The role of carbohydrates in supporting weight management: One Step Beyond!!!

Food matters live – Gary Frost
Dietary fibre & obesity

Over arching hypothesis:

$\uparrow$ fibre intake $\rightarrow$ $\downarrow$ appetite & energy intake

Paleolithic era:

- >100g/day
- 50% of energy needs

Today:

- <15g/day
- 2% of energy needs
Making the most of energy dilute diet

- Efficiently metabolised source of energy

Gut microbiome composition and metabolomic profiles of wild western lowland gorillas (*Gorilla gorilla gorilla*) reflect host ecology.

gut microbiomes and metabolomes of these gorilla groups. Distinctions seemed to relate to feeding behaviour, implying energy harvest through increased fruit consumption or fermentation of highly fibrous foods. These observations were supported by differential abundance of metabolites and bacterial taxa associated with the metabolism of cellulose, phenolics, organic acids, simple sugars, lipids and sterols between gorillas occupying different geographical ranges. Additionally, the gut microbiomes of a gorilla group
“Dietary fibre” and body weight
A major challenge

Mean changes in subjective appetite and body weight by fibre dose, viscosity and fermentability. Black symbols, more viscous fibres; white symbols, less viscous fibres. Squares, more fermentable fibres; circles, less fermentable fibres. Regression lines: —, overall; - - - -, more viscous fibres; ·····, more fermentable fibres.
Inulin and Appetite

Bar graphs showing the effect of inulin dose on hunger score and 24-hour energy intake. The graphs indicate a decrease in hunger score and energy intake with increasing inulin dose.

Line graph comparing PYY levels over time between inulin (35g/day) and control groups. The graph shows higher PYY levels in the inulin group compared to the control group.
A LITTLE LOOK AT CARBOHYDRATE
Complex structure
Does obesity represent a disruption of food structure
A LITTLE LOOK AT GUT HORMONES
Cholecystokinin
Gall bladder contraction
Gastrointestinal motility
Pancreatic exocrine secretion
**Secretin**
Pancreatic exocrine secretion
**GIP**
Incretin activity
**Motilin**
Gastrointestinal motility

**Ghrelin**
Hunger
Growth hormone release
**Gastrin**
Acid secretion

**Insulin and glucagon**
Glucose homeostasis
**Pancreatic polypeptide**
Gastric motility
Satiation
**Amylin**
Glucose homeostasis
Gastric motility

**GLP-1**
Incretin activity
Satiation
**GLP-2**
Gastrointestinal motility and growth
**Oxyntomodulin**
Satiation
Acid secretion
**PYY</script>**
Satiation

Duodenum
Pancreas
Colon
Small intestine
Post-prandial secretion of PYY

Adrian et al. (1985), Gastroenterology 89:1070-7
And nutritional status

Figure 1. Mean (±SE) Changes in Weight from Baseline to Week 62. The weight-loss program was started at week 0 and completed at week 10. ITT denotes intention to treat.

Figure 2. Mean (±SE) Fasting and Postprandial Levels of Ghrelin, Peptide YY, Amylin, and Cholecystokinin (CCK) at Baseline, 10 Weeks, and 62 Weeks.
WHAT HAS THIS TO DO WITH DIET?
Enteroendocrine cells

- P/D1 - ghrelin
- G cell – gastrin
- I cells - CCK
- K cells – GIP
- S cells – sectrin
- N cells - neurotensin
- L cell – GLP-1 and PYY
- All variants of one cell population

Each cell expresses a large array of G protein coupled receptor nutrient receptors.
Colon

Non-digestible carbohydrates

\[ \rightarrow \]

Colonic bacterial fermentation
Figure 2 Microbial microenvironments within the large intestine

Flint, H. J. et al. (2012) The role of the gut microbiota in nutrition and health
Short chain fatty acids (SCFA)

Non-digestible carbohydrates → Colonic bacterial fermentation →

- Acetic acid: 60%
- Propionic acid: 25%
- Butyric acid: 15%
Free Fatty Acid Receptor (FFAR) 2 and 3

Acetate = Propionate >> Butyrate

Propionate > Butyrate >> Acetate

GPR43

FFAR 2

FFAR 3

GPR41

GI Tract

Adipose Tissue

Pancreas

Peripheral Nervous System
Enteroendocrine L cells

Carbohydrates

Gut microbiota

SCFA (propionate, acetate, butyrate etc)

7TM chemosensors

SCFA

GPR41

GPR43

GI-tract hormones

Lower GI

PYY

GLP-1

GLP-2 etc.

Paracrine functions

Neuronal functions - afferent vagal, splanchnic and enteric nerves

Endocrine functions

Engelstoft et al., 2008
Density distribution of free fatty acid receptor 2 (FFA2)-expressing and GLP-1-producing enteroendocrine L cells in human and rat lower intestine, and increased cell numbers after ingestion of fructo-oligosaccharide

Izumi Kaji · Shin-ichiro Karaki · Ryo Tanaka · Atsukazu Kuwahara
Proposed mechanism

Increased body weight as a result of calorie excess

High fat diet

Nutrients

Appetite

Intestinal tract

PYY cell

Body weight gain

Appetite

Intestinal tract

PYY cell

FFAR2

High fat diet + inulin

SCFA
TRANSLATE THIS
Functional fibre: Propionate inulin ester

Inulin

Propionate

Douglas Morrison and Tom Preston
University of Glasgow
Inulin-Propionate Ester
Inulin-Propionate Ester
Inulin-Propionate Ester
Inulin-Propionate Ester

GLP-1 and PYY

Food Intake
Acute Supplementation: Results

![Bar graph showing food intake (Kcal) for Control and Propionate Ester groups.](image)

![Line graph showing individual food intake (Kcal) for Control and Propionate Ester groups.](image)
Acute Supplementation: Results

- **Δ PYY (pmol/L)**
  - Propionate Ester
  - Control
  - Time (min): 60, 120, 180, 240, 300, 360, 420

- **Δ GLP-1 (pmol/L)**
  - Propionate Ester
  - Control
  - Time (min): 60, 120, 180, 240, 300, 360, 420

- **Δ PYY AUC**
  - Propionate Ester
  - Control
  - Time: 0-240min, 240-420min

- **Δ GLP-1 AUC**
  - Propionate Ester
  - Control
  - Time: 0-240min, 240-420min
Randomised Controlled Trial: Results

- Graph showing change in body weight over weeks for Propionate Ester and Control groups.
- Bar chart comparing percentage of subjects with ≥3% and ≥5% weight gain in Propionate Ester (N = 25) and Control (N = 24) groups.
SCFA have positive biological effects – leading to improved appetite regulation and glucose homeostasis

- Increased concentrations of SCFA
- Increased dietary NDCs
- Increased fermentation
- Reduced cholesterol synthesis
- Reduced glucose output
- Reduced inflammation
- FFAR2/3
- FFAR2/3
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- Reduced free fatty acid output
- Increased lipogenesis
- Increased leptin secretion
- Reduced inflammation
- Change in gut flora
- Increase in PYY & GLP-1
- Increased anorexigenic signalling
- Reduced appetite and food intake
- Improved insulin sensitivity
Acknowledgements

Imperial College
Division of Diabetes, Endocrinology, and Metabolism: Gary Frost, Gavin Bewick, Kevin Murphy, Waljit Dhillon, Alex Viardot, Sagen Zac-Varghese, Arianna Psichas, Michelle Sleeth, Jen Parker, Ed Chambers, Steve Bloom
Metabolic and Molecular imaging group: Jimmy Bell, Louise Thomas, Tony Goldstone, Meliz Sahuri, Jelena Anastasovska, Leigh Brody
Cellular Stress Group: Dave Carling, Huza Zhang
Biological Imaging Centre: Magdy Khalil
Molecular Endocrinology: Aylin Hanyaloglu
Cancer and Surgery: Jermy Nicholson, Elaine Holmes and Isabel Garcia
Kings College: Shanta Persaud
University of Glasgow: Douglas Morrison, Tom Preston
IFR: Pete Wild
University of Leeds: John Blundell

UCL: Patrice Cani