Plant foods, gut bacteria and sleep – the effect of their interactions on our health.

Shanthi Parkar
Probiota Asia, 22-24th, October, 2019
Our Core Purpose:
Enhance the value and productivity of New Zealand’s horticultural, arable, seafood, and food and beverage industries to contribute to economic growth and the environmental and social prosperity of New Zealand.
» **In vitro & In vivo models** to study food-microbiota-host interactions

» **Identify novel bacteria** that breakdown plant foods

» **Foods & ingredients** that modulate gut bacteria

» **Science-validated food solutions** that benefit consumers globally

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Plant foods, sleep and gut bacteria

Adapted from Parkar, S.G.; et al. Microorganisms 2019, 7, 41
Circadian rhythm

- Highest testosterone secretion: 10:00
- Bowel movement likely: 08:30
- Melatonin secretion stops: 07:30
- Sharpest rise in blood pressure: 06:45
- Lowest body temperature: 04:30
- Deepest sleep: 02:00
- Noon: 12:00
- Best coordination: 14:30
- Fastest reaction time: 15:30
- Greatest cardiovascular efficiency and muscle strength: 17:00
- Highest blood pressure: 18:30
- Highest body temperature: 19:00
- Melatonin secretion starts: 21:00
- Bowel movements suppressed: 22:30

GYassineMrabet, Wikipedia
Circadian rhythm effects on health

Central and peripheral clock are controlled by core clock genes:

- Per 1/2/3
- Cry 1/2/3
- Clock
- Bmal1

Sleep is a periodically occurring state of reduced consciousness, precisely controlled by 3 factors - circadian rhythms, sleep drive and emotional/cognitive inputs

Rapid Eye Movement (REM) – information processing, mood
Non-REM – maintenance of body, immune, “cleaning up” the hard drive

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Sleep disruption has short term & long term consequences

- Normal adult ~7-8 h sleep, immune, metabolic and brain health

- Sleep deprivation has short term and long term consequences

1. Alzheimer’s disease
   - Increased Aβ & tau pathology
   - Increased Wakefulness & Decreased Sleep
     - ↑ ISF and CSF Aβ levels
     - ↑ ISF and CSF tau levels
     - ↑ Amyloid plaques
     - ↑ Tau propagation & spreading
     - ↑ Cognitive deficits
     - ↑ Inflammation

2. Type-2 diabetes
   - ↑ Glucose & insulin dysregulation
   - ↑ HbA1c
   - ↑ Hyperglycemia
   - ↑ Glucose intolerance
   - ↑ Insulin resistance
   - ↑ Inflammation

3. Glucose intolerance & Insulin Resistance

References:
1. Briancon-Marjollet, A.; et Al.. Diabetology & Metabolic Syndrome 2015, 7
Economic costs of insufficient sleep across five countries

Total % sleep < 7 h

Causes of poor sleep
- Insomnia
- Stress
- Frequent flying
- Shift work
- Social jet lag

Hafner, M.;et. al.. *Rand Europe Health Q* 2017, 6, 11.
People with poor sleep have poor gut microbiome

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Smith, R. P., et. al. *PLOS ONE*, 14(10)
Gut microbial balance and health

- Metabolism
- Synthesis of vitamins
- Extraction of energy
- Immune health
- Behaviour
- Mental health

- Obesity
- Diabetes
- Allergy
- Infections
- Intestinal disease
- Sleep
SCFA= Short Chain Fatty Acids
Acetate: Propionate: Butyrate ; ~ 60:20:20

Gut bacteria; $10^{11}$/g
~ 65 : 25: 10; Firmicutes: Bacteroidetes : (Actinobacteria, Proteobacteria, etc)
Butyrate affects clock genes and sleep measures

- saline
- butyrate

Intraportal butyrate “prepares” the body for sleep.

Hepato-portal peripheral sleep signal.

Lowers body temperature

Leone, V et al.. *Cell Host & Microbe*, 2015, 17, 681-689)

Gut bacteria have circadian rhythmicity

Feeding regime affects gut bacteria and circadian rhythms

- Inulin increases *Bifidobacterium*
- Prebiotics also stimulate Lachnospiraceae & Ruminococcaceae that generate butyrate \(^1\).
- **High fibre** advanced *per2* rhythms in mice as compared to fasting, and **low fibre diets** \(^2\).

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Studying kiwifruit in a gut model

- Green and gold kiwiruit
- Gastric digestion
  - Pepsin, pH 2.5, 30 min
- Small intestinal digestion and absorption
  - Pancreatin, amyloglucosidase, pH 6.0, 2 h, dialysis
- Colonic fermentation, 37°C, 16 h
  - 1% faeces (n = 10), 5% CO₂, 5% H₂, 90% N₂, 70 rpm
- Microbial organic acids assayed
- Microbiome analyses by 16S RNA sequencing

- ‘Hayward’ ↑ maximum lactate
- All the kiwifruit and inulin
  - ↑ Bifidobacterium
- All kiwifruit but not inulin
  - ↑ Ruminococcaceae and Faecalibacterium and
  - ↓ Bacteroides

Kiwifruit enhances *per2* in rat intestine

normal chow or 20% kiwifruit for 14 days
24 day old rat pups benefitted from better sleep when they were fed a cocktail containing two prebiotics i.e. galactooligosaccharides and polydextrose, along with milk components. A low abundance Deferribacteres negatively correlated with NREM. Lactobacillus casei strain Shirota increased the deep slow wave sleep as the exam approached (memory consolidation).
Meal timing and the eating window are important

- Time-restricted feeding (TRF) restores metabolic health and gut microbial rhythmicity

Circadian rhythm effects on health

Central and peripheral clock are controlled by core clock genes:

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Adapted from Takahashi, Science 2010, 330.; Parkar, S.G.; et al.. Microorganisms 2019, 7, 41.
Conclusions

» Poor sleep and diet affect gut bacteria.

» Plant foods rich in fibre and polyphenols help to restore gut microbial community balance.

» Microbial metabolites may improve many of the metabolic disturbances ensuing from poor sleep.

» What and when we eat may help us to regulate sleep and protect against health problems caused by poor sleep.
Chrononutrition

Improving energy and performance for consumers with poor sleep

SCIENTIFICALLY-VALIDATED CHRONONUTRITION SOLUTIONS:

→ Whole foods
→ Functional fibres & phytochemicals
→ Manufactured food & beverages

BENEFITS:

→ Energy
→ Alertness
→ Performance
→ Productivity

MARKET SIZE: 1/4 of world population

→ Late nights / early starts
→ Shift work
→ Social jet lag
→ Delayed bed times
Thank you

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Potential microbiome influence on circadian disruption

Parkar, S.G.; et al. *Microorganisms* 2019, 7, 41