) 46:109–124
https://doi.org/10.1007/s11614-021-00453-0

ÖZS

EDITORIAL

Meat and social change

Sociological perspectives on the consumption and production of animals

Frithjof Nungesser · Martin Winter

Accepted: 21 May 2021 / Published online: 7 July 2021

1 The sociological significance of meat

Meat is a crucial object of sociological research. The *consumption* of meat plays a significant role in the food supply of modern societies. The importance of meat is not, [illegible] of m[illegible] identities, as well as to gender relations and conceptions of health, purity, or naturalness. The *production* of meat is connected to numerous ecological problems, the breeding and killing of billions of animals, precarious working conditions and issues of public health (as, for example, the current pandemic demonstrates). Moreover, both the consumption and production of meat are linked to various *dynamics of transformation and conflict*: Technical and scientific innovations as well as political and economic decisions transform agriculture and meat production, leading to an unparalleled productivity but also to unprecedented environmental consequences. While the "normality" of meat consumption spreads further around the globe and is no longer exclusive to the Global North, in Western societies problems related to meat increasingly become the subject of public debates and social struggles.

Despite the diverse and far-reaching implications and consequences of meat production and consumption, the sociological debate on meat is rather new. At first sight this may be surprising since important aspects of meat production and consumption are addressed by classical sociological authors. Norbert Elias ([1939] 2000, p. 100),

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Österreich Z Soziol 46:109, 2021

Transition will not be easy

"The preparation and consumption of meat dishes is linked to cultural traditions and norms, collective and individual identities, as well as to gender relations and conceptions of health, purity, or naturalness."

Meat plays a central role in society

US SOY

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Transition and Maintenance Foods

Plant-based meat alternatives make the transition to a plant-based diet easier and make it easier to maintain one.

Plant-based Alternatives as Maintenance Foods

Do 84% Of Vegans And Vegetarians Really Go Back To Eating Meat?

BY DR. ALEX LOCKWOOD 7TH JANUARY 2019

18 MINUTES READ

Plant-based diet recidivism
(lots of former vegetarians)

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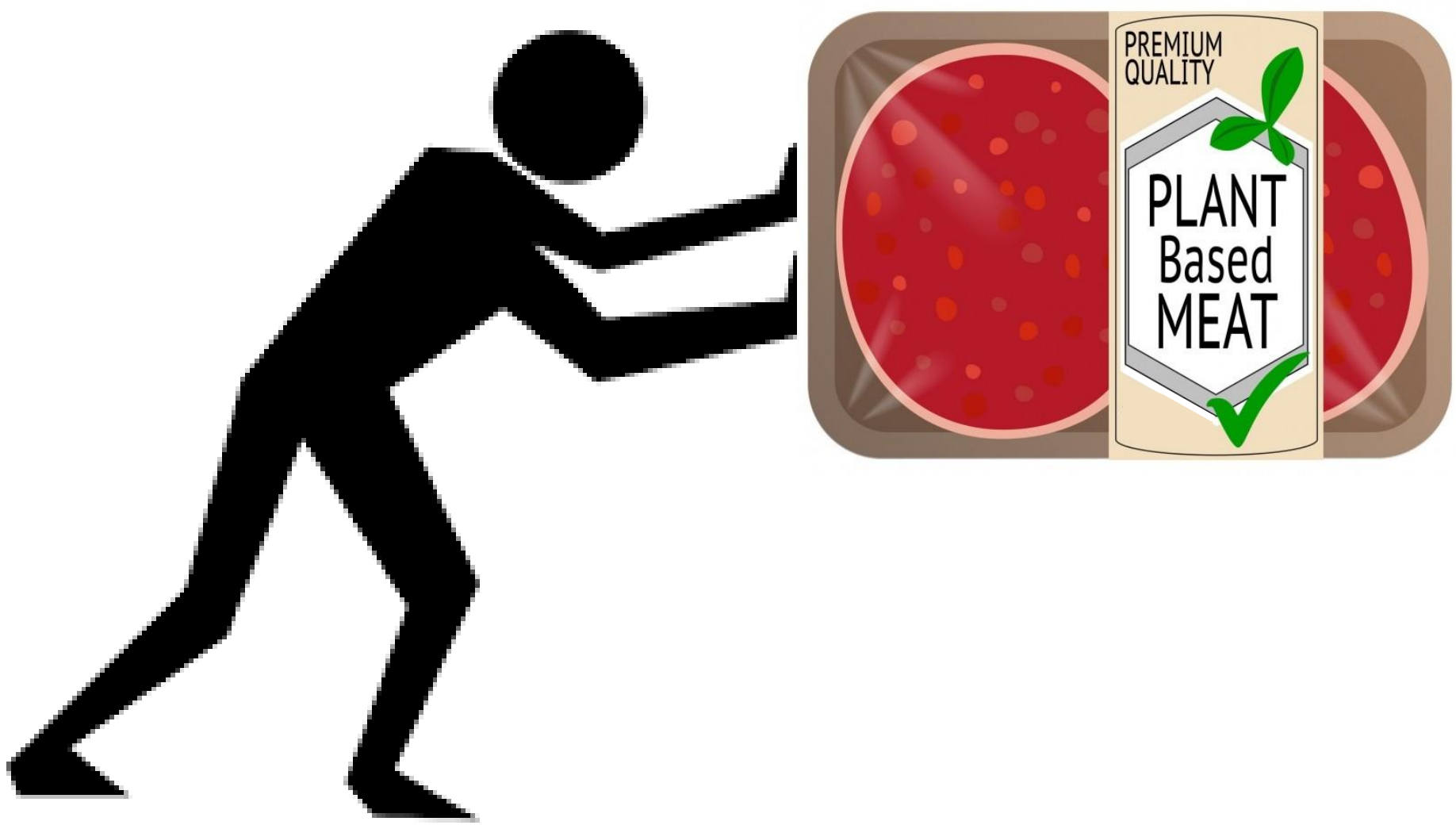
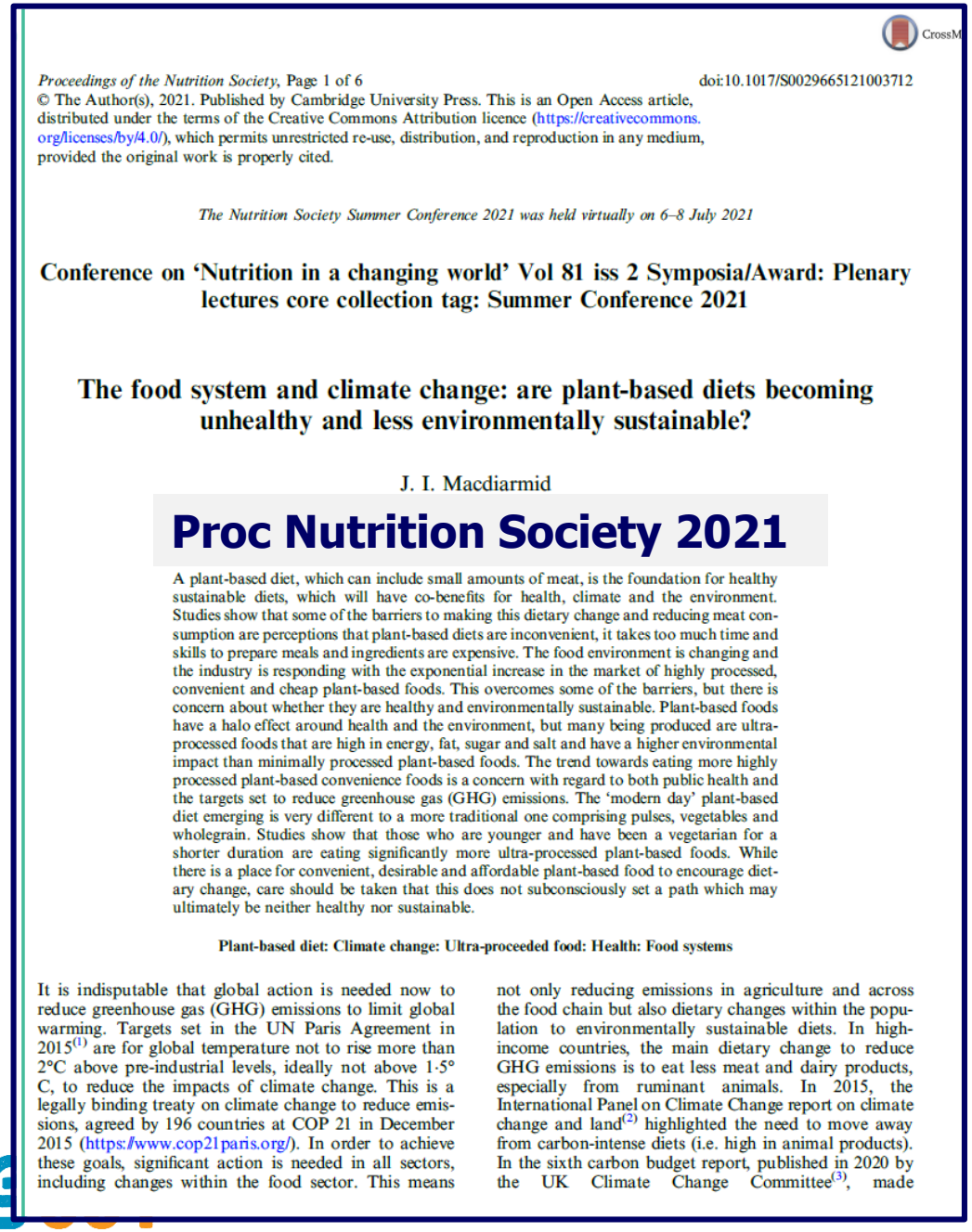

PREMIUM
QUALITY
PLANT
Based
MEAT



Proceedings of the Nutrition Society, Page 1 of 6 doi:10.1017/S0029665121003712

The Nutrition Society Summer Conference 2021 was held virtually on 6–8 July 2021

Conference on 'Nutrition in a changing world' Vol 81 iss 2 Symposia/Award: Plenary lectures core collection tag: Summer Conference 2021

The food system and climate change: are plant-based diets becoming unhealthy and less environmentally sustainable?

J. I. Macdiarmid

Proc Nutrition Society 2021

A plant-based diet, which can include small amounts of meat, is the foundation for healthy sustainable diets, which will have co-benefits for health, climate and the environment. Studies show that some of the barriers to making this dietary change and reducing meat consumption are perceptions that plant-based diets are inconvenient, it takes too much time and skills to prepare meals and ingredients are expensive. The food environment is changing and the industry is responding with the exponential increase in the market of highly processed, convenient and cheap plant-based foods. This overcomes some of the barriers, but there is concern about whether they are healthy and environmentally sustainable. Plant-based foods have a halo effect around health and the environment, but many being produced are ultra-processed foods that are high in energy, fat, sugar and salt and have a higher environmental impact than minimally processed plant-based foods. The trend towards eating more highly processed plant-based convenience foods is a concern with regard to both public health and the targets set to reduce greenhouse gas (GHG) emissions. The 'modern day' plant-based diet emerging is very different to a more traditional one comprising pulses, vegetables and wholegrain. Studies show that those who are younger and have been a vegetarian for a shorter duration are eating significantly more ultra-processed plant-based foods. While there is a place for convenient, desirable and affordable plant-based food to encourage dietary change, care should be taken that this does not subconsciously set a path which may ultimately be neither healthy nor sustainable.

Plant-based diet: Climate change: Ultra-proceeded food: Health: Food systems

It is indisputable that global action is needed now to reduce greenhouse gas (GHG) emissions to limit global warming. Targets set in the UN Paris Agreement in 2015[1] are for global temperature not to rise more than 2°C above pre-industrial levels, ideally not above 1·5° C, to reduce the impacts of climate change. This is a legally binding treaty on climate change to reduce emissions, agreed by 196 countries at COP 21 in December 2015 (https://www.cop21paris.org/). In order to achieve these goals, significant action is needed in all sectors, including changes within the food sector. This means not only reducing emissions in agriculture and across the food chain but also dietary changes within the population to environmentally sustainable diets. In high-income countries, the main dietary change to reduce GHG emissions is to eat less meat and dairy products, especially from ruminant animals. In 2015, the International Panel on Climate Change report on climate change and land[2] highlighted the need to move away from carbon-intense diets (i.e. high in animal products). In the sixth carbon budget report, published in 2020 by the UK Climate Change Committee[3], made

"There is a current trend towards eating more highly processed plant-based convenience foods, which is a concern with regard to both public health and achieving the targets of reducing GHG emissions."

SNI GLOBAL SOY NUTRITION INSTITUTE

Made using concentrated sources of plant protein (soy, pea, etc.)

US SOY

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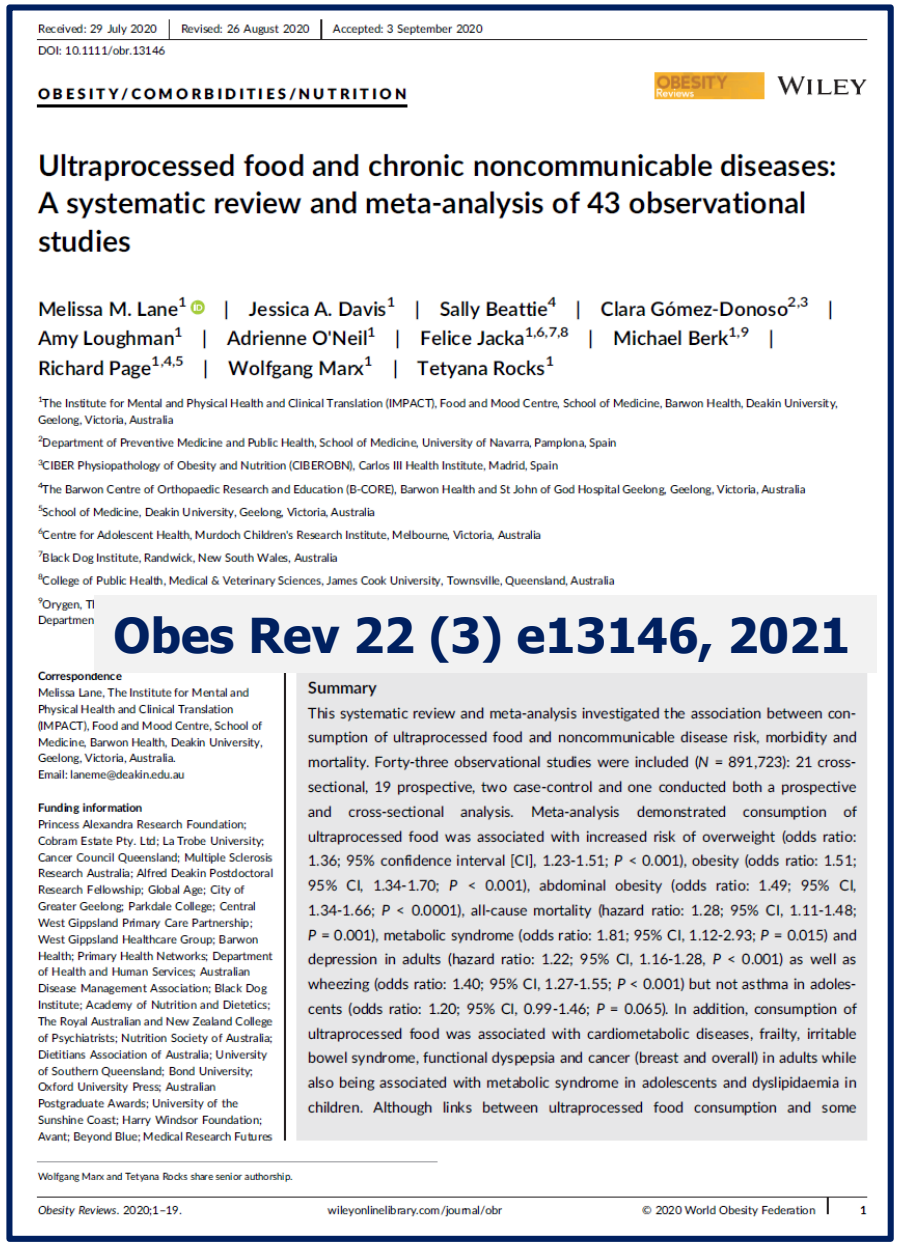

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DOI: 10.1111/obr.13146

OBESITY/COMORBIDITIES/NUTRITION

OBESITY Reviews WILEY

Ultraprocessed food and chronic noncommunicable diseases: A systematic review and meta-analysis of 43 observational studies

Melissa M. Lane[1] | Jessica A. Davis[1] | Sally Beattie[4] | Clara Gómez-Donoso[2,3] | Amy Loughman[1] | Adrienne O'Neil[1] | Felice Jacka[1,6,7,8] | Michael Berk[1,9] | Richard Page[1,4,5] | Wolfgang Marx[1] | Tetyana Rocks[1]

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Departmen

Obes Rev 22 (3) e13146, 2021

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Summary
This systematic review and meta-analysis investigated the association between consumption of ultraprocessed food and noncommunicable disease risk, morbidity and mortality. Forty-three observational studies were included (N = 891,723): 21 cross-sectional, 19 prospective, two case-control and one conducted both a prospective and cross-sectional analysis. Meta-analysis demonstrated consumption of ultraprocessed food was associated with increased risk of overweight (odds ratio: 1.36; 95% confidence interval [CI], 1.23-1.51; P < 0.001), obesity (odds ratio: 1.51; 95% CI, 1.34-1.70; P < 0.001), abdominal obesity (odds ratio: 1.49; 95% CI, 1.34-1.66; P < 0.0001), all-cause mortality (hazard ratio: 1.28; 95% CI, 1.11-1.48; P = 0.001), metabolic syndrome (odds ratio: 1.81; 95% CI, 1.12-2.93; P = 0.015) and depression in adults (hazard ratio: 1.22; 95% CI, 1.16-1.28, P < 0.001) as well as wheezing (odds ratio: 1.40; 95% CI, 1.27-1.55; P < 0.001) but not asthma in adolescents (odds ratio: 1.20; 95% CI, 0.99-1.46; P = 0.065). In addition, consumption of ultraprocessed food was associated with cardiometabolic diseases, frailty, irritable bowel syndrome, functional dyspepsia and cancer (breast and overall) in adults while also being associated with metabolic syndrome in adolescents and dyslipidaemia in children. Although links between ultraprocessed food consumption and some

Wolfgang Marx and Tetyana Rocks share senior authorship.

Meta-analysis Results

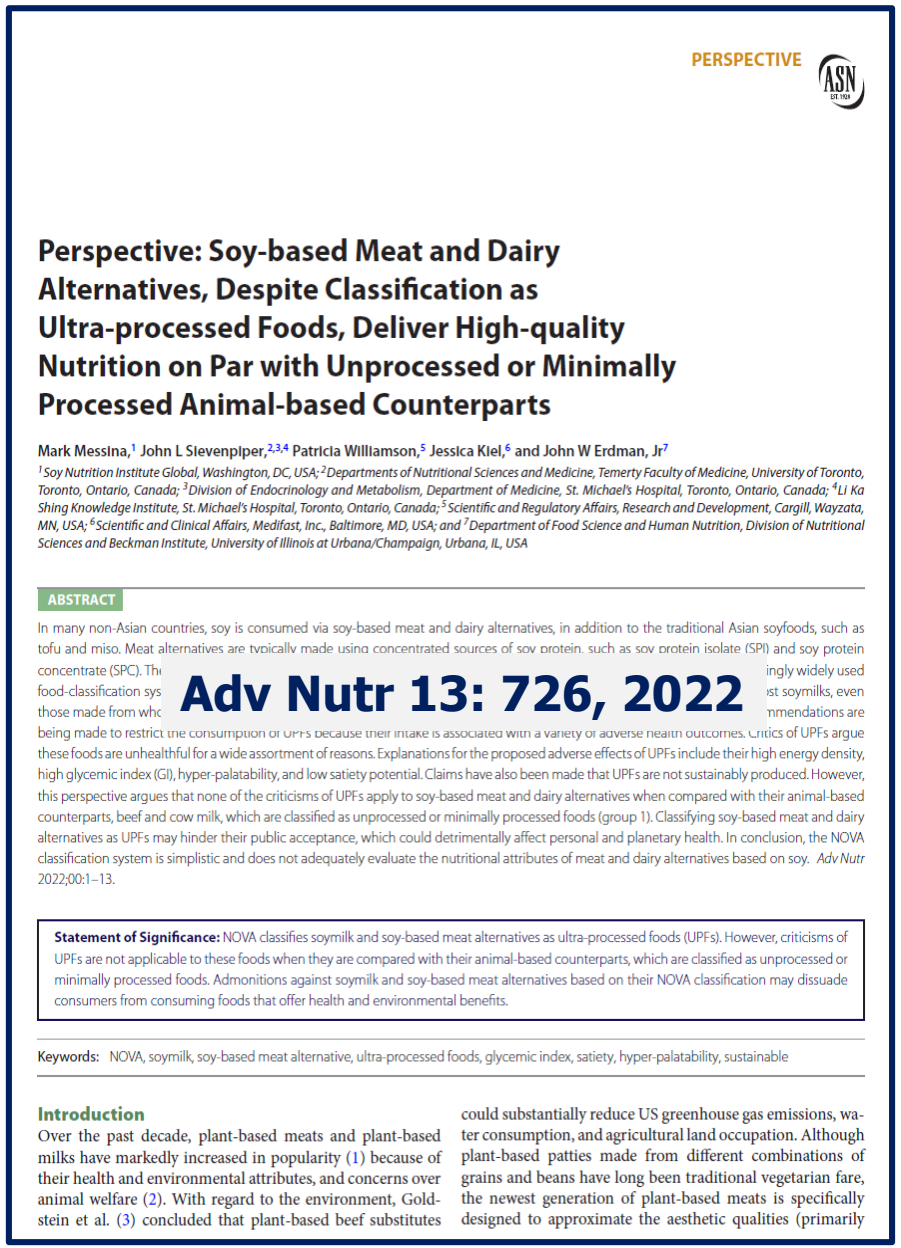
- 43 observational studies
- N = 891,723

UPF intake associated with risk of:

- Overweight
- Obesity
- All-cause mortality
- Metabolic syndrome
- Depression
- Wheezing
- Cardiometabolic diseases
- Frailty
- IBS
- Dyspepsia
- Cancer (overall)
- Breast cancer

US SOY

SNI SOY NUTRITION INSTITUTE GLOBAL



PERSPECTIVE

Perspective: Soy-based Meat and Dairy Alternatives, Despite Classification as Ultra-processed Foods, Deliver High-quality Nutrition on Par with Unprocessed or Minimally Processed Animal-based Counterparts

Mark Messina,[1] John L Sievenpiper,[2,3,4] Patricia Williamson,[5] Jessica Kiel,[6] and John W Erdman, Jr[7]

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ABSTRACT

In many non-Asian countries, soy is consumed via soy-based meat and dairy alternatives, in addition to the traditional Asian soyfoods, such as tofu and miso. Meat alternatives are typically made using concentrated sources of soy protein, such as soy protein isolate (SPI) and soy protein concentrate (SPC). The ingly widely used food-classification sys st soymilks, even those made from whc nmendations are being made to restrict the consumption of UPFs because their intake is associated with a variety of adverse health outcomes. Critics of UPFs argue these foods are unhealthful for a wide assortment of reasons. Explanations for the proposed adverse effects of UPFs include their high energy density, high glycemic index (GI), hyper-palatability, and low satiety potential. Claims have also been made that UPFs are not sustainably produced. However, this perspective argues that none of the criticisms of UPFs apply to soy-based meat and dairy alternatives when compared with their animal-based counterparts, beef and cow milk, which are classified as unprocessed or minimally processed foods (group 1). Classifying soy-based meat and dairy alternatives as UPFs may hinder their public acceptance, which could detrimentally affect personal and planetary health. In conclusion, the NOVA classification system is simplistic and does not adequately evaluate the nutritional attributes of meat and dairy alternatives based on soy. *Adv Nutr* 2022;00:1–13.

Adv Nutr 13: 726, 2022

Statement of Significance: NOVA classifies soymilk and soy-based meat alternatives as ultra-processed foods (UPFs). However, criticisms of UPFs are not applicable to these foods when they are compared with their animal-based counterparts, which are classified as unprocessed or minimally processed foods. Admonitions against soymilk and soy-based meat alternatives based on their NOVA classification may dissuade consumers from consuming foods that offer health and environmental benefits.

Keywords: NOVA, soymilk, soy-based meat alternative, ultra-processed foods, glycemic index, satiety, hyper-palatability, sustainable

Introduction

Over the past decade, plant-based meats and plant-based milks have markedly increased in popularity (1) because of their health and environmental attributes, and concerns over animal welfare (2). With regard to the environment, Goldstein et al. (3) concluded that plant-based beef substitutes could substantially reduce US greenhouse gas emissions, water consumption, and agricultural land occupation. Although plant-based patties made from different combinations of grains and beans have long been traditional vegetarian fare, the newest generation of plant-based meats is specifically designed to approximate the aesthetic qualities (primarily

None of the criticisms of ultra-processed foods apply to soy-based meat and dairy alternatives more than they do to their animal-based counterparts

Criticisms addressed

- ↑ palatability
- ↑ energy density
- ↑ eating rate
- ↑ energy intake rate
- ↓ satiety
- ↓ cost
- ↑ snackability, convenience
- ↑ glycemic index (milk only)

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Article

Plant-Based Meat Substitutes in the Flexitarian Age: An Audit of Products on Supermarket Shelves

Felicity Curtain [1,*] and Sara Grafenauer [1,2]

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Abstract: Demand for plant-based meat substitutes is growing globally for nutritional and environmental reasons, with Australia the third-fastest growing vegan market worldwide. This study aimed to profile and compare plant-based meat substitutes (mimicking meat) with equivalent meat products, and 2015 data. An audit undertaken in May (updated in September 2019) from four metropolitan Sydney supermarkets (Coles, Woolworths, Aldi, IGA), collected nutrition information and Health Star Rating (HSR) from 137 products (50 burgers, 10 mince, 29 sausages, 24 chicken, 9 seafood, 15 other). Mean (± standard deviation (SD)) and median (range) was calculated for nutrients a…turated fat, higher in c…ts were low in sodium …ith vitamin B12, 20% with iron, and 18% with zinc. HSR featured on 46% (3.6–4.4 stars). On-pack claims were vegetarian/vegan/plant-based (80%), protein (63%), non-genetically modified/organic (34%), gluten free (28%). Product numbers increased five-fold (↑429%) in four years. The plant protein trend has prompted innovation in meat substitutes, however wide nutrient ranges and higher sodium levels highlights the importance of nutrition guidelines in their development to ensure equivalence with animal-based proteins.

Keywords: meat substitute; meat alternative; plant protein; sustainability; flexitarian; vegetarian; vegan

Nutrients 2019, 11, 2603

1. Introduction

Food choice is strongly linked with human health and the health of our environment, with excessive meat consumption often viewed as detrimental for both factors [1]. Globally, agriculture and food production is responsible for more than 25% of all greenhouse gas (GHG) emissions [1], with effects widely varied based on food-type. It is well-accepted that animal-based foods have a greater environmental impact that plant-based foods, emitting more GHG, requiring more land and nitrogen, and impacting terrestrial and aquatic biodiversity [2]. Ruminant meats (beef and lamb) are considered of greater consequence than eggs, seafood, poultry, and pork [3] and global meat consumption has increased 58% over the past 20 years to 2018. Consumption, now at 360 million tonnes is accounted for through population growth (54%), and the remainder is due to increased consumption, which is expected to increase further [4,5].

Suboptimal diets are responsible for more deaths than any other risk factors globally, including tobacco smoking, causing an estimated 11 million deaths and 255 million disability-adjusted life years [6]. Worldwide, intake of red meat surpasses what is considered optimal by 18% (led by Australasia, southern, and tropical Latin America), and consumption of processed meat is 90% greater than the optimal amount (led by North America, Asia Pacific, and western Europe) [6]. However, compared to other dietary risks, high intake of red and processed meat ranked at the bottom end

Plant burger (N=50): 3.9

Meat burger: 2.9

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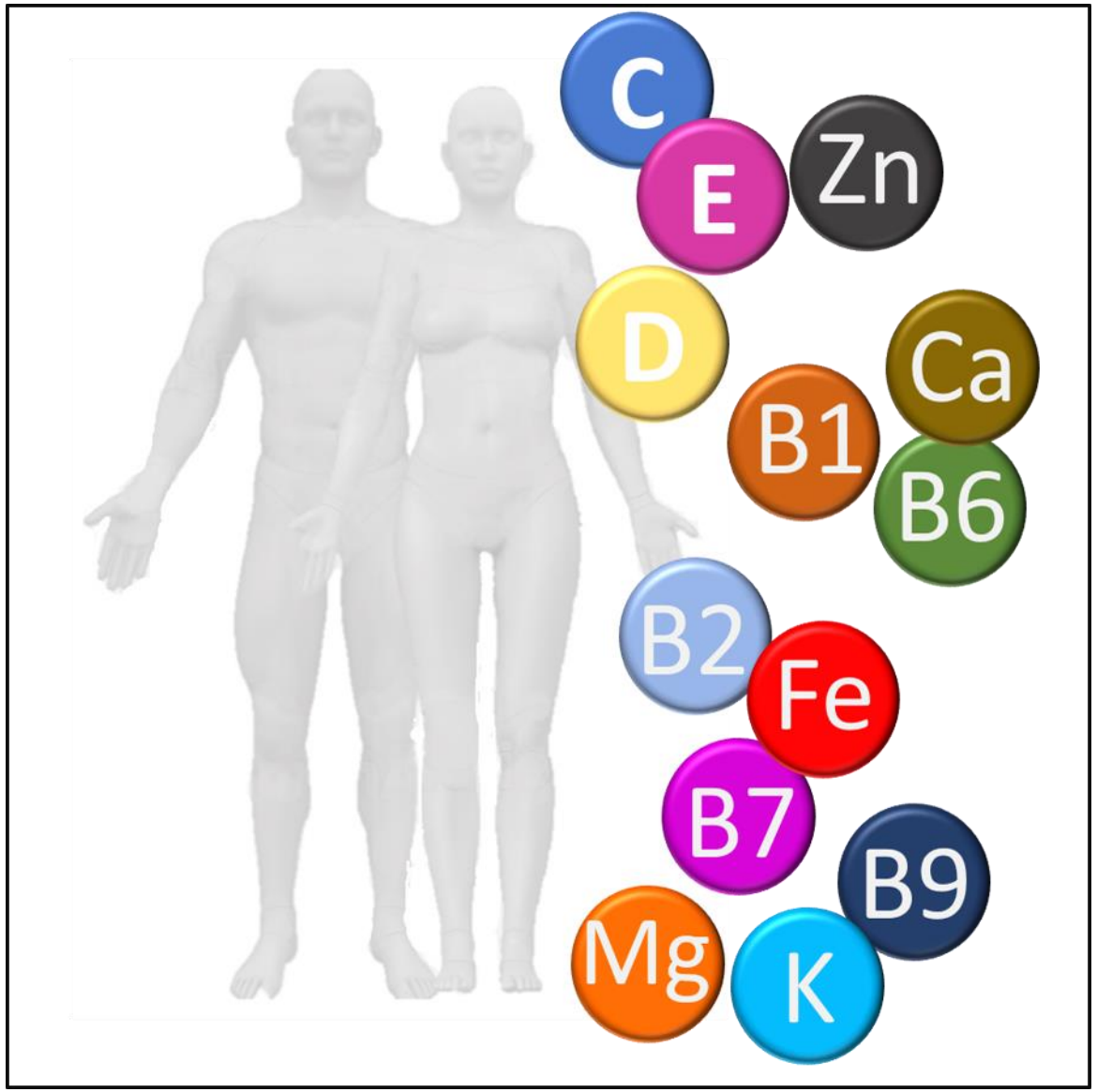
Relevant Questions

- **How do plant-based alternatives compare nutritionally to meat?**
- **How do plant-based alternatives compare nutritionally to legumes?**

Relevant Questions

How do plant-based alternatives compare nutritionally to meat?

How do plant-based alternatives compare nutritionally to legumes?



Less about protein, and more about the micronutrients provided by animal products

Contribution of Beef to the Energy and Nutrient Intake of Adults Age 19+

Nutrient	Percent
Energy	5.4
Zinc	21
Vitamin B12	20
Protein	14
Choline	11
Niacin	9.4
Vitamin B6	8.3
Iron	7.6
Phosphorus	6.8
Potassium	5.6
Magnesium	3.0

2011-18

nhanes

National Health and Nutrition Examination Survey

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Agarwal & Fulgoni III; Nutr Res 2022

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Journal Pre-proof

Contribution of beef to key nutrient intakes in American adults: an updated analysis with NHANES 2011-2018

Sanjiv Agarwal , Victor L Fulgoni III

PII: S0271-5317(22)00063-X
DOI: https://doi.org/10.1016/j.nutres.2022.06.009
Reference: NTR 8337

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Agarwal & Fulgoni III; Nutr Res 2022

" … if beef is eliminated from dietary recommendations efforts need to be made to replace nutrients provided by beef …"

2011-18

nhanes

National Health and Nutrition Examination Survey

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Notable Nutrients provided by Beef and/or Dairy

- Protein
- Calcium
- Iron
- Zinc
- Phosphorus
- Magnesium
- Vitamin B12
- Vitamin A[1]
- Vitamin D[1]
- Choline
- Niacin
- Vitamin B6

Shortfall Nutrients in Vegan Diets

- Zinc
- Vitamin B12
- Calcium
- Protein[2]
- Vitamin B6[2]
- Choline[2]
- Iron[2]
- Vitamin A[2]

[1]Due to fortification [2]Conditional

Shift toward a plant-based diet, not a vegan diet

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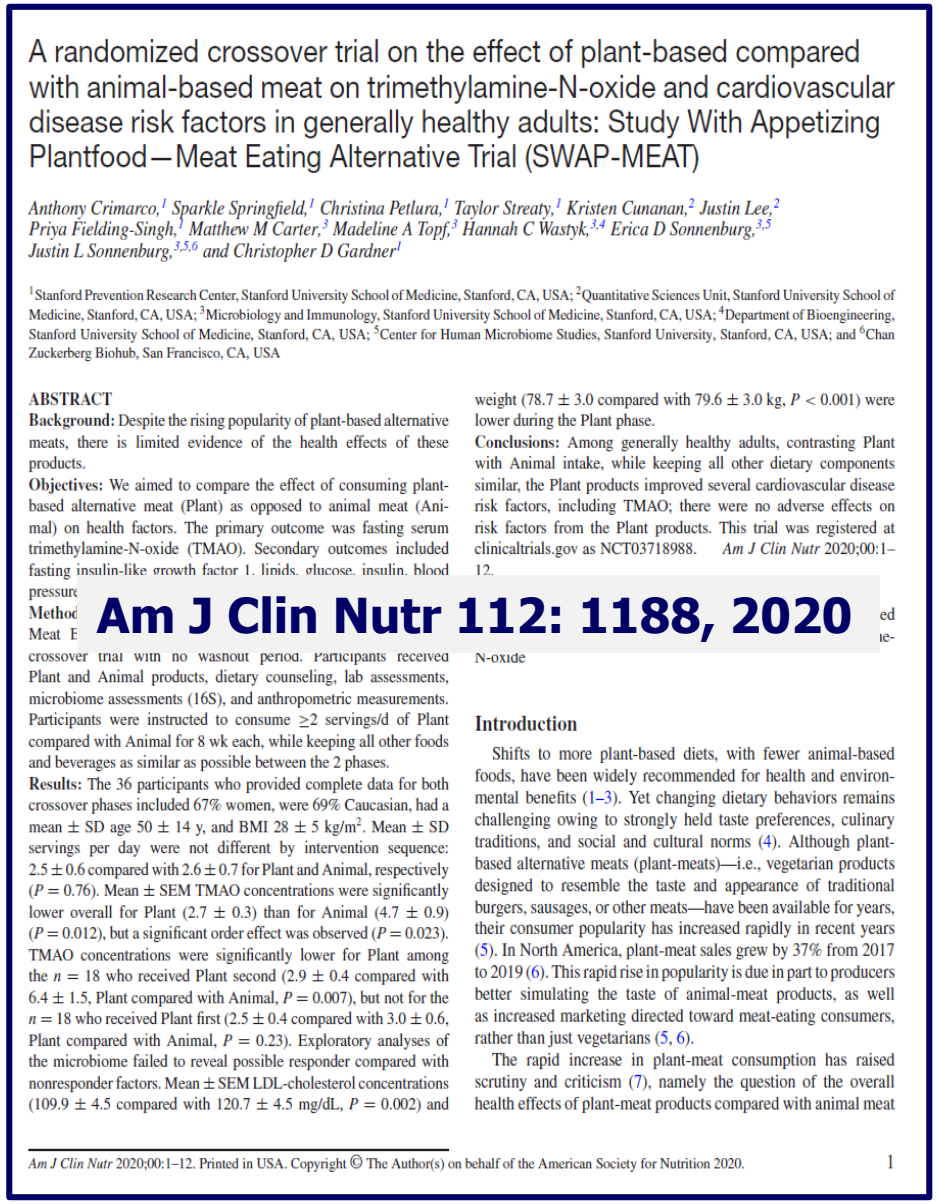
Relevant Questions

How do plant-based alternatives compare nutritionally to meat?

How do plant-based alternatives compare nutritionally to legumes?



A randomized crossover trial on the effect of plant-based compared with animal-based meat on trimethylamine-N-oxide and cardiovascular disease risk factors in generally healthy adults: Study With Appetizing Plantfood—Meat Eating Alternative Trial (SWAP-MEAT)

Anthony Crimarco,[1] Sparkle Springfield,[1] Christina Petlura,[1] Taylor Streaty,[1] Kristen Cunanan,[2] Justin Lee,[2] Priya Fielding-Singh,[1] Matthew M Carter,[3] Madeline A Topf,[3] Hannah C Wastyk,[3,4] Erica D Sonnenburg,[3,5] Justin L Sonnenburg,[3,5,6] and Christopher D Gardner[1]

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ABSTRACT

Background: Despite the rising popularity of plant-based alternative meats, there is limited evidence of the health effects of these products.

Objectives: We aimed to compare the effect of consuming plant-based alternative meat (Plant) as opposed to animal meat (Animal) on health factors. The primary outcome was fasting serum trimethylamine-N-oxide (TMAO). Secondary outcomes included fasting insulin-like growth factor 1, lipids, glucose, insulin, blood pressure

Method Meat E crossover trial with no washout period. Participants received Plant and Animal products, dietary counseling, lab assessments, microbiome assessments (16S), and anthropometric measurements. Participants were instructed to consume ≥2 servings/d of Plant compared with Animal for 8 wk each, while keeping all other foods and beverages as similar as possible between the 2 phases.

Results: The 36 participants who provided complete data for both crossover phases included 67% women, were 69% Caucasian, had a mean ± SD age 50 ± 14 y, and BMI 28 ± 5 kg/m^2. Mean ± SD servings per day were not different by intervention sequence: 2.5 ± 0.6 compared with 2.6 ± 0.7 for Plant and Animal, respectively ($P = 0.76$). Mean ± SEM TMAO concentrations were significantly lower overall for Plant (2.7 ± 0.3) than for Animal (4.7 ± 0.9) ($P = 0.012$), but a significant order effect was observed ($P = 0.023$). TMAO concentrations were significantly lower for Plant among the $n = 18$ who received Plant second (2.9 ± 0.4 compared with 6.4 ± 1.5, Plant compared with Animal, $P = 0.007$), but not for the $n = 18$ who received Plant first (2.5 ± 0.4 compared with 3.0 ± 0.6, Plant compared with Animal, $P = 0.23$). Exploratory analyses of the microbiome failed to reveal possible responder compared with nonresponder factors. Mean ± SEM LDL-cholesterol concentrations (109.9 ± 4.5 compared with 120.7 ± 4.5 mg/dL, $P = 0.002$) and weight (78.7 ± 3.0 compared with 79.6 ± 3.0 kg, $P < 0.001$) were lower during the Plant phase.

Conclusions: Among generally healthy adults, contrasting Plant with Animal intake, while keeping all other dietary components similar, the Plant products improved several cardiovascular disease risk factors, including TMAO; there were no adverse effects on risk factors from the Plant products. This trial was registered at clinicaltrials.gov as NCT03718988. *Am J Clin Nutr* 2020;00:1–12.

Am J Clin Nutr 112: 1188, 2020

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N-oxide

Introduction

Shifts to more plant-based diets, with fewer animal-based foods, have been widely recommended for health and environmental benefits (1–3). Yet changing dietary behaviors remains challenging owing to strongly held taste preferences, culinary traditions, and social and cultural norms (4). Although plant-based alternative meats (plant-meats)—i.e., vegetarian products designed to resemble the taste and appearance of traditional burgers, sausages, or other meats—have been available for years, their consumer popularity has increased rapidly in recent years (5). In North America, plant-meat sales grew by 37% from 2017 to 2019 (6). This rapid rise in popularity is due in part to producers better simulating the taste of animal-meat products, as well as increased marketing directed toward meat-eating consumers, rather than just vegetarians (5, 6).

The rapid increase in plant-meat consumption has raised scrutiny and criticism (7), namely the question of the overall health effects of plant-meat products compared with animal meat

Study with Appetizing Plantfood-Meat Eating Alternative Trial (SWAP-MEAT)

"This study found several beneficial effects and no adverse effects from the consumption of plant-based meats."

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Plant products	Animal products
Burger[1]	Burger
Beef crumbles[1]	Ground beef
Breakfast sausage[1]	Good morning pork breakfast sausage
Hot Italian sausage[1]	Hot Italian sausage
Brat sausage[1]	Pork bratwurst
Grilled chicken strips[2]	Chicken breast
Lightly seasoned chicken strips[2]	Chicken breast

(SWAP-MEAT)

Study Products Provided ≈25% of Total Calories and ≈50% of Total Protein

[1]Pea protein based [2]Soy protein-pea protein based.
AJCN 112: 1188, 2020. Cross-over design, 8 wk/phase

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Effects of Consuming ≈2.5 Servings Daily of Plant-based vs Meat-based Products on Selected Outcomes[1]

Outcome	Animal	Plant
TMAO (uM)[2]	4.7 ± 0.9	2.7 ± 0.3
LDL-C (mg/dL)	120.7 ± 4.5	109.9 ± 4.5
Weight (kg)	79.6 ± 3.0	78.7 ± 3.0

- N = 36 ± 14
- Age: 50 ± 14
- Cross-over
- 8 weeks per phase

[1]Final values, mean ± SEM [2]Trimethylamine oxide

All values statistically significant

No effects on IGF-1, insulin, glucose, HDL, TG, BP

AJCN 112: 1188, 2020

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Impact of Plant-Based Meat Alternatives on the Gut Microbiota of Consumers: A Real-World Study

Miguel A. Toribio-Mateas [1,2,*], Adri Bester [1] and Natalia Klimenko [3,4]

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2 School of Health and Education, Middlesex University, London SE1 0AA, UK
3 Center for Precision Genome Editing and Genetic Technologies for Biomedicine, Institute of Gene Biology, Russian Academy of Sciences, 119334 Moscow, Russia; lklimenko@genebiology.ru
4 Research and Development Department, Knomics LLC, Skolkovo Innovation Center, 121205 Moscow, Russia
* Correspondence: toribiom@lsbu.ac.uk

Abstract: Eating less meat is increasingly seen as a healthier, more ethical option. This is leading to growing numbers of flexitarian consumers looking for plant-based meat alternatives (PBMAs) to replace at least some of the animal meat they consume. Popular PBMA products amongst flexitarians, including plant-based mince, burgers, sausages and meatballs, are often perceived as low-quality, ultra-processed foods. However, we argue that the mere industrial processing of ingredients of plant origin does not make a PBMA product ultra-processed by default. To test our hypothesis, we conducted a randomised controlled trial to assess the changes to the gut microbiota of a group of ...with PBMA ...ol samples ...positionality-aware manner, using a range of innovative bioinformatic methods. Noteworthy changes included an increase in butyrate metabolising potential—chiefly in the 4-aminobutyrate/succinate and glutarate pathways—and in the joint abundance of butyrate-producing taxa in the intervention group compared to control. We also observed a decrease in the Tenericutes phylum in the intervention group and an increase in the control group. Based on our findings, we concluded that the occasional replacement of animal meat with PBMA products seen in flexitarian dietary patterns can promote positive changes in the gut microbiome of consumers.

Foods 2021, 10, 2040

check for updates

Citation: Toribio-Mateas, M.A.; Bester, A.; Klimenko, N. Impact of Plant-Based Meat Alternatives on the Gut Microbiota of Consumers: A Real-World Study. *Foods* **2021**, *10*, 2040. https://doi.org/10.3390/foods10092040

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Keywords: gut microbiome; gut microbiota; plant-based meat alternatives; flexitarian; flexitarianism; plant-based diets; meat alternatives; meat substitutes; plant protein; ultra-processed foods

1. Introduction

Demand for plant-based products is growing globally, led by increasing public knowledge of the extent to which our food choices affect human health. Researchers continue to unveil the strong links that exist between excessive meat consumption and the pathogenesis of non-communicable diseases such as obesity [1,2], type-2-diabetes [3–5], cardiovascular disease [6] and some forms of cancer [7,8]. Conversely, there is mounting evidence that diets characterised by a higher consumption of plant-based foods promote health and reduce the risk of a number of chronic conditions [9,10], and that high fibre and polyphenol content of plant-based diets promotes the changes in gut microbiota composition that mediate these positive health outcomes [11–15].

Recent research suggests that health- and environment-conscious flexitarians are more likely to incorporate animal-free foodstuffs—including plant-based meat alternatives—into their diets [16–18]. Research also shows that flexitarians, in addition to vegetarians and vegans, are more attracted to plant-based meat foods that imitate processed meat products, such as burgers, meatballs or sausages, than to those that imitate unprocessed meats, e.g., steak [19]. Additionally, dietary pattern analysis of consumers of plant-based foods has

" … the occasional* replacement of animal meat with PBMA [plant-based meat alternative] products seen in flexitarian dietary patterns can promote positive changes in the gut microbiome …"

***Approximately 5x/wk, mostly made using pea protein**

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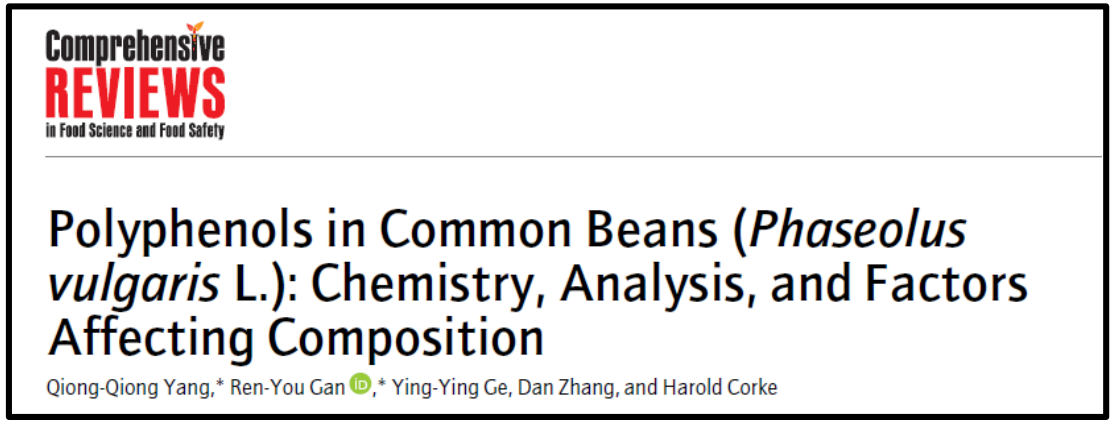
Relevant Questions

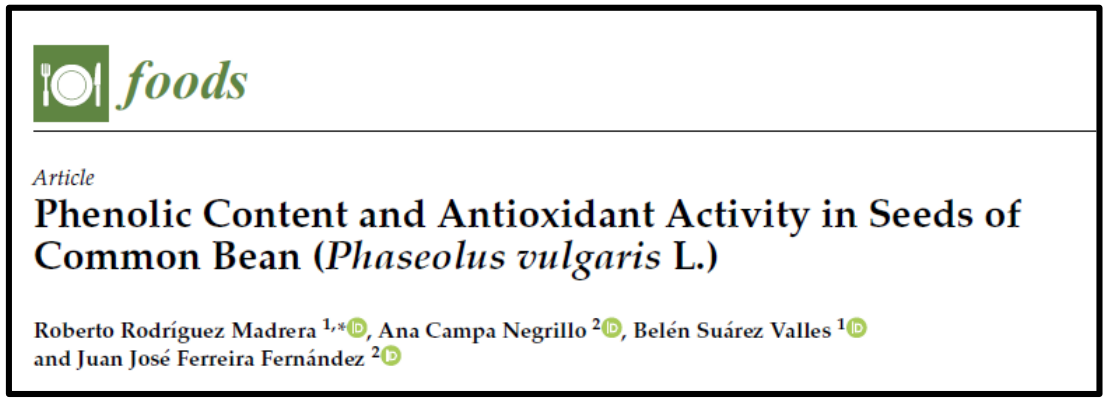
How do plant-based alternatives compare nutritionally to meat?

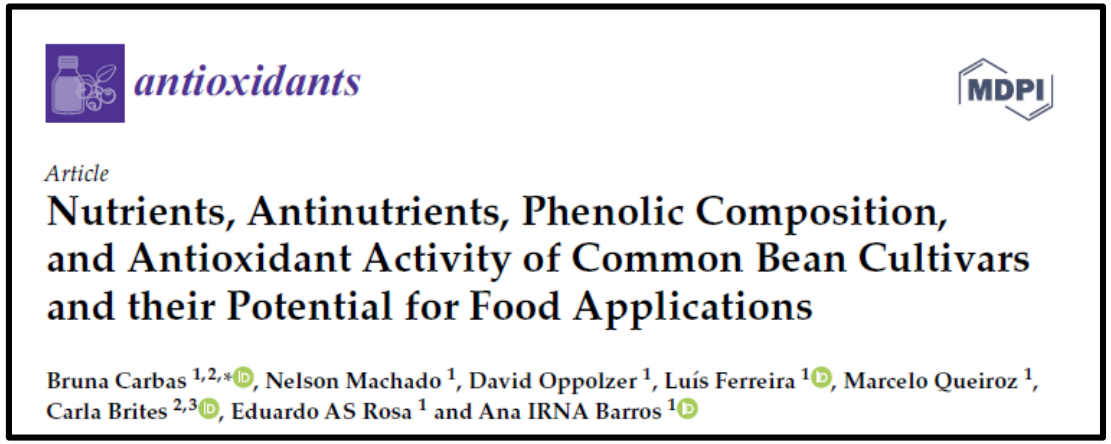
How do plant-based alternatives compare nutritionally to legumes?

Beans provide:

- Protein
- Fiber
- B vitamins
- Iron
- Potassium







Bean phenolics

- Chlorogenic acid
- Gallic acid
- p-hydroxy benzoic acid
- Caffeic acid
- Protocatechuic acid
- p-coumaric acid
- Rosmarinic acid
- Ferulic acid,
- Sinapic acid
- Ellagic acid
- Ellagic acid
- Epicatechin
- Catechin
- Gallocatechin gallate
- Epigallocatechin
- Gallate
- Quercetin
- Hesperidin
- Rutin

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Systematic Review

Do Common Beans (*Phaseolus vulgaris* L.) Promote Good Health in Humans? A Systematic Review and Meta-Analysis of Clinical and Randomized Controlled Trials

Eileen Bogweh Nchanji * and Odhiambo Collins Ageyo †

Dietary legume consumption reduces risk of colorectal cancer: evidence from a meta-analysis of cohort studies

Beibei Zhu[1]*, Yu Sun[1]*, Lu Qi[2], Rong Zhong[1] & Xiaoping Miao[1]

Relationship between legume consumption and metabolic syndrome: A systematic review and meta-analysis of observational studies

Yu-Ting Jiang [a,b], Jia-Yu Zhang [a,b], Ya-Shu Liu [a,b], Qing Chang [a,b], Yu-Hong Zhao [a,b], Qi-Jun Wu [a,b,*]

High Dry Bean Intake and Reduced Risk of Advanced Colorectal Adenoma Recurrence among Participants in the Polyp Prevention Trial

Elaine Lanza*,2, Terryl J. Hartman†, Paul S. Albert**, Rusty Shields‡, Martha Slattery††, Bette Caan‡‡, Electra Paskett#, Frank Iber§, James Walter Kikendall¶, Peter Lance##, Cassandra Daston§§, and Arthur Schatzkin¶¶,1

Pulse consumption improves indices of glycemic control in adults with and without type 2 diabetes: a systematic review and meta-analysis of acute and long-term randomized controlled trials

Maryam S. Hafiz[1,2] · Matthew D. Campbell[3,4,5] · Lauren L. O'Mahoney[6] · Melvin Holmes[1] · Caroline Orfila[1] · Christine Boesch[1]

Review Article

Legume Consumption and All-Cause and Cardiovascular Disease Mortality

Hua Li,[1] Jinmeng Li,[2] Yegen Shen,[1] Jie Wang,[1] and Depu Zhou[1]

Effects of dietary pulse consumption on body weight: a systematic review and meta-analysis of randomized controlled trials[1–3]

Shana J Kim,[4,7] Russell J de Souza,[4,7,10] Vivian L Choo,[4,7] Vanessa Ha,[4,7,10] Adrian I Cozma,[4,5,7] Laura Chiavaroli,[4,7] Arash Mirrahimi,[4,7,11] Sonia Blanco Mejia,[4,7] Marco Di Buono,[4,12] Adam M Bernstein,[13,14] Lawrence A Leiter,[4,5,7–9] Penny M Kris-Etherton,[15] Vladimir Vuksan,[4,5,7–9] Joseph Beyene,[6,10] Cyril WC Kendall,[4,7,16] David JA Jenkins,[4,5,7–9] and John L Sievenpiper[4,7–9]*

Phaseolus beans: impact on glycaemic response and chronic disease risk in human subjects

Andrea M. Hutchins[1]*, Donna M. Winham[2] and Sharon V. Thompson[3]

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Plant-based meat alternatives have the potential to be fortified with shortfall nutrients in plant-based diets and can be tailored to specific populations

Fortificants added to one popular soy-based meat alternative

- Zinc
- Iron
- Thiamin
- Niacin
- Vitamin B2
- Vitamin B6
- Vitamin B12

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True Fecal Digestibility in Humans of Soy Protein

Source (% En protein)	Percent
Soybeans (42)	78
Soy protein concentrate (65)	86
Soy protein isolate (90)	95

Gilani et al. JAOAC Int 2005; 88:967-87

Potential to eliminate some compounds in legumes that may be objectionable to some consumers – such as oligosaccharides which may cause flatulence.

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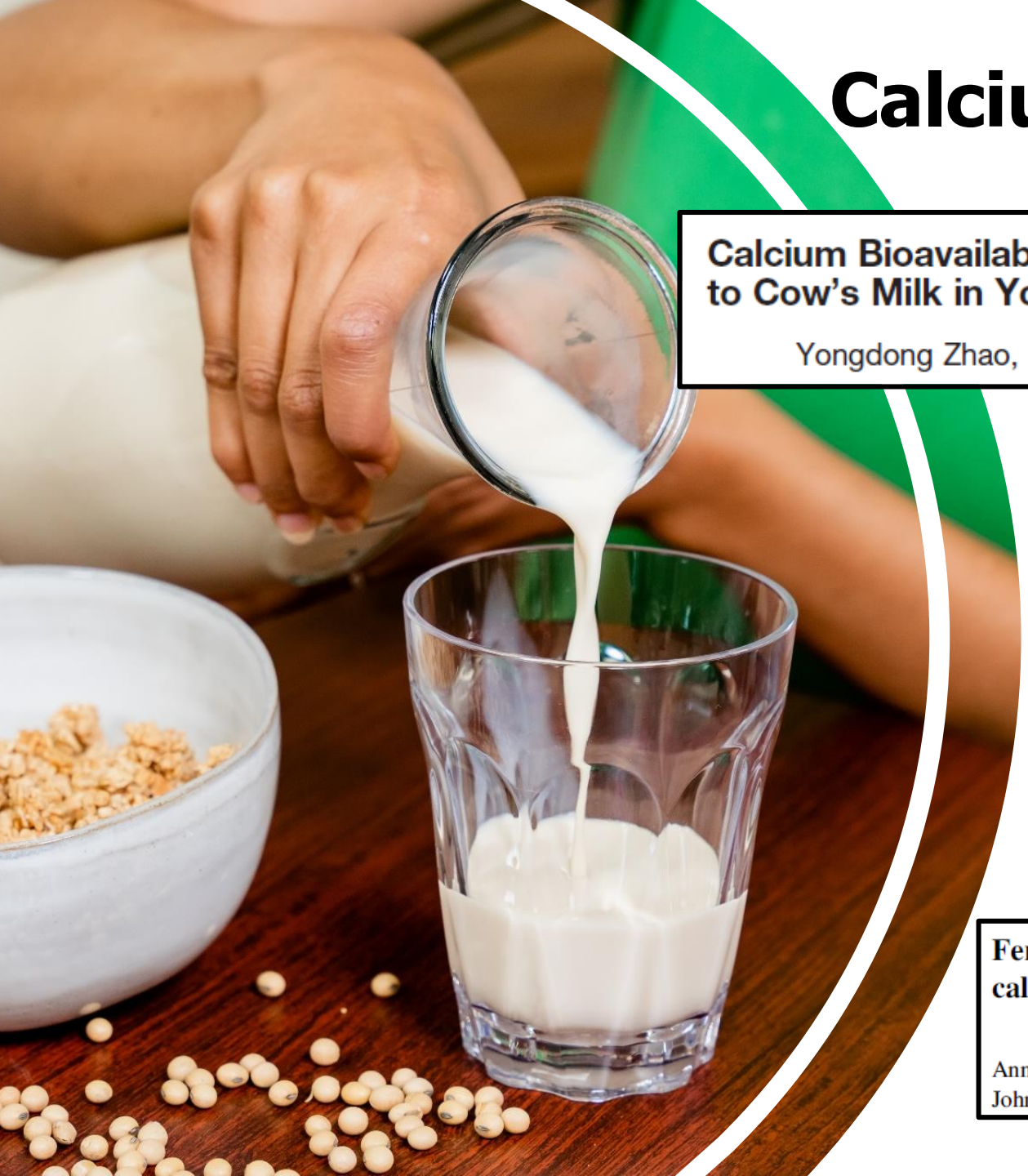
Research Opportunities

Need data on the bioavailability of nutrients in plant-based meat and dairy alternatives



Calcium Bioavailability from Soy

Calcium Bioavailability of Calcium Carbonate Fortified Soymilk Is Equivalent to Cow's Milk in Young Women[1,2]

Yongdong Zhao, Berdine R. Martin, and Connie M. Weaver[3]

Bioavailability of Calcium from Tofu as Compared with Milk in Premenopausal Women

C.M. Weaver, R.P. Heaney, L. Connor, B.R. Martin, D.L. Smith, and S. Nielsen

Calcium absorption in Australian osteopenic post-menopausal women: an acute comparative study of fortified soymilk to cows' milk

Anne Lise Tang BSc(Hons)[1], Karen Z Walker PhD[2], Gisela Wilcox MD[3], Boyd J Strauss MD[3], John F Ashton PhD[4], Lily Stojanovska PhD[1]

Fermentation of calcium-fortified soya milk does not appear to enhance acute calcium absorption in osteopenic post-menopausal women

Anne Lise Tang Fook Cheung[1], Gisela Wilcox[1,2], Karen Z. Walker[3], Nagendra P. Shah[1], Boyd Strauss[2], John F. Ashton[4] and Lily Stojanovska[1]*

Modified SWAP-MEAT

(Study With Appetizing Plantfood-Meat Eating Alternative Trial)

Plant-based meat alternatives vs legumes

Plant-Based Alternatives as Transition and Maintenance Foods

Summary

- Global protein needs will increase substantially by 2050
- Necessary shift in the direction of a plant-based diet
- Legumes are good sources of protein but are likely to play only a minor role in this shift
- Plant-based meat alternatives that emulate the orosensory properties of meat may gain mass appeal
- Through fortification alternatives can compare nutritionally with animal products

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Thank You

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