Dietary protein as a functional food

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The research leading to these results has received funding from the European Community’s Seventh Framework Programme and the Scottish Government.
Topics

• Why we shouldn’t ignore protein

• Current protein recommendations – are they functional enough?

• New research on types of proteins and benefits (plant vs. animal)

• Ideas for protein NPD and examples of products

• Protein claims and how to use them
Why we shouldn’t ignore protein: Substantial evidence supports the increased consumption of high-quality protein to achieve optimal health outcomes

Protein intakes well above the current Recommended Dietary Allowance help to promote healthy aging, appetite regulation and weight management

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- Higher protein intakes may help prevent age-related sarcopenia, the loss of muscle mass, and strength that predisposes older adults to frailty, disability, and loss of autonomy.

- Higher protein diets also improve satiety and lead to greater reductions in body weight and fat mass compared with standard protein diets, and may therefore serve as a successful strategy to help prevent and/or treat obesity.

- Athletes can also benefit from higher protein intakes to maximize athletic performance given the critical role protein plays in stimulating muscle protein remodelling after exercise.

Higher protein intakes may help prevent age-related sarcopenia, the loss of muscle mass, and strength that predisposes older adults to frailty, disability, and loss of autonomy.

• Protein quality, per meal dose, and timing of ingestion are also important considerations. Despite persistent beliefs to the contrary, we can find no evidence-based link between higher protein diets and renal disease or adverse bone health.

• Current evidence indicates intakes in the range of at least 1.2 to 1.6 g/(kg·day) of high-quality protein is a more ideal target for achieving optimal health outcomes in adults.


Why we shouldn’t ignore protein: Substantial evidence supports the increased consumption of high-quality protein to achieve optimal health outcomes.

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The joint statement from the World Health Organization (WHO)/Food and Agriculture Organization of the United Nations (FAO)/United Nations University (UNU) (WHO/FAO/UNU) committee on dietary protein states the following (WHO, 2011):

...the protein requirement of adults can be defined as the minimum intake that will allow nitrogen equilibrium (zero nitrogen balance), at an appropriate body composition during energy balance and at moderate physical activity. In practice, the nitrogen balance studies... involve studies on healthy adults assumed to be in energy balance, usually on the basis of weight maintenance and of an ‘appropriate’ body composition, but without specific measurement to ensure that this was the case.

Insofar as muscle is concerned, there is evidence that we may be able to begin to define a more “optimal” level of protein intake (Phillips 2012) rather than a minimal level that offsets deficiency.


How much is enough?

• The protein composition of an individual's diet can be considered in different ways
  • Grams (g), or g/kg body weight
  • % of total energy (calories) as protein

• UK is ~16% of energy intake for a sedentary adult (approx 64-88g/d)

RNI is the amount of a nutrient that is enough to ensure that the needs of nearly all a group (97.5%) are being met i.e. the majority will need less.

The amount of each nutrient needed differs between individuals and at different life stages. Individual requirements of each nutrient are related to a person’s age, gender, level of physical activity and health status.

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How much is too much?

- Global patterns of meat consumption reveal trends towards increased meat consumption.
- Consumption of red and processed meat has been associated with an increased risk of colorectal cancer.

- WCRF & WHO recommendations for cancer prevention encourage people to limit their consumption of red meat to less than 500g a week (with emphasis on less processed meat).
- From systematically reviewed evidence linking diet and food intake patterns to cancer risk.


High protein diets for weight loss

Satiety and weight control

- Increased protein intake during calorie deficit is beneficial for appetite control
- Around 30% protein, 30% fat and 40% carbohydrate from energy
- The amount of protein is more important than the type

- Increased dietary protein may serve as one dietary strategy to improve weight management by reducing body weight and fat mass while concomitantly preserving lean mass (Leidy et al. 2015a, 2015b).

- These improvements appear to occur as a result of key modulations in appetite control and satiety, leading to reductions in daily intake (Leidy et al. 2015a, 2015b).

- Notably, protein quantity, quality, and timing of consumption may have effects on the practical outcomes and ingestive behaviour mechanisms-of-action that influence weight management.
Satiety and weight control

Not a low-carbohydrate diet
- 30% protein
- 40% CHO
- 30% Fat

- Greater fat loss
- Retention of lean body mass
- Compliance – adherence up to 6 months
- Palatable diet
- Mixed protein sources

- Weigh up benefits of fat loss versus risk of dietary restriction

One of the main reasons people do not stick with their weight loss diet is because they feel hungry

Protein is effective at reducing hunger so you are not tempted to snack


30% protein for an overweight man 100kg is 148g for example 50g per meal

30% protein for an overweight woman 75kg is 90g for example 30g per meal
Satiety and weight control

Over the past 4 years, there have been 6 meta-analyses performed to assess whether high-protein diets differentially impact weight loss and changes in body composition over the short- and longer term.

*Bueno et al. 2013; Clifton et al. 2014; Dong et al. 2013; Santesso et al. 2012; Schwingshackl and Hoffmann 2013; Wycherley et al. 2013*

In the shorter term studies of ≤1 year, the high-protein diets, ranging from 16%–45% of daily intake as protein (i.e. 1.2–1.6 g/(kg·day)) illustrated greater weight loss, fat mass loss, and/or preservation of lean mass compared with the normal-protein diets containing 5%–23% of intake as protein.

*Dong et al. 2013; Santesso et al. 2012; Wycherley et al. 2013*

The longer term studies (≥1 year), the high-protein diets within the meta-analyses again led to greater weight loss and fat mass losses compared with the normal-protein versions.

*Bueno et al. 2013; Clifton et al. 2014*

*Issues - the greater preservation of lean mass detected in the shorter term studies was not found with the longer term studies. One potential reason for these conflicting findings might include the lack of dietary compliance to the longer term diets.*
Functional use of protein for healthy ageing

• Few studies directly assess *appetite* in the elderly and how to deliver food to maximize nutrition.

• Incorporating more *protein* into the diet may be an intervention target for frailty prevention (prevent sarcopenia), as higher protein intakes are shown to decrease the risk of frailty.

• Designing foods for specific situations like in *elderly* subjects with poor appetite may modulate the pathophysiological processes leading to muscle loss.

• The data collected in elderly subjects address a key nutrition area on undernourished elderly, where *optimizing protein and calorie intake* can be a challenge with poor appetite associated with ageing.

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Muscle development (Muscle hypertrophy)

• Just increasing protein intake will not increase muscularity!

• General rule for adults - more than 30 g protein in a single meal does not further enhance the stimulation of muscle protein synthesis in young and elderly

• Irrespective of source, meals should contain a moderate amount of high-quality protein (slight differences in digestability and bio-availability of protein rich foods)

The aim is to assess food-gut-brain interactions in the regulation of appetite across the lifespan.

Assess differences between:
- Four different age groups (children, adolescents, adult, and elderly)
- Two sexes (male and female)
- Two different weight categories (normal and overweight/obese)
- Different cultures across EU

Three levels of operation:
- Behavioural pattern – when & what you eat
- Peripheral physiology & metabolism – blood samples
- Brain activity – fMRI scanning

Expression of Appetite across the lifecourse

Investigation of the role of dietary protein at breakfast on appetite control in lean, and normal weight, elderly subjects: body mass influence on appetite?

23 subjects as lean (16F, 7M, BMI 18-22; age 65-74 years)
27 as normal weight (13F, 14M, BMI 22-27; age 65-75 years)

Subjects received two drinks (XXL Nutrition, Whey Delicious, Helmond, the Netherlands), on two separate days, presented in a randomised order, relating to
(i) high protein 60g
(ii) normal protein 30g

Assessment of appetite
Subjects consumed the drink for breakfast and recorded subjective appetite throughout the morning, up to 3 hours after consumption.

Assessment of nutrition
Subjects were then recorded ad libitum food intake and a food diary to record intake for the rest of the day.
• On average, subjects (n=50) report feeling more hungry (p<0.001) and less full (p<0.001) and elevated appetite score (p<0.001) after consuming the normal protein drink compared to the high protein drink.

• Elderly subjects were able to detect differences in appetite in response to a short-term morning meal manipulation.

• There were no gender effects noted.

Even although subjects detected a difference in subjective motivation to eat, they consumed a similar amount of food and energy during the remainder of the day (1,491 kcal and 1,476 kcal after the HP and NP breakfast drinks, respectively).
Summary-
• Healthy lean and normal weight subjects responded similarly to the dietary protein intervention, suggesting appetite physiological cues were intact: neither group compensated for the increased protein/calorie intake.
• Liquid calories may be a beneficial strategy for improving protein-energy intake to prevent sarcopenia in elderly.
• A high protein breakfast could be especially beneficial to the undernourished elderly.

Key findings -
• It has been identified that undernourished elderly do not detect a protein-calorie surplus as a breakfast meal and this had no impact on subsequent calorie intake later the same day.
• Thus, a high protein, high calorie breakfast meal, in a diary liquid format was beneficial at maximizing nutrition quality in a group of undernourished elderly.
Summary

• Substantial evidence indicates that protein intakes higher than the current RDA can be an important strategy to help promote healthy aging and weight management.

• Protein quality, per-meal dose, and timing are also important considerations in practice.

• Current evidence suggests that intakes of high-quality protein in the range of 1.2–1.6 g/(kg·day) is a more ideal target to achieve optimal health outcomes in adults with plant-based protein sources.
Topics

• Why we shouldn’t ignore protein

• Current protein recommendations – are they functional enough?

• New research on types of proteins and benefits (plant vs. animal)

• Ideas for protein NPD and examples of products

• Protein claims and how to use them
In the UK, according to the NDNS, for adults aged 1964 years, the main protein intake was from animal sources, especially meat and processed meat, as follows:

- chicken and turkey 20.3%
- followed by beef and veal 15.5%
- other types of meat and processed meat 17%
- fish (oily and white) 9.3%
- eggs 6.7%

The only plant-based protein source mentioned in the survey was baked beans at 7.0% (Henderson, Gregory, Irving, & Swan, 2003).
The main source of protein in the Western world diet is of animal origin, followed by dairy, and scarcely from plant sources.

Top 10 protein sources in the UK

1. Chicken and Turkey dishes 20.3%
2. Beef and Veal dishes 15.5%
3. Baked Beans 7.0%
4. Eggs 6.7%
5. Bacon and Ham 6.6%
6. Meat Pies and Pastries 6.3%
7. Oily Fish 5.4%
8. Sausages 4.2%
9. Pork and Pork dishes 3.9%
10. White Fish coated and/or fried 3.9%
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Sans and Combris (2015) have recently published a review which encompassed worldwide meat consumption pattern over the last 50 years, observing that this rose from 23.1 kg per person per year in 1961 to 42.20 kg/person/year in 2011.

Sustainability of protein source

- Current global meat consumption impacts on the environment, and yet consumption is rising in many developing nations.
- As much as 32 per cent of greenhouse gas emissions come from rearing livestock, a third of the world’s cultivated land is used to grow animal feed, and it takes 15,500 (a small swimming pool) to produce 1kg of beef
- ‘Eat less meat but better’
- Alternative, sustainable sources of protein for farm (animal feed) to fork (human food)
Definition of a sustainable diet

‘Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.’

‘Diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations.

• Test the compatibility of dietary requirements for health and dietary changes to reduce greenhouse gas emissions, using mathematical modelling.
• To create and prepare a sample menu to test whether the food list from the model was realistic, acceptable and affordable.

Besides the environmental and ethical considerations mentioned above, a transition towards plant-based diets is also supported by public health considerations.

The World Health Organization (WHO) actively promotes an increase in consumption of fruits and vegetables, legumes, whole grains, and nuts among other dietary recommendations for nutrient intakes in order to prevent chronic diseases (WHO, 2015).

World Cancer Research Fund (WCRF) report suggests that if people eat 50g of processed meat a day then their bowel cancer risk is increased by 20 per cent.
Nine amino acids are classified as dietary essentials in human nutrition: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine (Tome, 2012)

- Amino acid balance in a particular protein source can be scored against that of a reference protein, typically hen’s egg (regarded as well-balanced in relation to adult human metabolic needs) or milk (Michaels, 2004)

- Plant-based proteins cannot replicate this balance on their own, because each type of plant protein displays a characteristic set of limiting amino acids

- However, the amino acid composition of foods only represents the potential quality of a protein food and not its quality in practice (biological value)

- A critical factor is the bioavailability of the amino acids within the human body after ingestion, which offers the required supply of amino acids in human diet (effect of cooking)

From a nutritional point of view, all legume-derived proteins are relatively low in sulfur-containing amino acids, methionine, cysteine, and tryptophan, but the amounts of other essential amino acids, such as lysine, are much greater than in cereal grains (e.g. beans on toast)

In order to achieve a diet balanced in amino acids, complementation and diversification of plant-based proteins would be a feasible and sustainable solution.

Protein distribution

Besides protein quantity, considerable interest currently focuses on patterns of protein intake throughout the day.

The suggestion to distribute protein intake equally at each meal to favour protein anabolism stems from 2 main concepts (Paddon-Jones and Rasmussen, 2009).

(i) First, because essential amino acids (EAA), leucine in particular, themselves stimulate muscle protein synthesis (Volpi et al. 2003), a threshold of high-quality protein intake must be reached at each meal.

(ii) Second, excess dietary amino acids beyond the capacity to maximally stimulate protein synthesis are not stored but oxidized, and may therefore be considered “wasted”.

Unique benefit of including 30 g of protein at the morning meal for longer term improvements in weight management.

Protein quality and weight management

Appetite control for weight loss: plant protein

- High protein diets are satiating during weight loss but there is limited evidence on different sources of protein on appetite during chronic feeding.

- Vegetable and animal (meat) protein diets can have contrasting effects on indices of health, and may influence appetite.

- We investigated if vegetarian (plant protein, soya) weight loss diet had a similar effect as animal (meat) protein rich diet.

Type of protein for appetite control: animal and plant sources

- Weight loss of 2.41 and 2.27 kg on vegetarian & meat diets, respectively (p=0.356, SED 3.7)
- Similar appetite control (motivation to eat)

- Scant evidence to support/reject plant protein for appetite control
- Gilbert et al, (2011) reviewed protein source on body composition during weight loss, aside from the appetite effects.
- Animal proteins, especially those from dairy, seem to support better muscle protein synthesis during weight reduction regimes in comparison to plant proteins because they contain all essential amino acids and are generally well digested.


Protein as a functional food – the future

Protein plays a critical role in human nutrition. Although animal-derived proteins constitute the majority of the protein we consume, plant-derived proteins can satisfy the same requirement with less environmental impact.

*Sustainable Protein Sources* allows readers to understand how alternative proteins such as plant, fungal, algal, and insect protein can take the place of more costly and less efficient animal-based sources.
New non-meat plant protein products

- Canola/Rapeseed
- Sorghum and Millets
- Rice Protein Protein From Flaxseed
- Hemp Seed
- Protein From Oat
- Pea
- Lentil: Revival of Poor Man’s Meat
- Lupin (but allergen)
- Peanut Products (but allergen)
- Quinoa
- Amaranth
- Chia
- Mycoprotein
- Edible Insects
- Microalgae (Chlorella)

Canola or Rapeseed oil

- OIL - 35-38% of seed dry weight
- PROTEIN – 21-23% seed dry weight can be recovered from the oil-extracted meal, which contains all seed constituents other than oil and oil-soluble compounds

Oil is generally used worldwide for human consumption and a small fraction is used as feedstock for biodiesel production in Europe and Canada

- saturated FA (~7%)
- monounsaturated FA (61%)
- polyunsaturated FA (32%)
- omega-6 (21%) & omega-3 (one-third of total PUFA)

Approximately 90% of the proteins are storage proteins. The major seed storage proteins of crucifers are 11S cruciferin of cupin superfamily and 2S napin of prolamin superfamily.

Other minor proteins, the oil body proteins (OBP), and lipid transfer proteins (LTP)
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Few studies directly assess *appetite* in the elderly and how to deliver food to maximize nutrition and prevent sarcopenia (multi-nutritional strategy).

‘One diet approach’ does not fit all people - public health advice and food strategies need to be tailored for specific phenotypes to generate a sustainable & healthy approach for appetite control.

Identify barriers to acceptance (consumers/industry)

Research and innovation – reformulation for ‘health by stealth’ or substitution for ‘reformulation’

Preparation of protein isolates for food industry
Targeted marketing (evidence base)
Gluten free or free from growth
Lifestyle choice – target ageing population
The big breakfast study: chrono-nutrition influence on energy expenditure and body weight (2017-2020)
Chrono-nutrition – circadian biology and timing of eating

- ‘Eating breakfast’ is already an important public health message - time of the day a large meal is eaten may influence body weight
- ‘Breakfast like a king and dine like a pauper’ is not just a myth?
- Time of day is a modifiable factor influencing energy balance and body weight and thus, disease risk – important for shift workers
- Dietary intervention studies show that calories ingested at different times of the day have different effects on energy utilization, leading to differential weight loss, even at iso-caloric amounts

From Jakubowicz et al (2013). Between group comparison of weight loss of women on isocaloric weight loss diets
Open circles small breakfast, big dinner
Closed circles: big breakfast, small dinner
By 2050 40% of the UK population will be over 50 (ONS)

- This is a public health challenge
- This is a market opportunity

‘Ageing well’ – is priority public health message (WHO)

- 50% of adults fail to meet the RDA for protein
- Failure to address this will have significant impact on public health
- Unmet need for this consumer - We are failing to address this need

OUR RESEARCH QUESTION IS: How do we maintain a healthy protein intake in an ageing population?

OUR AIM IS: To develop and to disseminate a set of design rules for formulation of palatable higher-protein foods, for an ageing population

Clear benefit to industry for effective reformulation and new product development.

Cost

Palatability
Future application of dietary protein for weight management in food industry context

Working alongside the food/drinks industry, food scientists and food manufacturers can develop plant sources of protein can be effectively utilised as part of a healthy but sustainable diet.

Protein remains a promising dietary tool to control appetite during weight loss:
- Type of protein less important than amount (g/kcal or %)
- Elevated levels of dietary protein during energy restriction is effective for satiety & satiation – in combination with carbohydrate
- Reproducible results over longer term required, especially for type of protein (plant)

It is unlikely that the population will turn to a complete vegetarian diet, but substitution of alternative (non-meat) sources of protein may be a sustainable route for consumers.

Collectively, these data support the consumption of higher protein diets (1.2–1.6 g/(kg·day)), including 30 g protein per eating occasion, to improve appetite control, satiety, and weight management.
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• Protein claims and how to use them
king prawn, hot smoked Scottish Lochmuir™ salmon, quinoa & couscous salad
with a lemon vinaigrette

Serves 1. This pack provides
Energy Fat Saturates Sugars Salt
7.2g 1.8g 0.5g 6.2g 1.06g
18% 11% 0% 7% 16%

of your Reference intake
per 100g Energy 457kcal 1088kcal

USE BY 25/11/2016
1. Must result in changes in energy intake (if this is claimed physiological effect rather than decreased body weight)
2. Must be sustained across day – no compensation
3. Must be enduring – observable e.g. Up to four weeks during dosing
4. Biomarkers useful for proof-of-concept but not necessary for efficacy
5. Appetite ratings must be assessed using VAS.

Appetite

1. Considered only in context of decreased body weight - intake no longer as important but body weight is (most claims to date focus on intake – and are negative)?
2. Must be sustained (12 weeks) with continuous consumption of food to exclude adaptation through compensatory mechanisms – must have body weight change to make any communication on appetite (how many claims have actually been reviewed with body weight)?
3. Biomarkers may support behavioural assessment
4. Behavioural assessment (appetite ratings) must be assessed using VAS.

‘Claims on changes in appetite ratings have been made in the context of body weight. In this context evidence for a sustained effect on appetite ratings and body weight with continuous consumption of the food, should be provided’

Food approach for improving nutritional intake (emphasis on obesity)

• Healthy and safe food: Understanding the links between diet and health - optimisation of product formulation through new uses of existing ingredients, novel ingredients and novel formulations

• Different foods have different effects on appetite systems
• Can effects on short-term appetite regulation be translated into sustained reductions in energy intake and then into long term health benefit?
• Current requirements for a successful EFSA health claim – striking the right balance between protecting the consumer and discouraging innovation in the food sector
• Population level application through behaviour change
• Targeted approaches for different consumer groups
Improving nutritional intake
- bioactives and bioavailability

Satiety – efficacy of macronutrients/metabolites
- protein
- fibre
- SCFAs

Sustainability of ingredients
- maintaining the healthiness of foods
- trade-offs between healthiness and GHG emissions

Natural products and health
- blueberries and glycaemic control
- wholegrains and blood pressure

Consumer (food) choice, barriers to change
- socioeconomic, psychological, educational
- demographics, inequalities

Diet and lifestyle change to address chronic ill health and promote healthy ageing

Dietary choices are a key component of 'health' behaviour - what people choose to eat ultimately determines the relationship between diet and health

Promoting healthier dietary choices and exploiting habitual choice? - reformulation

Bringing together academics, policy makers and the food and drink industry

Multidisciplinary approaches – molecular/mechanistic, sensory, psychological, economic

Behaviour change – a non-invasive approach to managing the epidemic of non-communicable disease

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**Shoppers prioritise health ahead of ethics and the environment**

- Given shoppers’ current priority of saving money, it is no surprise that price and promotions play the most significant role in product choice decisions
- Quality ranks third and is often the gateway to thinking about sustainability issues
- Shoppers are primarily focused on the direct benefit to both themselves and their families when choosing products, and health ranks above ethical considerations in most people’s shopping decision hierarchy
- Nearly half of shoppers (49%) say healthy options are important when they are choosing which products to buy. This is significantly higher than those stating that ethical considerations are important (one in five)
- However, sustainability can play an important role when shoppers are choosing between products

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**Importance of differing factors in product choice**

1. Price 91%
2. Promotions 68%
3. Quality or performance 63%
4. Taste or smell 53%
5. Healthy option 49%
6. Use by or sell by date 47%
7. Familiarity 46%
8. Brand 35%
9. Ease of use 20%
10. Ethical or eco-friendly 19%

Q. Rank your five most important considerations when shopping. Please think about the individual food and grocery products that you buy.

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• Dietary choices are a key component of ‘health’ behaviour - what people choose to eat ultimately determines the relationship between diet and health

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• Multidisciplinary approaches – molecular/mechanistic, sensory, psychological, economic

Take-home messages

• Because of anabolic resistance, sedentary lifestyles, and common illnesses, older adults need higher protein intakes (≥1.2 g/(kg·day)) to help prevent age-related sarcopenia.

• Including a high-quality protein source at breakfast, the meal generally containing the least protein, is a simple and pragmatic approach to increase intakes in older adults, and has also been shown to reduce unhealthy snacking behaviour in younger individuals.

• The consumption of higher protein diets (1.2–1.6 g/(kg·day)), including 30 g protein per eating occasion, improves appetite control, satiety, and weight management.

• High-quality protein from animal-based sources (e.g., milk, meat, poultry, and eggs) provide a concentrated source of essential amino acids, including leucine, to maximize muscle protein synthesis, with relatively few calories compared with plant-based protein sources.

Acknowledgments

http://www.abdn.ac.uk/rowett/research/strategic-partnership.php

‘Healthy safe diets’ & Health impacts of sustainable ingredient selection in the food and drink industry

Full4Health http://www.full4health.eu

SATIN http://www.satin-satiety.eu

NeuroFAST http://www.neurofast.eu
Knowledge Exchange

Impact of our research

- Working with food industry
- Education
- Communicating science

Academic partnership with food industry

Massive Open Online Course (MOOC)
Delivered worldwide as a free digital learning tool

May Festival
Explore your imagination
Thank you – questions?

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