

Mycoprotein: The Food for the Future?

Andy T. Kusumo PhD
Director of Science and Technology
MONDE NISSIN SINGAPORE PTE LTD



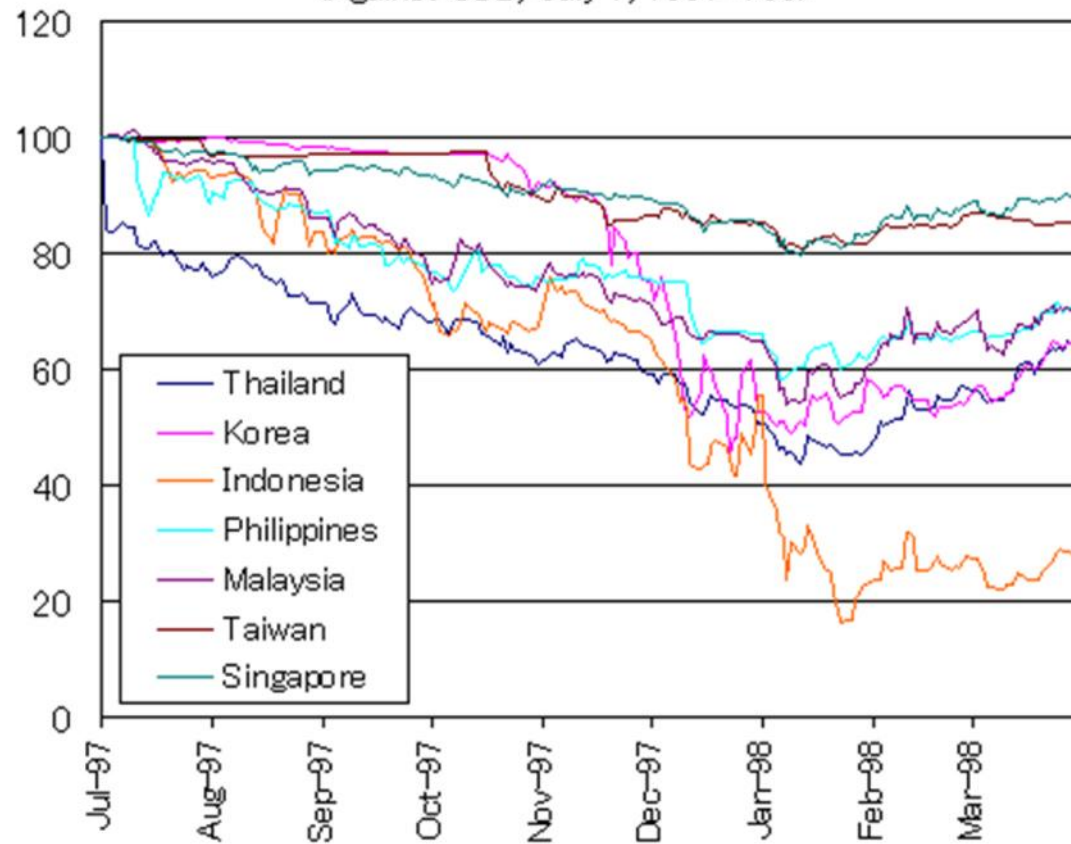


TIME^{and} CHANCE

WWW.SWEETTEATRADITIONS.COM

1998

Collapsing Currencies
(Against USD; July 1, 1997=100)



Time and chance



1998



PURDUE
UNIVERSITY

BSc in Chem. Eng.



Cornell University

Master of Engineering in ChE (Bioeng.)



PhD in ChE



Pharmaceutical

AMGEN

Biopharmaceutical



Monde Nissin

Food / Biotechnology

2015

Serving sustainability worldwide

In October 2015, Monde Nissin purchased the Quorn Foods business. I am incredibly proud of this. The vision of Monde Nissin is to build a business respectful of our planet as well as contributing to improved public health and food security. Quorn will play a big part in this journey. We want to increase availability of Quorn products around the world, investing in further improving their outstanding sustainable qualities.

We are confident that by making meat reduction easier for consumers, there will be a continual shift toward healthier options especially in countries where consumption levels are unsustainable. In essence, we're passionate about bringing leadership and commitment to the sustainable food community.

Henry Soesanto, CEO Monde Nissin Corporation



Today

1. Humankind: Our Food
journey

2. Mycoprotein Story

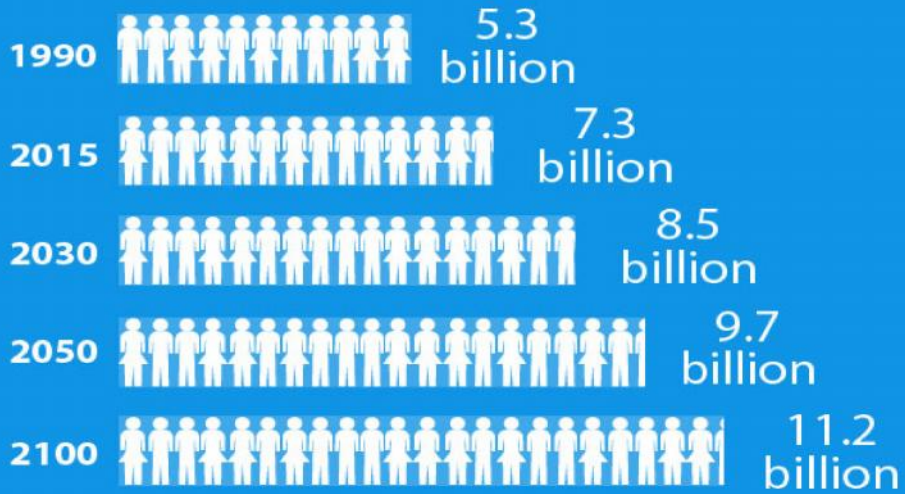
3. Our Future

Humankind: Our Food Journey

Population and GDP

World Population

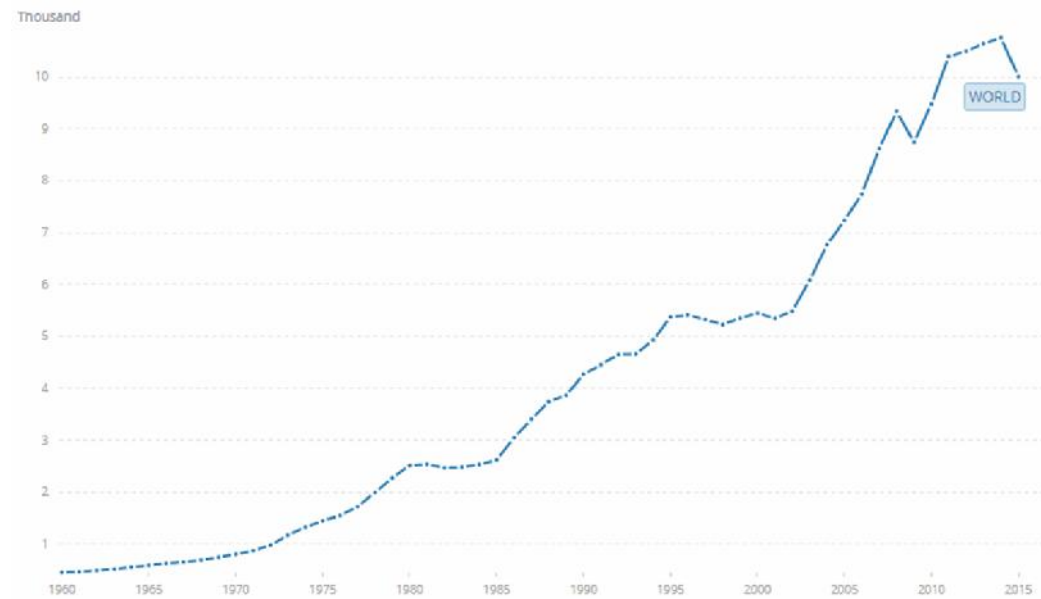
Projected world population until 2100



Source: United Nations Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2015 Revision*
Produced by: United Nations Department of Public Information

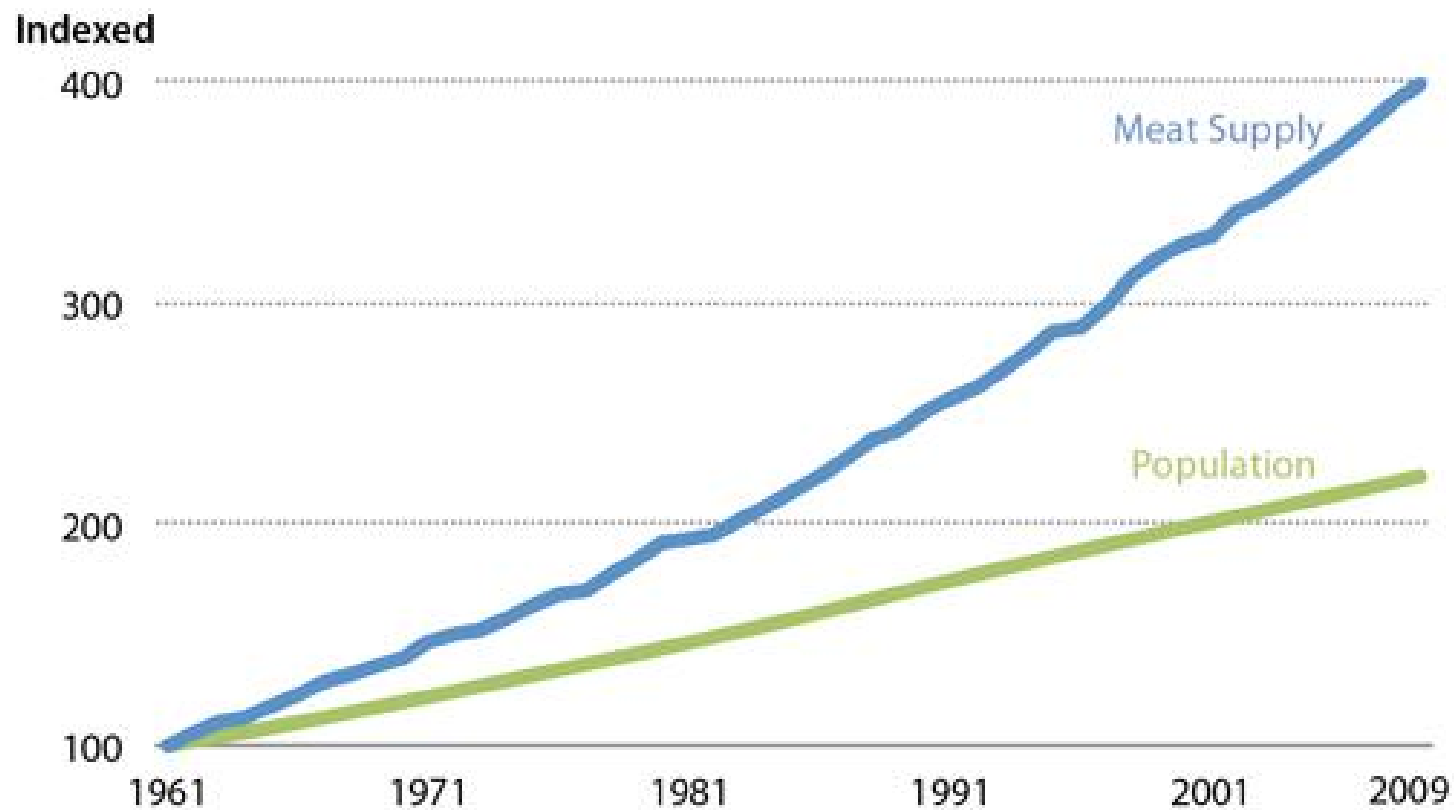


World GDP Per Capita



Data Source: The World Bank

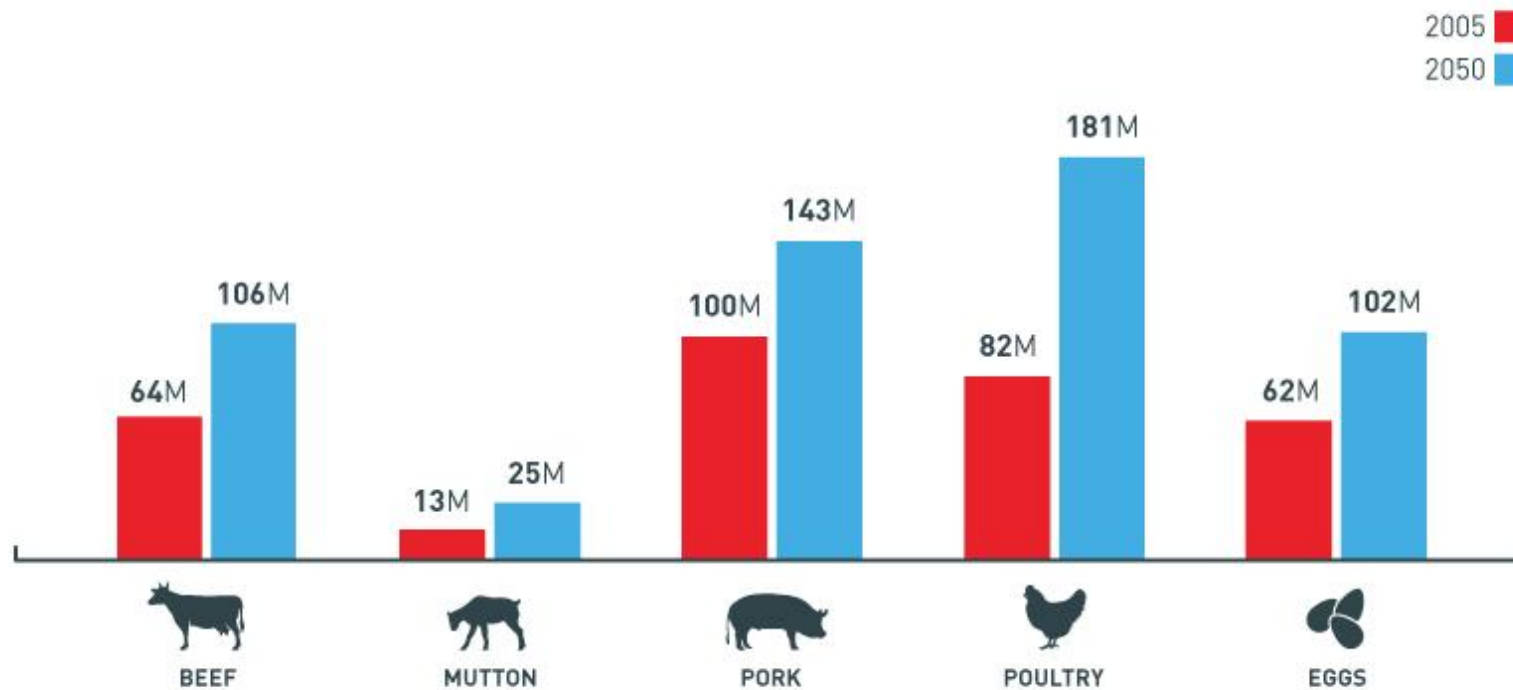
Population and Supply of Animal Protein



FAO 2012a, UN 2012

Global Demand for Animal Protein

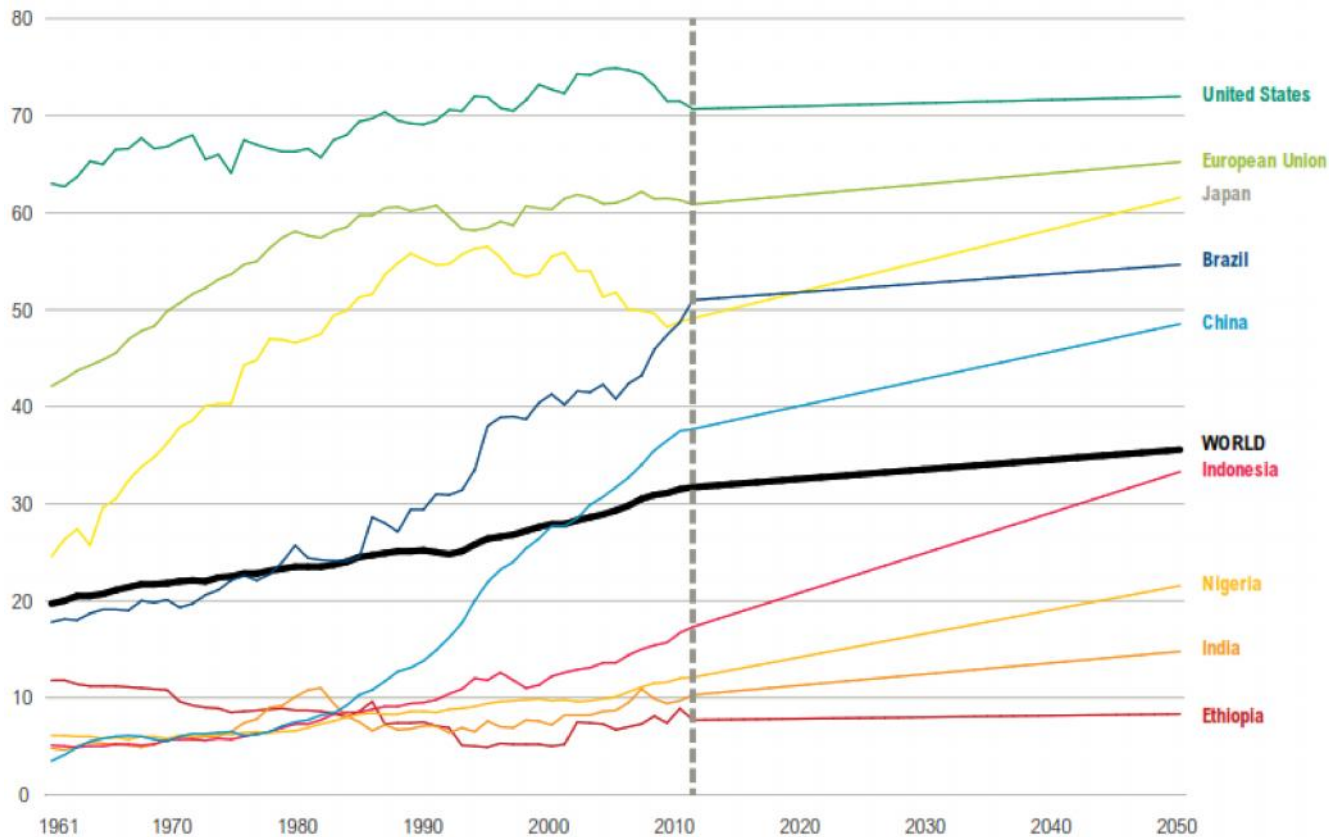
2005 vs. **2050**
[in tonnes]



Source: Food and Agriculture Organization of the United Nations, ESA Working Paper No. 12-03, p. 131

Growth of Animal Protein Consumption

- Faster growth for rising economy (Brazil, China, Indonesia, etc)



WORLD
RESOURCES
INSTITUTE

Installment 11 of "Creating a Sustainable Food Future"

SHIFTING DIETS FOR A SUSTAINABLE FOOD FUTURE

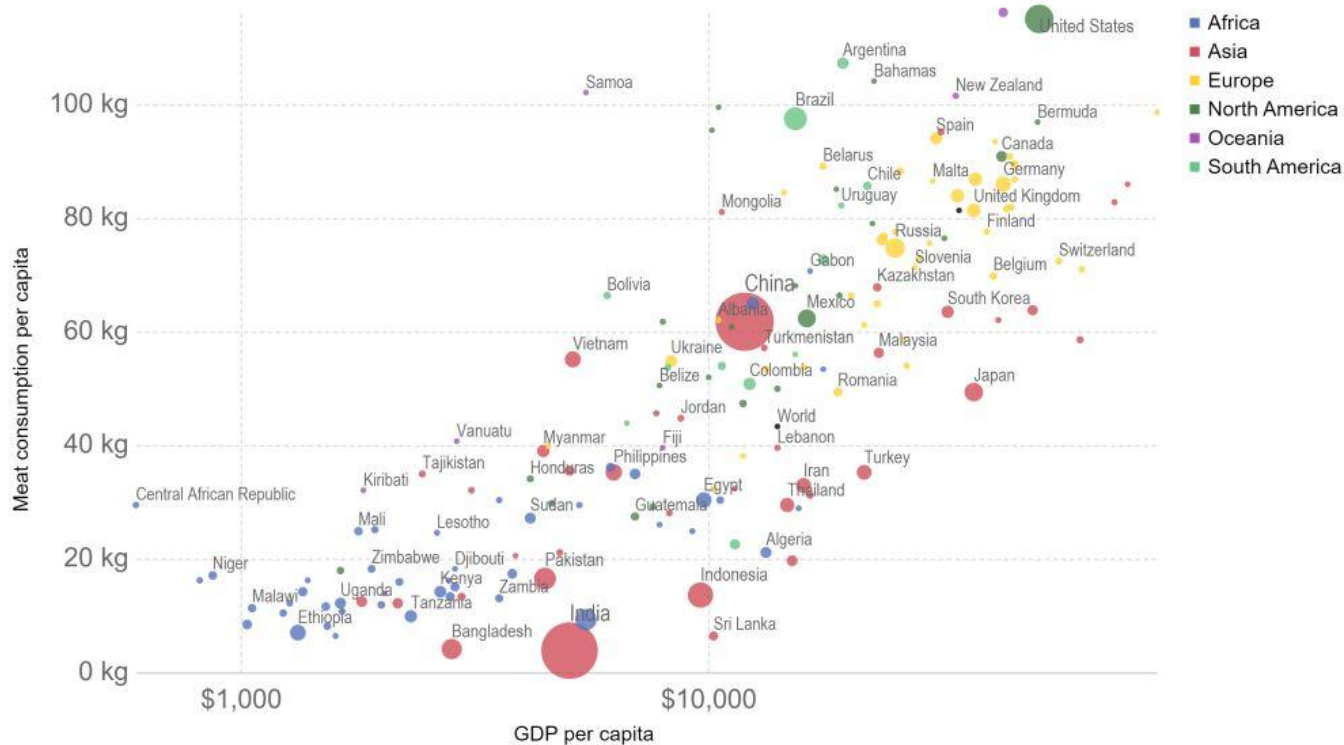
JANET RANGANATHAN, DANIEL VENNARD, RICHARD WAITE, PATRICE DUMAS,
BRIAN LIPINSKI, TIM SEARCHINGER, AND GLOBAGRI-WRR MODEL AUTHORS

Income vs. Meat Consumption

Meat consumption vs. GDP per capita, 2013

Average meat consumption per capita, measured in kilograms per year versus gross domestic product (GDP) per capita measured in 2011 international-\$. International-\$ corrects for price differences across countries. Figures do not include fish or seafood.

Our World
in Data



Source: UN FAO; World Bank, World Development Indicators

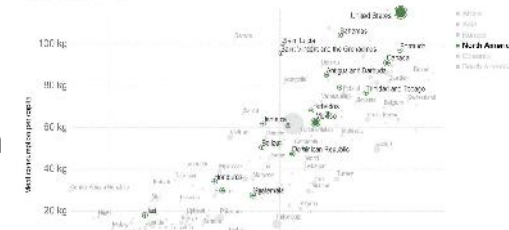
OurWorldInData.org/meat-and-seafood-production-consumption/ • CC BY-SA

North
America

Europe

Asia

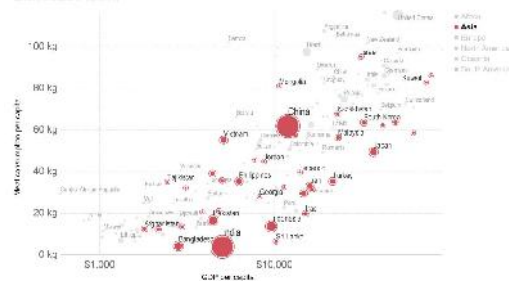
Meat consumption vs. GDP per capita, 2013
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Source: UN FAO; World Bank, World Development Indicators

Stress on Natural Resource

Land



DATA FROM: P. SMITH ET AL. 2013. GLOBAL CHANGE BIOLOGY 19: 2285-2302, FIG 1;
ORIGINAL ANALYSES BY F. KRAUSSMAN ET AL. 2008. ECOLOGICAL ECONOMICS 65: 471-487

Union of
Concerned Scientists
www.ucsusa.org/cowsarehogs

Water

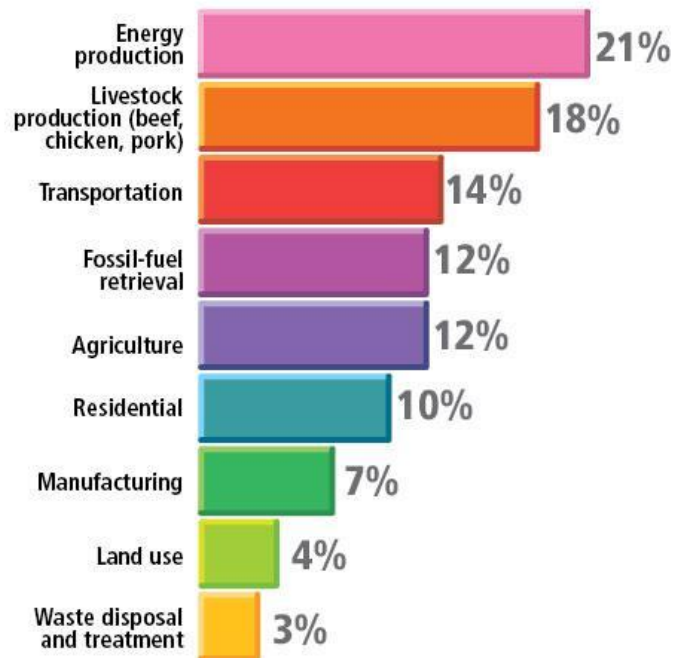


"...raising meat takes a great deal of land and water and has a substantial environmental impact. Put simply, there's no way to produce enough meat for 9 billion people"

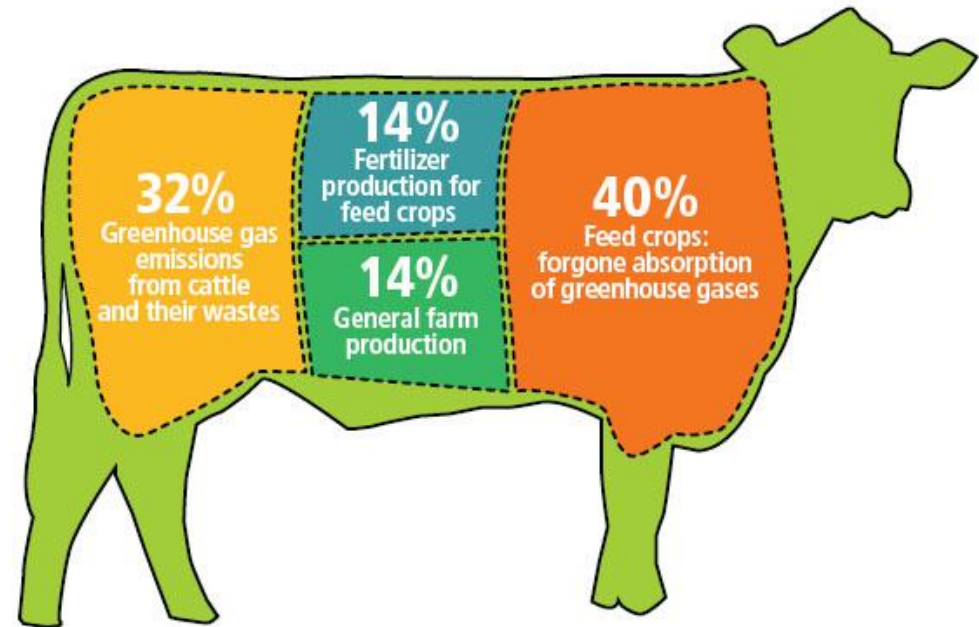
- Bill Gates, Future of Food (2013)

Stress on Planet

Livestock production being the second highest contributor to greenhouse gases



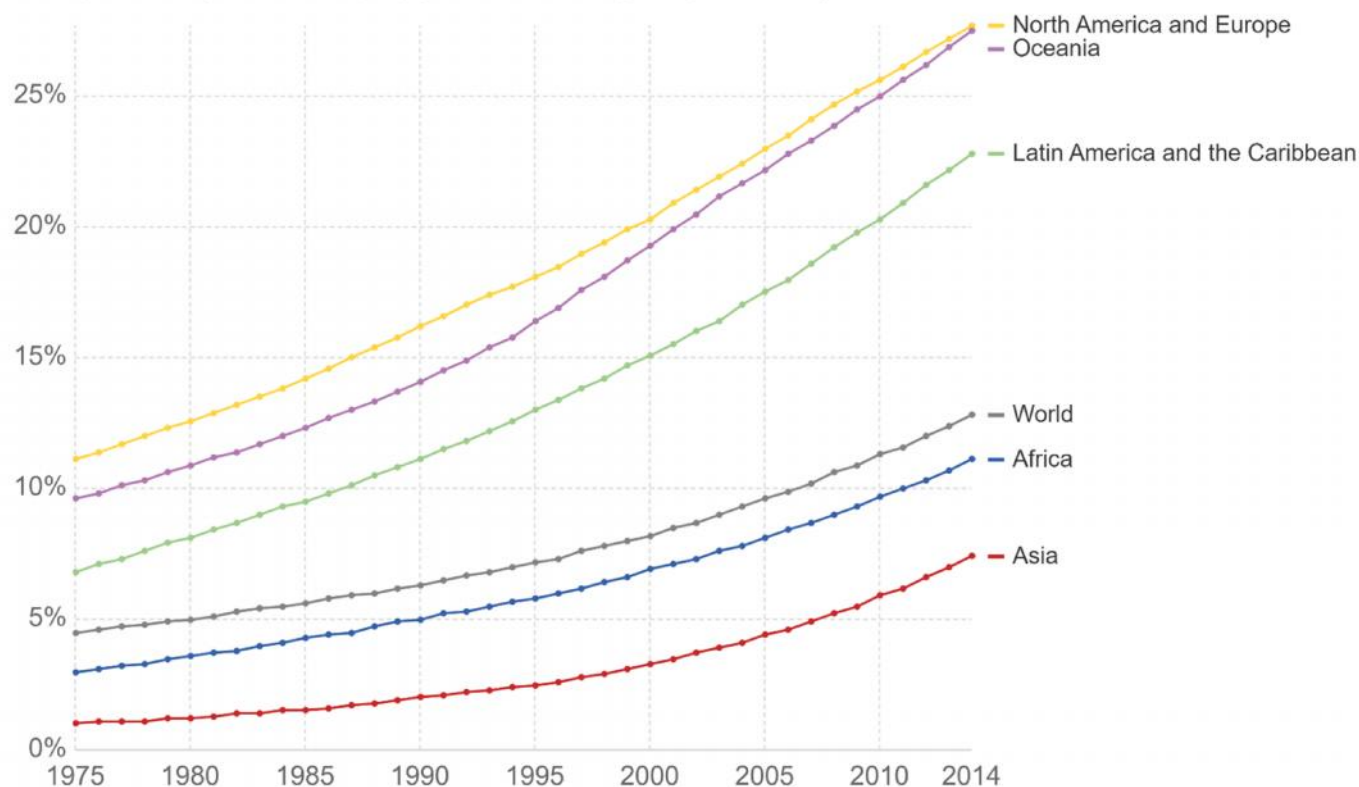
Total is greater than 100% because of rounding



Growing Obesity

Prevalence of obesity in adults by region

The prevalence of obesity in adults, measured as the percentage of adults aged 18 years and older (both male and female) with a body-mass index (BMI) greater than 30 kilograms per metre squared.



Source: UN Food and Agricultural Organization/WHO

OurWorldInData.org/obesity/ • CC BY-SA

Obesity in Asia

OVERWEIGHT POPULATIONS IN SOUTHEAST ASIA

Overweight prevalence (%) for adults of both sexes (BMI of > 25 kg/m²)



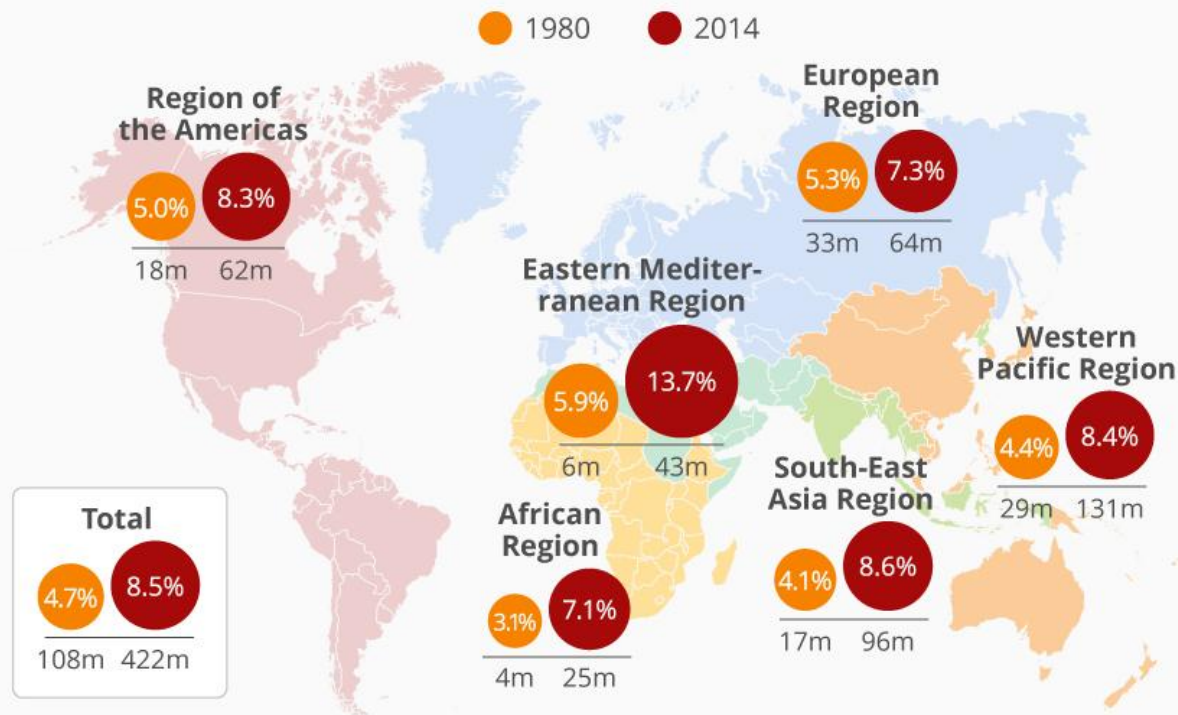
Source: WHO Non-Communicable Diseases Country Profiles, 2011

<https://www.thailand-business-news.com/asean/49065-thailand-ranks-second-asean-prevalence-obesity-mcot-net.html>

Growing Diabetes

The Unrelenting March Of Diabetes

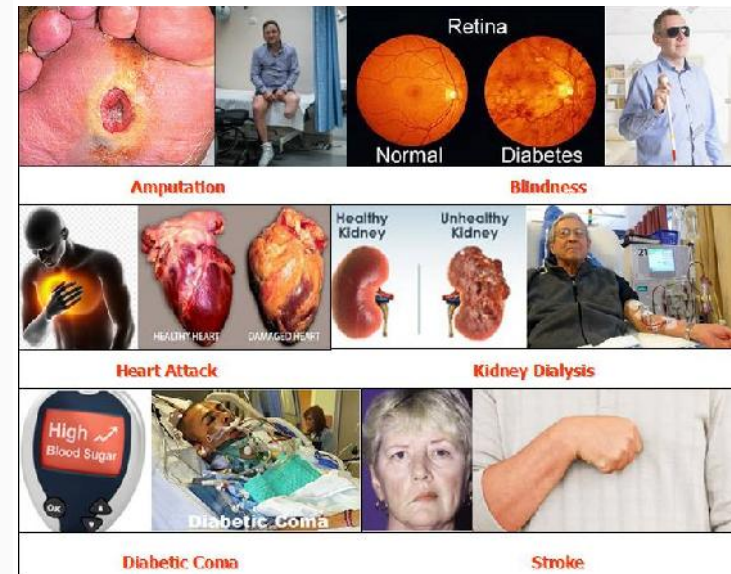
% prevalence and number of adults with diabetes by WHO region in 1980 and 2014*



CC BY ND * Millions of people and % of total regional population
 @StatistaCharts Source: World Health Organization

statista

Complications



<https://www.deathtodiabetes.com/type-2-diabetes.php>

Diabetes in Asia

Table 1. Top 10 Countries in Asia With the Highest Number of Persons With Type 2 Diabetes and Impaired Glucose Tolerance in the Age Group 20 to 79 Years in 2007 and Projected Data in 2025^a

Country	Diabetes		Impaired Glucose Tolerance	
	2007	2025	2007	2025
India	40 850	69 882	35 906	56 228
China	39 809	59 270	64 323	79 058
Japan	6978	7171	12 891	12 704
Bangladesh	3848	7416	6819	10 647
Korea	3074	4163	3224	4240
Thailand	3162	4660	1896	2399
Philippines	3055	5572	4410	7582
Indonesia	2887	5129	14 144	20 597
Malaysia	1530	2743	2915	4442
Vietnam	1294	2500	1175	1902
Subtotal ^b				
Western Pacific	66 993	99 401	111 898	142 693
Southeast Asia	46 543	80 341	45 169	70 525
Grand total Asia ^b	113 536	179 742	157 067	213 218

^aSource: International Diabetes Federation.² All values are in thousands.

^bIncludes numbers from Asian countries not shown here.

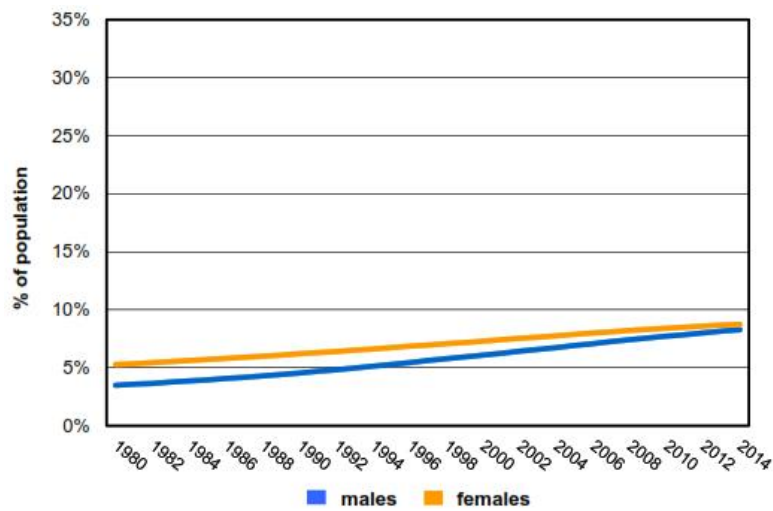
Diabetes in Asia Epidemiology, Risk Factors, and Pathophysiology
[Juliana C. N. Chan, MBChB, MD](#); [Vasanti Malik, MSc](#); [Weiping Jia, MD, PhD](#); et al
[Takashi Kadowaki, MD, PhD](#); [Chittaranjan S. Yajnik, MD, PhD](#); [Kun-Ho Yoon, MD](#); [Frank B. Hu, MD, PhD](#)
 JAMA. 2009;301(20):2129-2140.
 doi:10.1001/jama.2009.726

Diabetes: Thailand and Singapore

Thailand

Prevalence of diabetes and related risk factors

	males	females	total
Diabetes	9.1%	10.1%	9.6%
Overweight	27.7%	35.4%	31.6%
Obesity	6.1%	12.1%	9.2%
Physical inactivity	12.8%	16.4%	14.6%

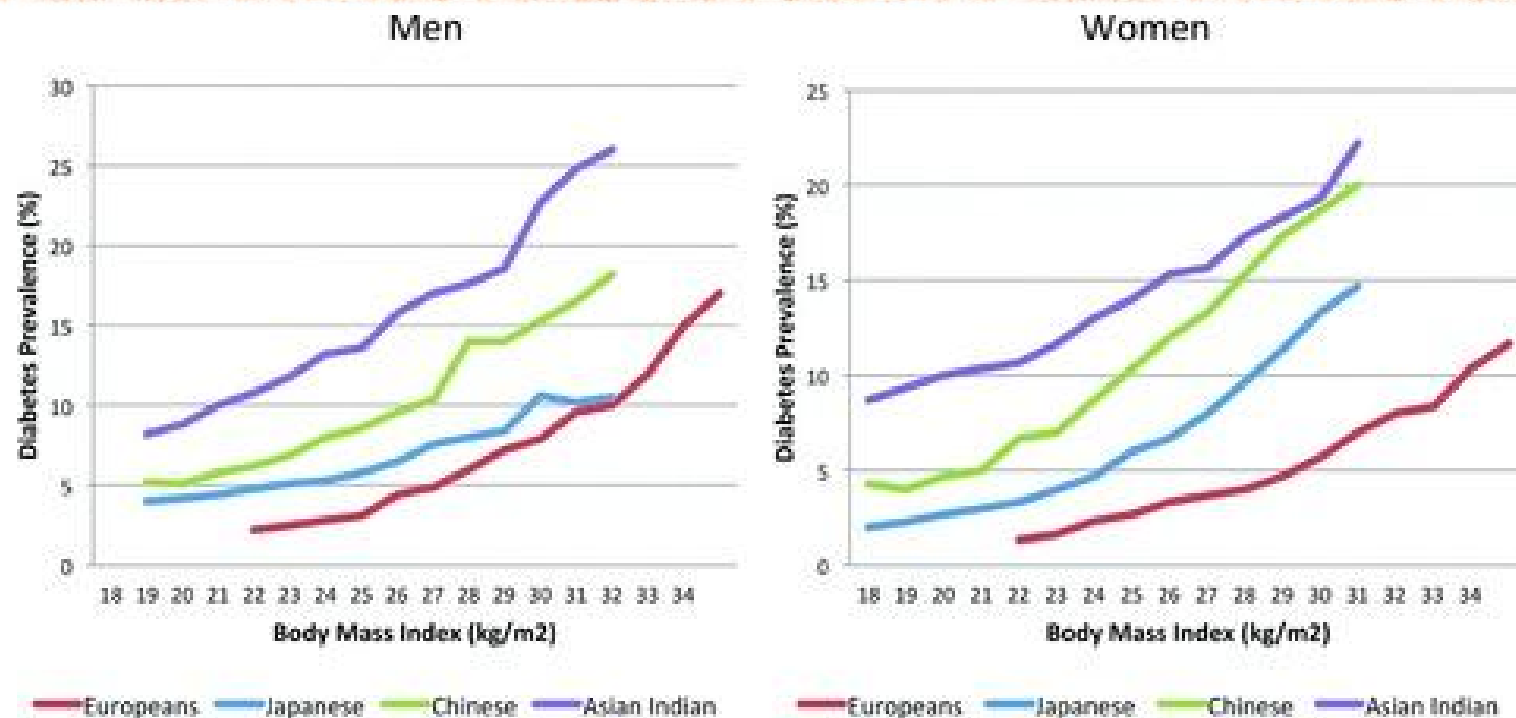


Singapore



<http://www.who.int/diabetes/country-profiles>

BMI and Diabetes Prevalence between ethnicities



Ma, Ronald & C.N. Chan, Juliana. (2013). Type 2 diabetes in East Asians: Similarities and differences with populations in Europe and the United States. *Annals of the New York Academy of Sciences*. 1281. 64-91. 10.1111/nyas.12098.

WHO - Childhood Overweight and Obesity

Childhood obesity is one of the most serious public health challenges of the 21st century

The prevalence has increased at an **alarming rate**

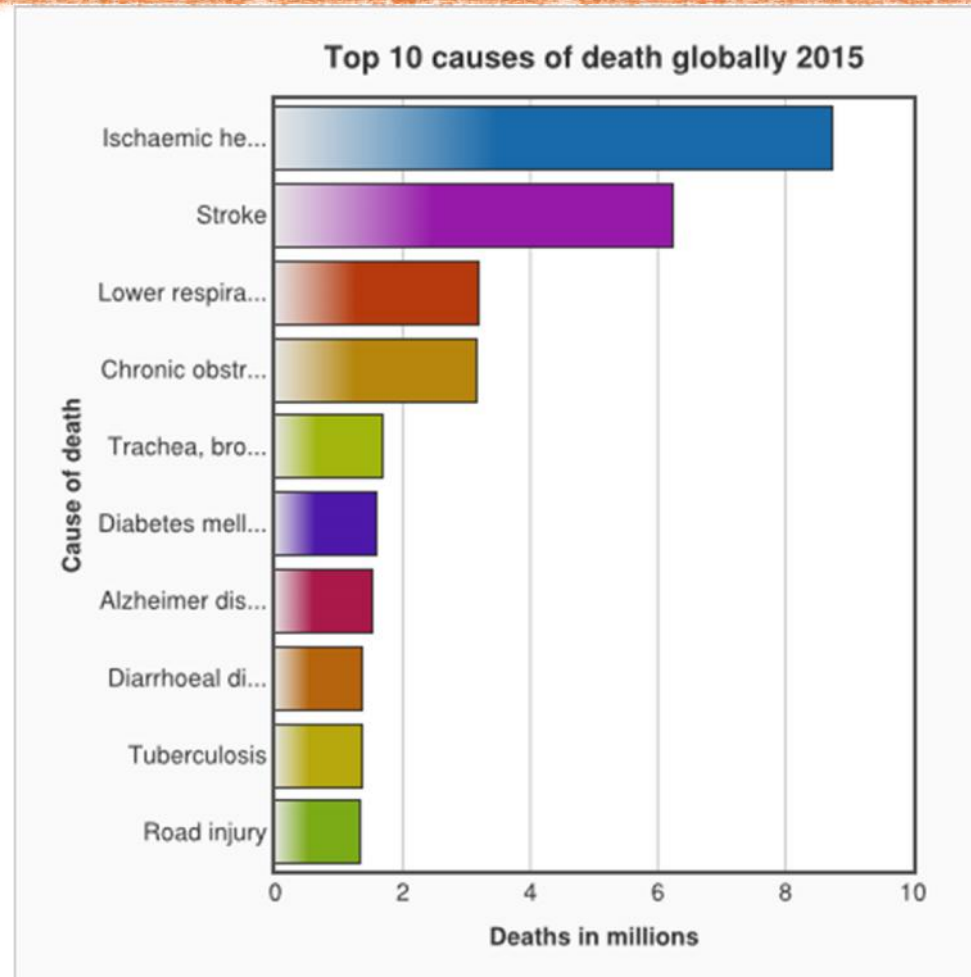
Almost half of all overweight children under 5 lived in Asia and one quarter lived in Africa.

Globally, in 2016 the number of overweight children under the age of five, is estimated to be over **41 million**

Overweight and obese children are likely to stay obese into adulthood and more likely to develop **noncommunicable diseases like diabetes and cardiovascular diseases at a younger age.**

<http://www.who.int/dietphysicalactivity/childhood/en/>

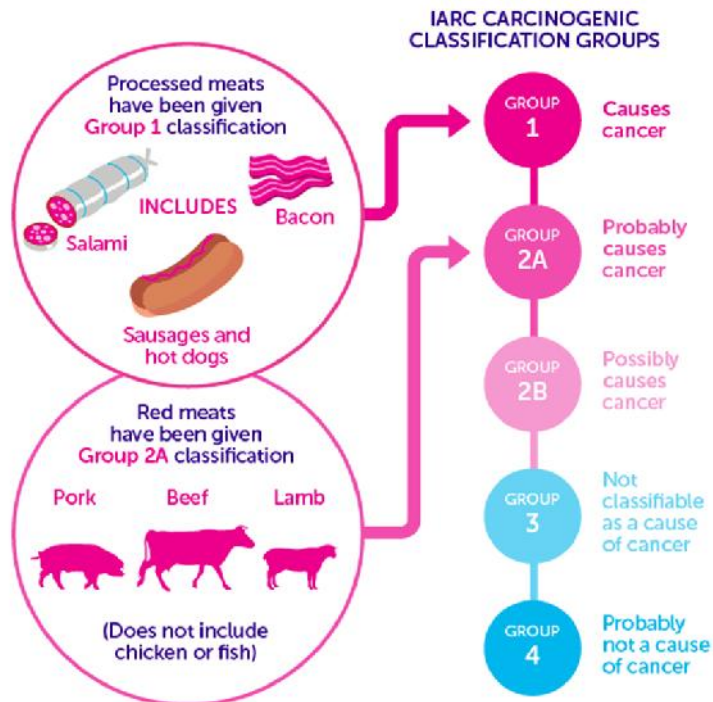
Ischaemic heart disease and stroke are the biggest killers



<http://www.who.int/mediacentre/factsheets/fs310/en/>

Risks

MEAT AND CANCER HOW STRONG IS THE EVIDENCE?



These categories represent how likely something is to cause cancer in humans, not how many cancers it causes.

WE WILL BEAT CANCER SOONER
cruk.org



According to the World Health Organization...

Eating **50g** of processed meat a day - less than two slices of bacon - increased the chance of developing colorectal cancer by **18%.**



Source: IARC/WHO

© Global News

Pressure on Government

Impact on global GDP¹

\$2.1 trillion



Smoking

\$2.1 trillion



Armed violence,
war, and terrorism

\$2.0 trillion



Obesity

\$1.4 trillion



Alcoholism

¹In 2014 dollars at purchasing-power parity.

Source: Literature review; World Health Organization global burden of disease (GBD) database; McKinsey Global Institute analysis

Investment in Meatless Space

Seeking Alternative Proteins



Targeting Food Waste



Increasing Farm Productivity



Adapting to New Environments



Bioengineering New Food Sources



Meat substitute company investment 2013 - 2017 YTD (10/18/17)



<https://www.cbinsights.com/research/future-of-meat-industrial-farming/>

Consumer Trend

FOOD & DRINK TRENDS 2017

Sticking with tradition

Consumers are seeking the recognisable not revolutionary, longing for safe, traditional products that are easily recognisable.



of French consumers like the appeal of authentic flavours



of Polish consumers like the appeal of authentic flavours



of Spanish consumers like the appeal of authentic flavours

Plant Power

There has been a substantial rise in foods with vegan & vegetarian claims



257%

increase in vegan claims in global food and drink launches*

25%

increase in vegetarian claims in global food and drink launches*



55%
of UK adults include vegetables in meals



25% SUPER FOODS
incorporated in UK adults meals

Time is precious

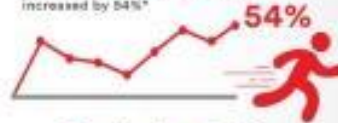
2017 will place emphasis on 'time saved' by purchasing the particular product.

Mintel GNPD revealed that global food and drink launches that include "slow" in the product description grew nearly 214%*

214% INCREASE

slow cooked claims

The number of global food and drink launches with ON THE GO claims increased by 54%*



Sustainability

2017 will see more consumer awareness and consideration of global food waste



one third of food produced for human consumption is lost or wasted

51%

of US adults are open to buying less-than-perfect vegetables

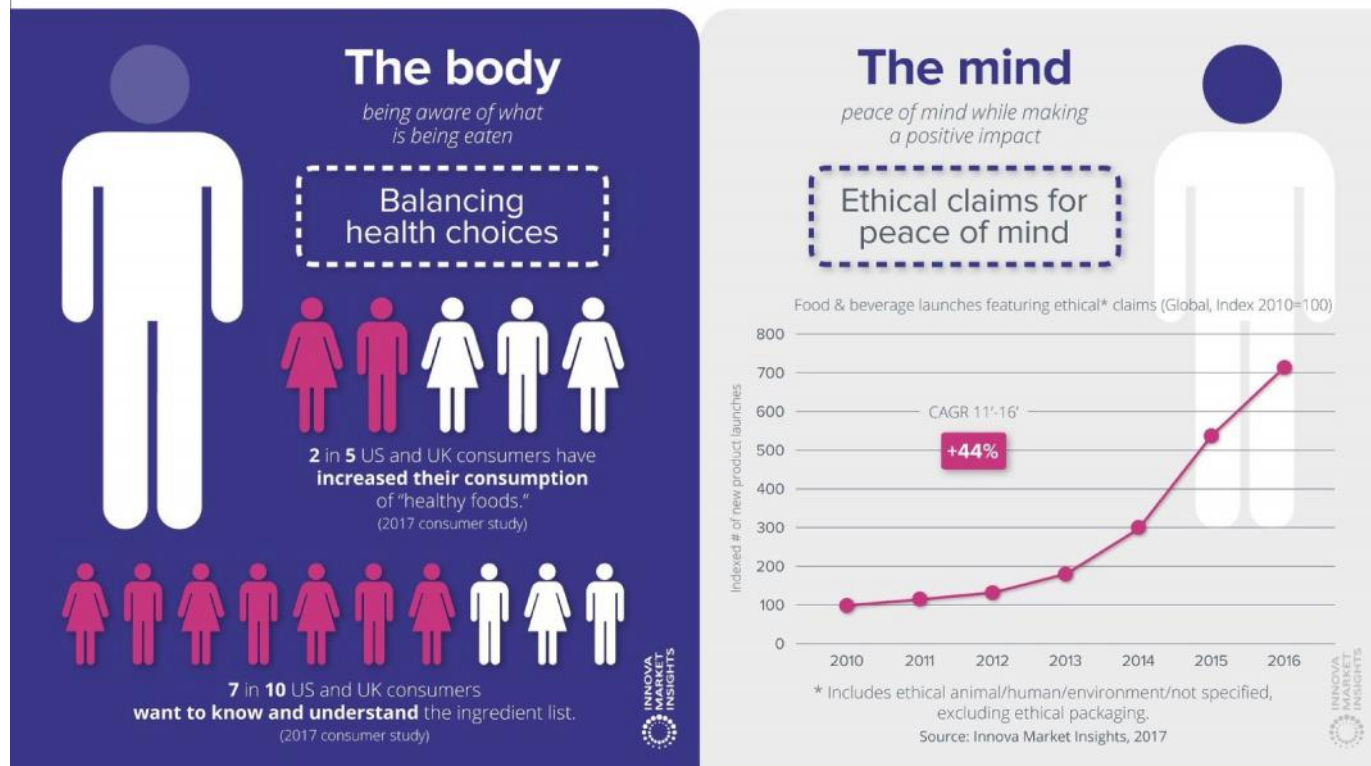
*between September 2010 – August 2011 and September 2015 – August 2016. Sources: Mintel Global Food & Drink Trends 2017 & Mintel GNPD



DIGITAL
CREATIVE
PACKAGING

Consumer Trend

TREND #1 MINDFUL CHOICES ADDRESSING BODY & MIND

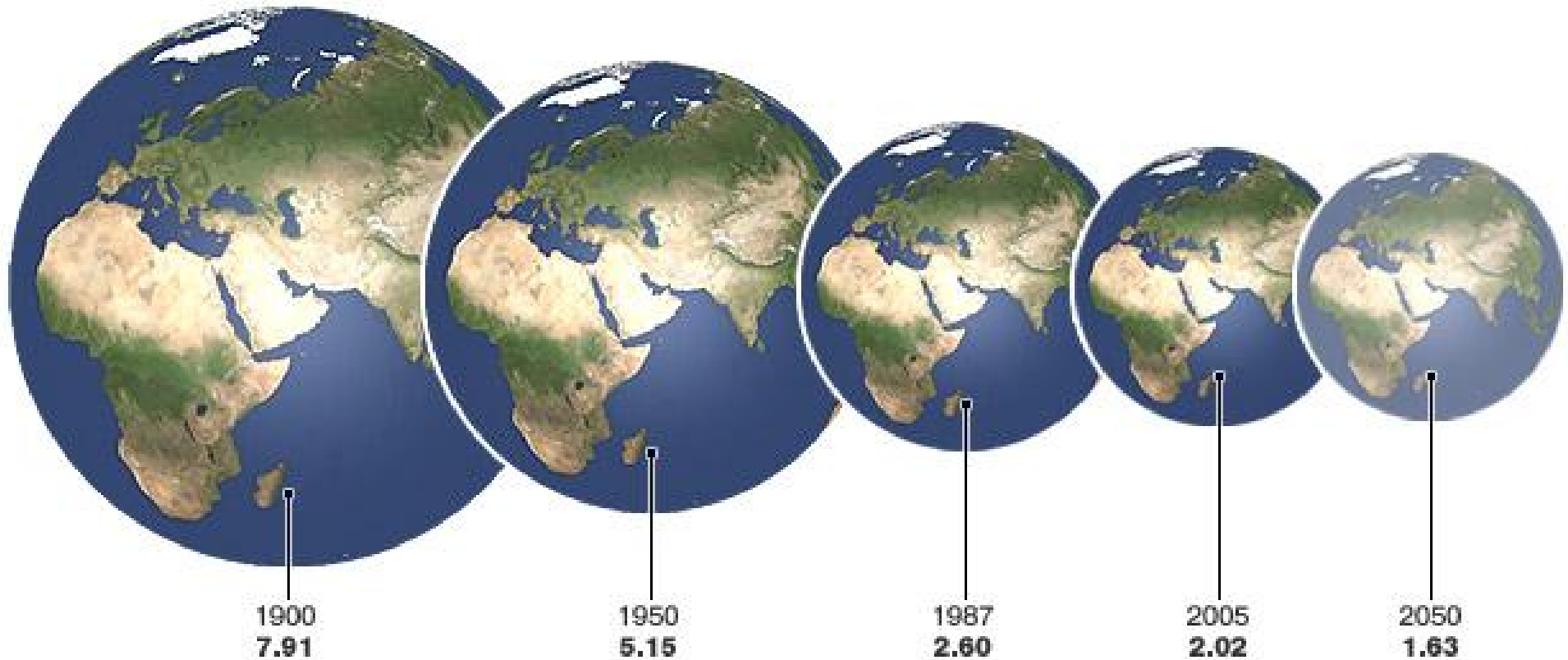


Mindful Choices: The Key Food Driver for 2018, says Innova Market Insights (PRNewsfoto/Innova Market Insights)

Shrinking World – Transportation & Communication

RISING POPULATION

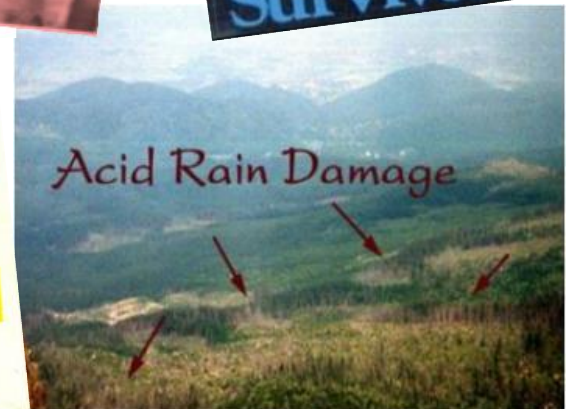
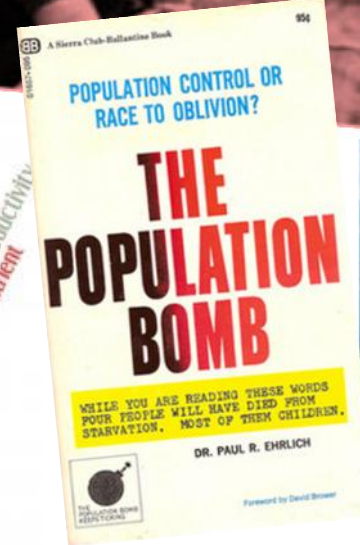
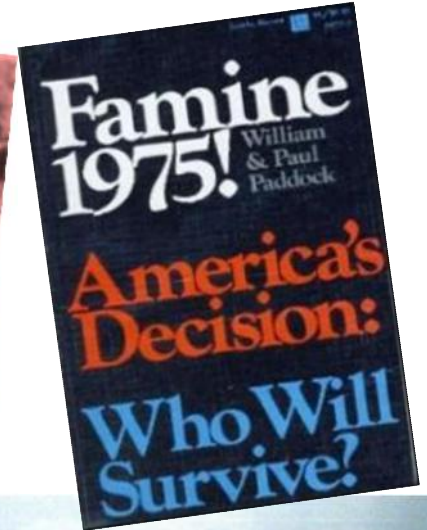
Hectares of available land per person



<http://init.planet3.org/2008/06/my-little-world-revisited.html>

Mycoprotein Story

1960's

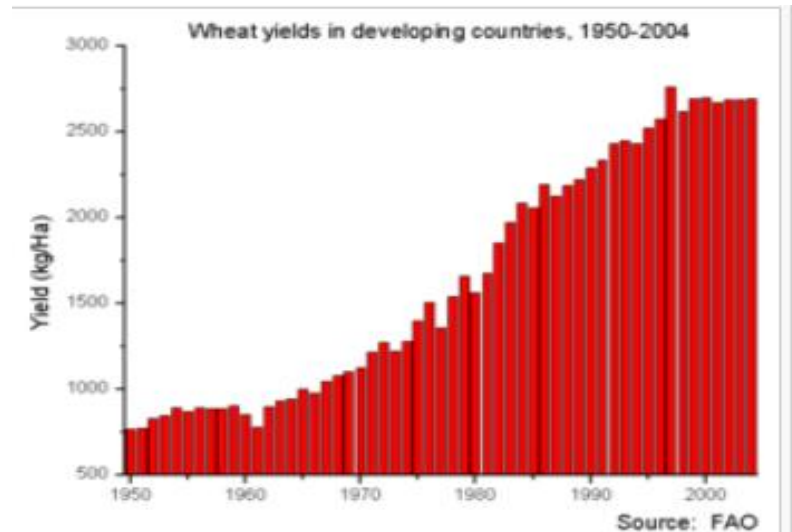


Malthusian predictions receded in the face of “The Green Revolution”

Norman Borlaug

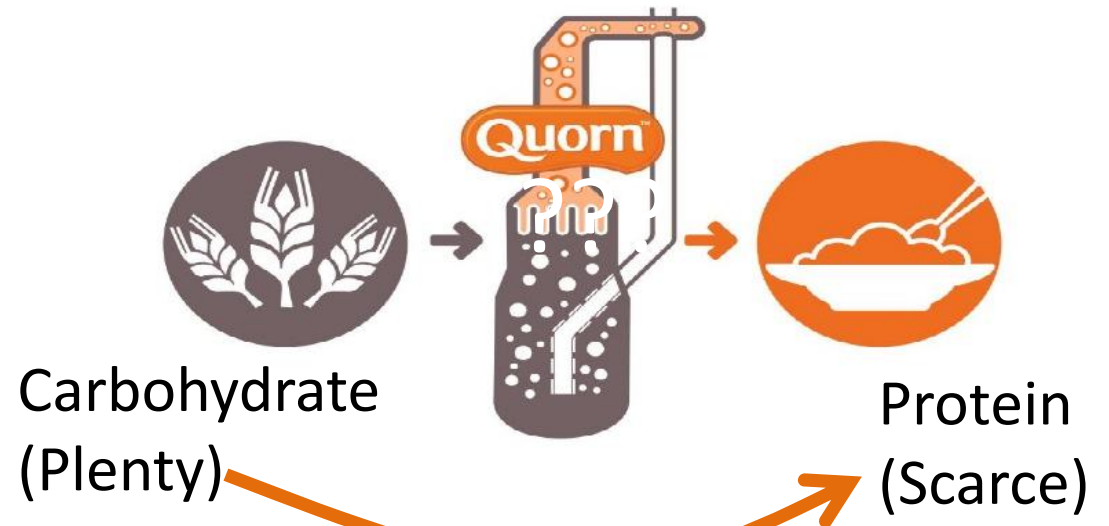
Agricultural Scientist

Norman Ernest Borlaug was an American agronomist, humanitarian and Nobel laureate who has been called "the father of the Green Revolution", "agriculture's greatest spokesperson" and "The Man Who Saved A Billion Lives". Wikipedia



Wheat yields in developing countries, 1950 to 2004, kg/HA baseline 500. The steep rise in crop yields in the U.S. began in the 1940s. The percentage of growth was fastest in the early rapid growth stage. In developing countries maize yields are still rapidly rising.^[6]

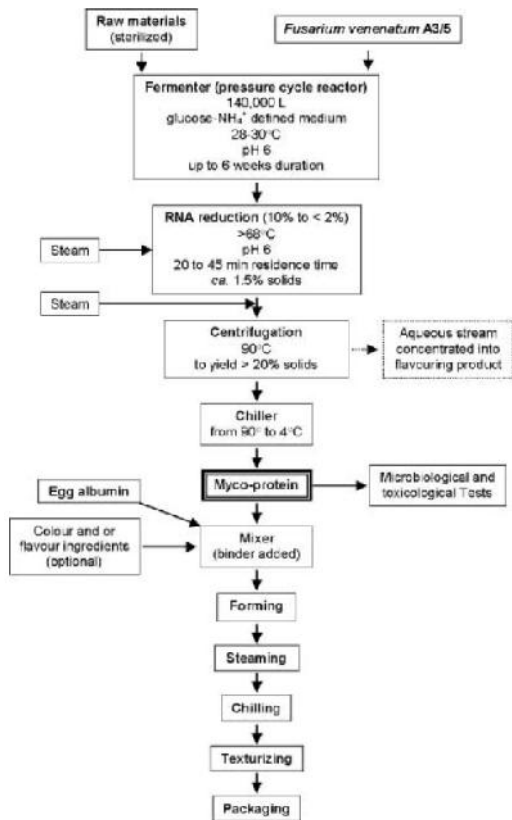
A man with an idea




- 3000 microorganisms
- 1967 – *fusarium venenatum*, **mycoprotein**
 - Safety
 - Organoleptic
 - Nutrition content
 - Scalability

Continuous Fermentation Technology

- Continuous fermentation to efficiently convert glucose to protein
- Heat shock – stop growth, reduce RNA to meet WHO limit
- Centrifuge to harvest biomass



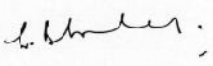
The Ministry of Agriculture, Fisheries and Food (UK) - 1985



CERTIFICATE OF FREE SALE
IMPORTATION OF FOOD PRODUCTS


The Ministry of Agriculture, Fisheries and Food hereby certify that the product 'Quorn' Mycoprotein may lawfully be sold in the United Kingdom of Great Britain and Northern Ireland, subject to the provisions of the Food Act 1984.

Dated this eleventh day
of October nineteen
hundred and eighty five

Signed: 

Mr L B Linley

For and on behalf of
the Ministry of Agriculture,
Fisheries and Food



DESCRIPTION OF FOOD PRODUCTS

The product named 'Quorn' Mycoprotein is produced by cultivation of Fusarium *Graminearum* CMI145425 in aseptic conditions using food grade raw materials and subsequently processed to reduce its Ribonucleic Acid (RNA) content to a level suitable for human consumption.

PF7ACD 4



Extensive database to establish safety of mycoprotein

- Analytical data (identity, composition, potential impurities)
- Manufacturing process
- In vitro test
 - Determine that mycoprotein is non-mutagenic
- Animal studies
- Digestibility and nutritional evaluation
- Human studies
- Historical consumption

Animal Studies – Subchronic Studies

Four studies in rats, one study in dogs, one study in baboons

Species	Study Duration	Dietary Concentration of Mycoprotein	Observations
Rats	22 weeks	26 or 52%	No effects in histology and clinical pathology were observed.
Rats	13 weeks	17.5 or 35%	No toxicologically significant adverse effects in growth, food and water consumption, clinical condition, or clinical pathology, or histopathology.
Rats	90 days	5, 10, or 20%	No toxicologically significant adverse effects in growth , blood parameters, organ weights, histopathology, or mineral balances were observed.
Rats	90 days	20 or 40%	No differences in pregnancy and litter parameters were observed. Rats receiving 40% mycoprotein exhibited a slightly lower liver weight, attributed to a slight decrease in food consumption. No toxicologically relevant differences in body weights, haematology, and urinalysis were observed.
Dogs	90 days	20 or 40%	No differences in weight gain, gross or histopathological findings , or organ weights were observed. No toxicologically significant differences in haematological parameters were observed. Reductions in plasma cholesterol and triglycerides were reported.
Baboons	13 weeks	26 or 51.5%	No adverse effects on growth, food and water consumption, haematological parameters , or electrocardiograms were observed. Increases in serum alkaline phosphatase activity, serum alkaline transaminase, and aspartate transaminase activities also were observed.

Miller SA, Dwyer JT (2001). Evaluating the safety and nutritional value of mycoprotein. Food Technology Vol. 55, No. 7. Cited In: Marlow Foods, 2001 [Annex III].

Animal Studies – Chronic Studies

Two 2-year carcinogenicity in rats, 1-year dog study, 2-generation study in rats

Species	Study Duration	Dietary Concentration of Mycoprotein	Observations
Rats ^[1]	2 years	21 or 41%	<p>No adverse effects in food consumption, growth, or reproduction were observed. Decreases in plasma cholesterol and plasma triglyceride concentrations were noted with mycoprotein administration.</p> <p>Slight differences in urine parameters were attributed to water retentive properties of the fibre in mycoprotein.</p> <p>Some histological findings were noted to be not injurious to the cell or its functions.</p> <p>No differences in the incidence of tumours were observed.</p>
Rats ^[2]	2 generation	12.5, 25, or 50%	<p>No adverse effects in growth, reproductive function, microscopic, or pathological findings were observed</p>
Rats ^[1]	2 years	27 or 57% (in utero), and 20 or 40% (chronic)	<p>No test article-related effects were observed in general condition, ophthalmoscopic examination, survival, growth, clinical chemistry, or haematology.</p> <p>An increase in urinary protein was observed in female animals.</p> <p>An increase in kidney weight was observed in rats receiving mycoprotein; no other differences in organ weights were noted.</p> <p>Significant increases in the incidence of renal microlithiasis and testicular tubular atrophy were noted to be attributed to mineral imbalances between the experimental diets.</p>
Dogs ^[2]	1 year	20 or 40%	<p>No adverse effects in growth, clinical signs, haematology, urinalysis, growth, or histopathology were observed.</p> <p>Dogs exhibited lower plasma cholesterol and triglyceride concentrations.</p>

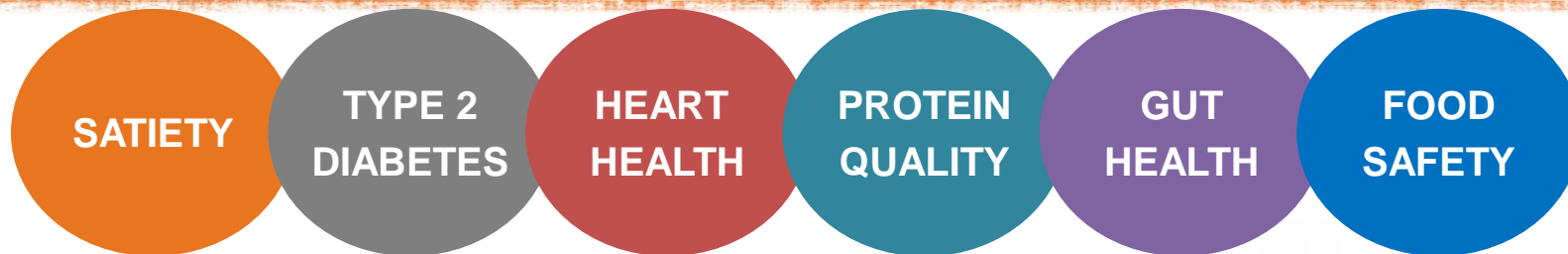
Tolerance Studies and Global Consumption

- Based on consumer data, the annual complaint rate represents less than **11 to 16 per million consumers or around 1 per million servings of Quorn™ product**. This compares favorably with soya and wheat with an incidence of about 1 in 200 of the general population and with egg and milk in the range of approximately 1 in 100
- Based on the amount of mycoprotein produced, the proportion of mycoprotein found in the finished products sold by Quorn, the average pack weight of a finished product sold, the average number of servings per pack, **the total number of meals consumed is about 4.8 billions**

Regulatory Approval

- 1985: United Kingdom
- 1990 - 2008: Europe (Belgium, Luxemburg, Netherlands, Sweden, Denmark, Switzerland, Norway)
 - Since European Union Novel Food EC Reg 258/97, mycoprotein can be sold in any EU member
- 2001: United states
- 2008: Australia and New Zealand
- 2013: Canada
- 2016: Thailand
- 2016: Philippines
- 2017: Singapore

20 year history of peer reviewed nutrition research



Science • Health •
Food • Innovation



Udall JN, Lo CW, Young VR, Scrimshaw NS. The tolerance and nutritional value of two microfungus foods in human subjects. *American Journal of Clinical Nutrition*. 1984;40:285-92

Cummings, J (1990) Ileal digestibility of mycoprotein in ileostomy patients. Dunn Research Institute Report

Turnbull, WH, *et al* (1990) Effect of Myco-protein on Blood Lipids. *Am J Clin Nutr* 52(4) 646-650

Turnbull, WH, *et al* (1991) The Effect of Myco-protein on Hunger, Satiety and Subsequent Food Consumption, in *Obesity in Europe 9* 1: 67-70, ed. Ailhaud G. *et. al.* 13 respondents

Turnbull, WH, *et al* (1992) Myco-protein Reduced Blood Lipids in Free Living Subjects. *Am J Clin Nutr* 55, 415-419

Burley, VJ, *et al* (1993) Influence of High Fibre Food (Myco-protein) on Appetite: Effects of Satiation (Within Meals) and Satiety (Following Meals). *Euro J Clin Nutr* 47, 409-418

Turnbull, WH, *et al* (1993) Acute Effects of Myco-protein on Subsequent Energy Intake and Appetite Variables. *Am J Clin Nutr* 58 (4): 507-512

Nakamura H, Ishikawa T, Akanuma M, Nishiwaki M, Yamashita T, Tomiyasu K, *et al.* Effect of Myco-proteins intake on serum lipids of healthy subjects. *Progress in Medicine*. 1994;14:1972-76

Homma Y, Nakamura H, Kumagai Y, Ryuzo A, Saito Y, Ishikawa T, *et al.* Effects of 8 week ingestion of mycoprotein on plasma levels of lipids and Apo (Lipo) proteins. *Progress in Medicine*. 1995;15:183-95

Ishikawa T, Ohsuzu F, Yoshida H, Yamashita T, Miyajima E, Nakamura H, *et al.* The effect of mycoprotein intake (12 and 24g per day) over 4 weeks on serum cholesterol levels. *Progress in Medicine*. 1995;15:61-74

Turnbull, WH & Ward, T, (1995) Myco protein reduces glycemia and insulinemia when taken with an oral glucose tolerance test. *Am J Clin Nutr* 61 (1) 135-140.

Antal, M *et al* (1998) Cross over study for the clinical evaluation of the benefit of mycoprotein in weight reducing programme. Hungarian Schools research. Report to Marlow Foods

Turnbull, WH, *et al* (1998) Myco-protein as a Functional Food: Effects on Lipemia, Glycemia and Appetite Variables. *Proc. 16th Intl Cong Nutr*.

Marks, L (2005) Effects of mycoprotein foodstuffs on glycaemic response and other factors beneficial to health PhD Thesis Univ \ulster

Williamson, DA, *et al* (2006) Effects of consuming mycoprotein, tofu or chicken upon subsequent eating behaviour, hunger and safety. *Appetite* 46: 41-48

Ruxton, CS.s and McMillan, B. (2010) The impact of mycoprotein on blood cholesterol levels ; apilot study. *Brit Food Journal* 112 (10), 1092 -1101

Bottin, J (2014). Nutritional and surgical influences on appetite regulation and body composition in overweight and obese humans. PhD Thesis. Imperial College London.

Bottin, J, Cropp, E, Ford, H, Betremieux, L, Finnigan, TJA and Frost G (2011) Mycoprotein reduces insulinaemia and improves insulin sensitivity. *Proc Nutr Soc* 70 E372

Bottin, J, Cropp, E, Finnigan, TJA, Hogben, A, and Frost, G (2012) Mycoprotein reduces energy intake and improves insulin sensitivity compared to chicken. *Proc ECO* . Lyon May 2012

Bottin, J *et al* (2015) Mycoprotein reduces energy intake and postprandial insulin release compared with chicken without altering GLP-1 and PYY concentrations in healthy overweight adults. *Br J Nutrition* 116 360-374

Dunlop M *et al* (2017) Mycoprotein represents a bioavailable and insulinotropic non-animal derived dietary protein source: a dose-response study *Br J Nutr* In Press

Human Studies highlights mycoprotein potential

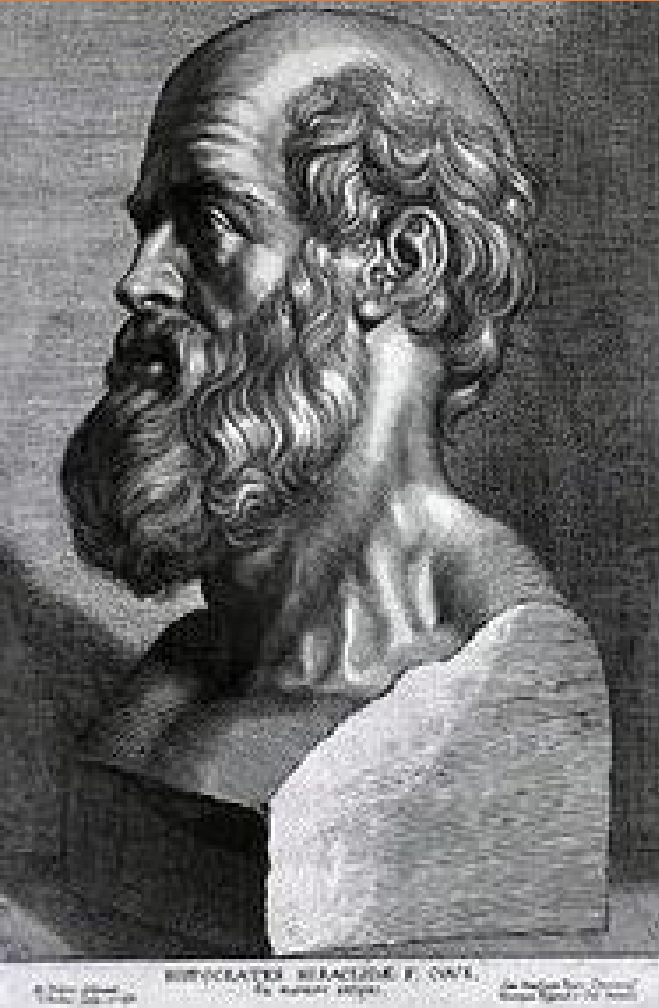
Subjects	Route of exposure	Dose of mycoprotein	Duration of study	Findings	Reference
100 healthy subjects, aged 18 to 59 years	In cookies	20 g/day	30 days	No reports of adverse events were observed. No differences were found in any haematological parameters, with the exception of a decrease in cholesterol. No changes in urinalysis parameters were observed.	Udall <i>et al.</i> , 1984
17 healthy subjects aged 19 to 48 years with blood cholesterol between 5.2 and 6.2 mmol/L	In the diet	191 g/day	3 weeks	No changes in mean body weight, systolic or diastolic blood pressure, glycaemic or insulinaemic variables were observed. Total cholesterol was reduced in the mycoprotein treatment group compared to baseline. LDL cholesterol was decreased in the mycoprotein group compared to baseline. No statistically significant changes in apolipoproteins A-1 and B were observed between groups, though there was a significant decrease in both variables in subjects given mycoprotein compared to baseline. No perceived differences in fluid intake were observed. 6 of 9 subjects in the mycoprotein group experienced transient flatulence. A slight perceived increase in the frequency of defecation and faecal bulk was reported in the mycoprotein group.	Turnbull <i>et al.</i> , 1990
13 healthy female subjects	In the diet	Not specified	1 day	A decrease in desire to eat, hunger, and an increase fullness score was observed following consumption of the mycoprotein meal compared with chicken.	Turnbull <i>et al.</i> , 1992a
21 healthy subjects aged 25 to 61 years with blood cholesterol greater than 5.2 mmol/L.	Biscuits	26.9 g dry weight/day, (approx. 130 g mycoprotein at normal moisture content)	8 weeks	Total cholesterol and LDL cholesterol were significantly reduced in both groups, though the effect was significantly greater in subjects given mycoprotein. No changes in HDL were observed. No changes in triglycerides were observed. No significant changes in apolipoproteins A-1 or B were noted.	Turnbull <i>et al.</i> , 1992b
13 female subjects, mean age of 24.8 years, with unrestrained eating habits.	In the diet	130 g/meal	3 days	Subjects reported feeling less desire to eat, and reduced prospective consumption after eating a mycoprotein-containing diet compared to the chicken diet. No statistically significant changes in hunger and fullness scores were observed between treatment groups. No safety endpoints were examined in the study.	Turnbull <i>et al.</i> , 1993
4 male and 15 female subjects, mean age of 22.8 years with sufficient intake of carbohydrates.	In a milkshake	30 g dry weight/day	2 days	Postprandial serum glucose was lower following mycoprotein consumption compared to control. Serum insulin response was significantly lower following mycoprotein consumption compared with control. The area under the curve for serum glucose and insulin also was significantly lower in the mycoprotein treatment group. No safety endpoints were examined in the study.	Turnbull <i>et al.</i> , 1995
9 male and 9 female healthy subjects	In a frozen chicken-style chunk, or in a freeze-dried powder	150 g/meal, 1 meal/day	1 day	No significant differences in hunger scores were observed. A decrease in portion size of foods selected was observed in subjects consuming mycoprotein. Satiety was enhanced 4 hours post-meal. No safety endpoints were examined in the study.	Burley <i>et al.</i> , 1993

Cholesterol reduced

Satiety

Lowered glycaemic response

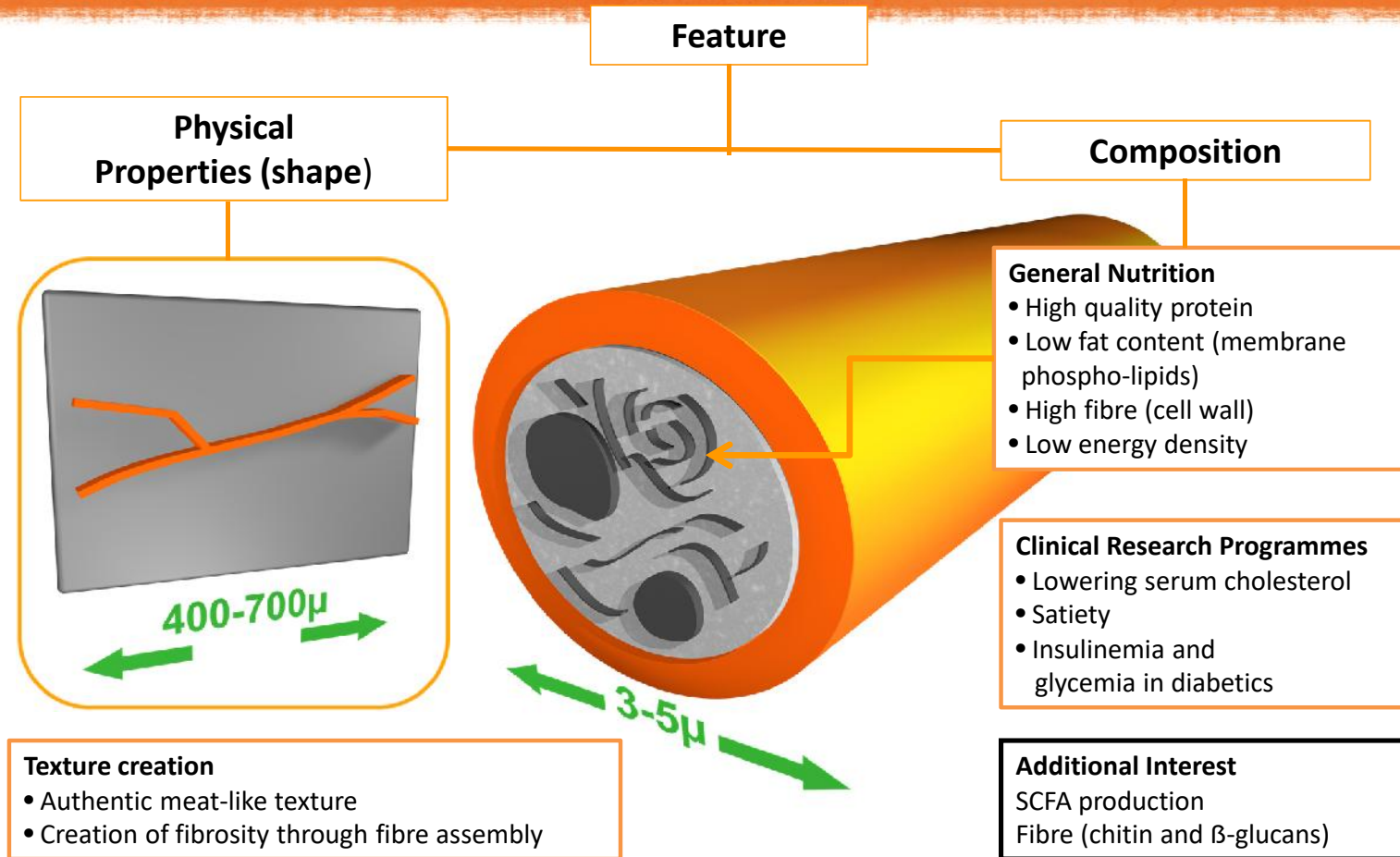
460 – c. 370 BC



“Let food be thy medicine
and medicine be thy food”
– Hippocrates

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Mycoprotein Unique Profiles



Denny, A, Aisbitt, B and Lunn, J (2008) Mycoprotein and health. BNF Nutrition Bulletin 33: 298 – 310.

Bottin, J. (2014) Nutrition and Surgical Influences on appetite regulation in obese adults. PhD Thesis Imperial College London

Mycoprotein Nutrition Profile

	Data 1	Data 2
	per 100g	per 100g
Energy (kcal)	111	96
Protein (g)	13.7	13.2
Carbohydrate (g)	< 0.1	< 0.1
- Sugars (g)	< 0.1	< 0.1
Fat (g)	3.1	3.0
- Saturated Fat (g)	0.48	1.0
- Mono-unsaturated Fat (g)	0.29	1.0
- Poly-unsaturated Fat (g)	2.2	0.9
- Trans-unsaturated Fat (g)	< 0.1	< 0.1
Cholesterol (mg)	< 0.5	< 0.5
Fibre (g)	7.5	8.3

Nutrition Comparison to Other Protein

	Quorn pieces	Quorn burger	Chicken (skinless)	Beef (lean)	Ground beef (lean)	Milk (2%)	Tofu	Tempeh
Calories (kcal)	92	117	119	160	264	50	76	193
Total fat (g)	3.2	4.6	3.1	7.8	20.7	1.9	4.8	10.8
Saturated fat (g)	0.6	2.3	0.8	2.8	8.3	1.2	0.7	2.2
Cholesterol (mg)	0	0	70	62	75	7.5	0	0
Total carbohydrate (g)	1.8	5.8	0	0	0	4.8	1.9	9.4
Sugars (g)	0.8	2.5	0	0	0	4.8	1.5	ca. 4.6
Fibre (g)	4.8	4.1	0	0	0	0	0.3	ca. 4.3
Protein (g)	14	12.8	21.4	20.8	17.7	3.3	8.1	18.6
Sodium (g)	0.3	0.5	0.8	0.05	0.07	0.05	<0.01	<0.01
Iron (mg)	0.7	0.4	0.5	9.8	6.2	0.02	4.3	1.6

Appl Microbiol Biotechnol (2002) 58:421–427
DOI 10.1007/s00253-002-0931-x

MINI-REVIEW

M.G. Wiebe

Myco-protein from *Fusarium venenatum*: a well-established product for human consumption

Protein Quality

Recent Work Shows a PDCAAS Score of 0.996

Test Material	Rat PER	Rat NPU	Man Digestibility	Man Biological Value	Man NPU (calculated)
Mycoprotein	2.4	61	78	84	65
Mycoprotein + methionine	3.4	82	79	92	73
Casein	2.5	70	-	-	-
Skimmed Milk	-	-	95	85	80

Using the above apparent protein digestibility of mycoprotein in man, the protein digestibility corrected amino acid score (PDCAAS) was calculated, giving a figure of 0.91, similar to beef (see Miller & Dwyer, 2001).

The research conducted at the Dunn Laboratory, Cambridge, UK, referred to below yielded an ileal digestibility of 89.8% for the protein in mycoprotein. Some of this may have been attributable to digestible non-protein nitrogen, so a more cautious figure of 86% was used for an updated PDCAAS calculation. This yielded a score of 0.996 (Edwards & Cummings, 2010).

Edwards, DG, & Cummings, JH (2010) The protein quality of mycoprotein. *Proc Nutr Soc* 69(OCE4): E331

Miller, SA, & Dwyer, JT (2001) Evaluating the safety and nutritional value of mycoprotein. *Food Technol* 55(7): 42-47.

Food Texture

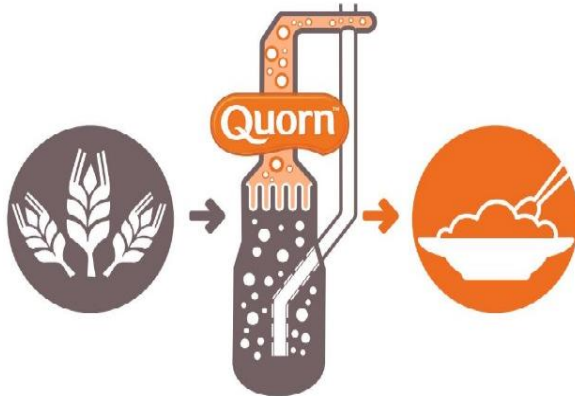
SOYA

POULTRY

QUORN



Production with low environmental impact



Water



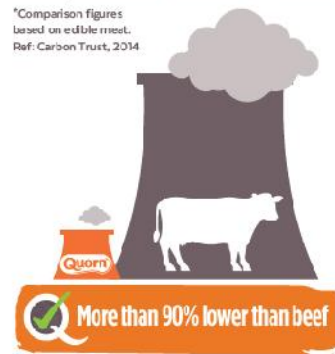
The water footprint of Quorn mince = up to 10 times smaller than that of beef



GHGs

Comparative carbon emissions*

*Comparison figures based on edible meat.
Ref: Carbon Trust, 2014



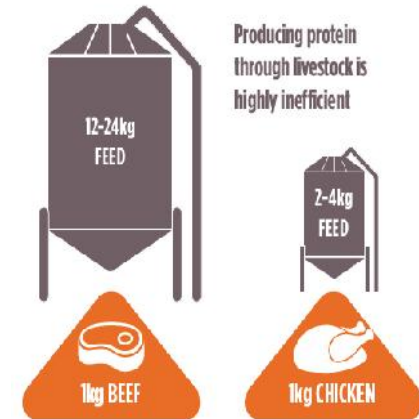
Quorn Mince

The results are remarkable. They show that Quorn products can have a carbon footprint up to thirteen times lower than beef, and up to 4 times lower than chicken²⁵.



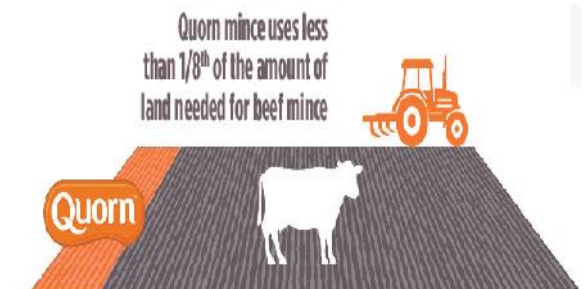
Quorn Pieces

Feed efficiency



Producing protein through livestock is highly inefficient

Land use



Partnership with Carton Trust

ENVIRONMENTAL COMPARISON PROTEINS AND MYCOPROTEIN

	GHG (kg/kg)	LAND (ha/te)	WATER (m3/te)																										
MYCOPROTEIN	1.6	0.17	860																										
source#4: carbon trust lifecycle analysis of mycoprotein. Report 2014																													
QUORN MINCE	2.4	0.4	1900																										
SOYABEAN	0.1 - 17.8	0.43	2500	<table><tr><th colspan="4">Compared with Quorn mince ex factory</th></tr><tr><th></th><th>GHG</th><th>LAND</th><th>WATER</th></tr><tr><td>Beef (mixed)</td><td>X12</td><td>X9</td><td>X10</td></tr><tr><td>Beef (grazed)</td><td>X50</td><td>X12</td><td>X11</td></tr><tr><td>Poultry</td><td>X4</td><td>X2</td><td>X2</td></tr></table>						Compared with Quorn mince ex factory					GHG	LAND	WATER	Beef (mixed)	X12	X9	X10	Beef (grazed)	X50	X12	X11	Poultry	X4	X2	X2
Compared with Quorn mince ex factory																													
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Poultry	X4	X2	X2																										
	source#1	source#2	source#3																										
BEEF (GRAZED)	121 (114 - 130)	5	21500																										
BEEF (MIXED)	30 (16 - 69)	3.5	19500																										
source#4: carbon trust lifecycle analysis of mycoprotein. Report 2014																													
POULTRY	9	0.7	3970																										

working with
the Carbon Trust



- ☐ By working closely with **Carbon Trust** we have established that Quorn foods offer **significant environmental benefits** relative to meat.
- ☐ Quorn is the **first and only** meat free brand to have carried out such a **systematic third party** analysis of its environmental footprint.

1. Gheraldes, E & Freire F (2013) Greenhouse gas assessment of soyabean production: implications of land use change J Cleaner Production **54**, 49 -60
2. Matsuka, T& Goldsmith, P (2009) World soyabean production: Area yield and projections. In: J Food Agric Management review **12** (4) 143-161
3. Ercin, AE Aldaya, M &Hoekstra, AYI (2011) The water footprint of soymilk, soyburger and equivalent animal products. UNESCO IHE Inst Water Education. Report **49**
4. Carbon Trust. Report to Marlow Foods (2014) Available on request





Our Future

Journey continues

	Country	Year
1	 United Kingdom	1985
2	 Belgium	1992
3	 Netherlands	1992
4	 Switzerland	1996
5	 Republic of Ireland	1999
6	 Sweden	1999
7	 United States of America	2002
8	 Denmark	2006
9	 Norway	2007

	Country	Year
10	 Australia	2010
11	 Germany	2012
12	 South Africa	2013
13	 France	2015
14	 Spain	2015
15	 Italy	2016
16	 Philippines	2016
17	 Thailand	2016
18	 Singapore	2017

Our 50-year journey produces a third category - natural, nutritious fungi

1. Animal Based Protein



2. Plant Based Protein



3. Fungi Based Protein



Collaboration

Biotechnology & Bioengineering

- Identify new alternative
- Develop fermentation process suitable for local context

Interdisciplinary Product Development

- Develop food, beverage and snacks from sustainable protein (mycoprotein and others) through interdisciplinary approach to achieve organoleptic profile and nutrition profile

Packaging & Manufacturing technology

- Develop sustainable solution to packaging
- Develop packaging and manufacturing technology to produce shelf stable product
- Develop manufacturing system that produce customized product efficiently

Nutrition & Safety

- Create evidence to highlight potential benefit of alternative protein to consumers
- Create studies to further understand the potential benefit of alternative protein

THANK YOU

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