



Effects of spices and green tea on energy balance

– Opportunities for prevention of obesity

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Øresund Food Network, Winter School
Seminar "Bioactive compounds – Potential for prevention of diseases"

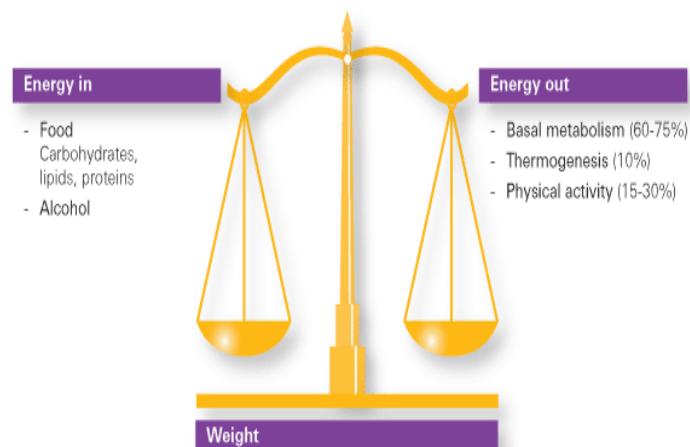
March 9, 2010, 14.40-15.10 hr.
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ENERGY BALANCE

ENERGY BALANCE



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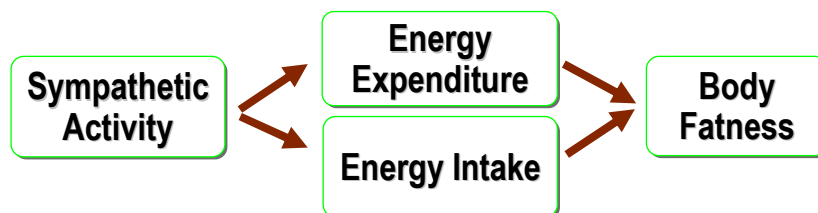
WHY IS THIS SUBJECT INTERESTING?

- During adulthood the EE decrease by approximately 40 kJ/d/y
- When changes this small may lead to obesity – there is a possible relevance for using bioactive components to induce these effects
- Bioactive components – Def.:
 - Essential and non-essential compounds (e.g., vitamins or polyphenols) that occur in nature, are part of the food chain, and can be shown to have an effect on human health (Biesalski et al., Nutrition 2009)



MECHANISMS – BRIEF OVERVIEW

- TRPV1-receptor found on free nerve endings can be activated by BC's (Trigeminal nerve)
- Food sensed, digested and absorbed in the GI tract – satiety signals and sensory input provide negative feedback via the Vagus nerve – to the brain



- Catecholamines – especially noradrenaline (NA) a neurotransmitter in the SNS – transduces the signals between neurones
- Increased NA – Increased SNS activity
- NA binding to both β 1- and β 2-adrenoreceptors results in increased thermogenesis and lipolysis



METHODS USED WHEN EXAMINING EFFECTS ON ENERGY BALANCE

- **Effects on EI/appetite can be measured using:**

- Visual Analogue Scales (VAS)
- Ad libitum meals
- Blood samples – appetite hormones
 - GLP-1, PYY, OXM, PP, CCK – and Ghrelin

- **Effects on EE can be measured using:**

- Indirect calorimetry
 - Ventilated hoods, Respiration chambers

- **Long-term:**

- Weight loss
- Fat loss

1. Hvor sulten er du? _____
 Jeg er ikke sulten _____ Jeg har aldrig været mere sulten

2. Hvor fyldt føler du dig? _____
 Min mave er helt tom _____ Jeg kan ikke få en bid mere ned

3. Hvor mæt føler du dig? _____
 Jeg er overhovedet ikke mæt _____ Totalt mæt

4. Hvor meget tror du, du kan spise? _____
 Intet overhovedet _____ En masse

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SPICES

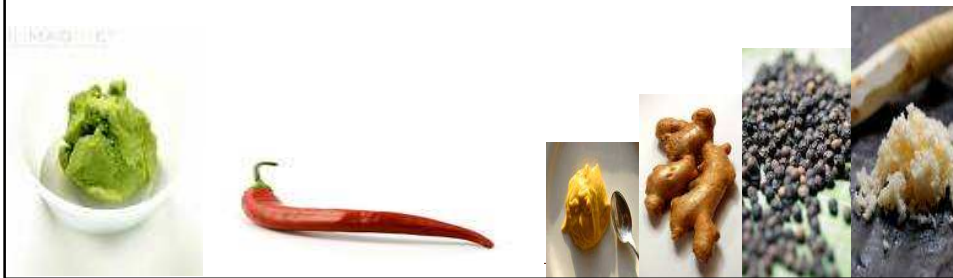


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SPICES AND THEIR MAIN BC'S

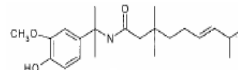
- **Chilli** – capsaicinoids: especially capsaicin
- **Black pepper** – piperine
- **Ginger** – gingerols, zingerone and shogaol
- **Horseradish** – sinigrin → isothiocyanates
- **Mustard** – sinigrin → isothiocyanates (AITC & Crotonyl ITC)
- **Wasabi** – sinigrin → isothiocyanates (AITC & sec-Butyl ITC)



CAPSAICIN (Chilli)

Capsaicin = the main bioactive component in chilli

Molecular structure (Dedov *et al.*, 2002)



- The most well-studied BC (from spices) on energy balance

Measure of how spicy a chilli is:

- The Scoville heat unit scale (amount of sugar added to neutralize the pungency, Liquid/gas chromatography, "Electric nose")

Mechanisms:

- Activation of a TRPV1-receptor (Trigeminal nerve)
- Increased secretion of catecholamines – and thereby increased thermogenesis
- β -adrenerg stimulation (β -blocking → the effect is diminished)



CAPSAICIN

Short-term studies:

- Acute increase in diet-induced thermogenesis (DIT) with up to 23%!
 - But a lot less on a 24-hr basis
- Reduction in daily EI with up to 10 %

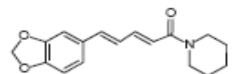
Long-term studies:

- Weight maintenance not improved – may be a compliance problem (Lejeune et al., BJN 2003)

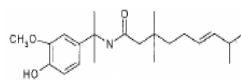


PIPERINE (Black pepper)

- The irritative component in black pepper is **Piperine**
- Molecular structure (Belitz & Grosch 1999):



1-peperoylpiperidine



capsaicin

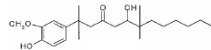
- Structural similarities with capsaicin
- Infusion of piperine in rats resulted in an increase in catecholamine levels (Kawada *et al.* 1988; Iwasaki *et al.* 2006)
- No human studies published at present
- Gregersen *et al.* showed no effects of black pepper on EE and EI (Unpublished data)



GINGEROLS, ZINGERONE AND SHOGAOL (Ginger)

Ginger:

- Rhizome of the plant *Zingiber officinale roscoe*
- The bioactive components are:
 - Gingerols (6-gingerol, 8-gingerol og zingerone)
 - Shogaol (Borrelli *et al.* 2004; Dedov *et al.* 2002)



8-gingerol

- Infusion with zingerone and shogaol in rats increased the secretion of catecholamines (Kawada *et al.* 1988; Iwasaki *et al.* 2006)
- A single published human study did not show any effects on EE in the postprandial period (n=8) (Henry *et al.* 1987)
- Gregersen *et al.* (unpublished data) did not find any effects of ginger on EE or EI (n=22) (Unpublished data)



ISOTHIOCYANATES (Mustard)

(Also relevant for horseradish and wasabi)

- Especially Allyl ITC (AITC) is responsible for the pungent taste – but not necessarily the most relevant for energy balance.
- Infusions with AITC in rats did not increase catecholamine levels
- Study: Henry & Emery (Hum. Nutr. Clin. Nutr. 1986):
 - Combination of chilli and mustard sauces added to meal
 - Large increases in DIT
 - (No single treatments)
- Gregersen *et al.* (unpublished data) showed a tendency towards an increase in DIT (30 kJ/4-hr, p=0.08) after mustard intake – but NOT horseradish



VARIATION IN CONTENT AND STRENGTH OF BC'S

Species:

- With respect to ginger there are approximately 2000 different species

Variation within the same specie:

- Climate
- The place where the plant grows
- Threats – fx from animals – can result in a very pungent taste/strong smell

These differences can result in:

- The results of clinical studies may vary as a result of the above described factors – and thus different results may not necessarily be due to differences in subjects, study design, etc.
 - This is however not true if one is studying isolated BC's – but only if you study these at a "spice level"



GREEN TEA



GREEN TEA (Catechins) – 1/2

Green tea is made from dried tea leaves that are harvested while green and fresh

Catechins is a specific group of polyphenols, which are found in large amounts in green tea

The 4 most common catechins in green tea are:

- Epigallocatechin gallate (EGCG) (the most bioactive)
- Epigallocatechin (EGC)
- Epicatechin gallate (ECG)
- Epicatechin (EC)

EGCG is believed to be primarily responsible (together with caffeine) for the effects of green tea on energy balance

(Green tea contains caffeine, so in some studies it can be difficult to distinguish the effects of caffeine and catechins)



GREEN TEA (Catechins) – 2/2

Mechanism:

- Catechins inhibits the enzyme catechol-O-methyl-transferase (COMT), which breaks down noradrenaline (NA)
- Caffeine inhibits phosphodiesterase which breaks down cAMP to AMP, and more cAMP will be present – meaning increased SNS activity

Acute effects:

- Some studies have shown large effects of green tea on EE and fat oxidation – also in addition to the caffeine effect (Dulloo *et al.*, AJCN 1999, Rumpler *et al.*, J Nutr 2001(Oolong te))
- Other studies have shown small/no effects of catechins/green tea – or effects that seemed to be primarily due to caffeine (Blom *et al.*, unpublished data, Gregersen *et al.*, BJN 2009)

Long-term effects:

- Reduction in body weight and body fat (Hase *et al.* 2001, Nagao *et al.* 2001)
- No effect of 13-week supplementation (Kovacs *et al.* 2004)



GREEN TEA meta-analysis

Hursel R et al., IJO 33(9);956-61:2009.

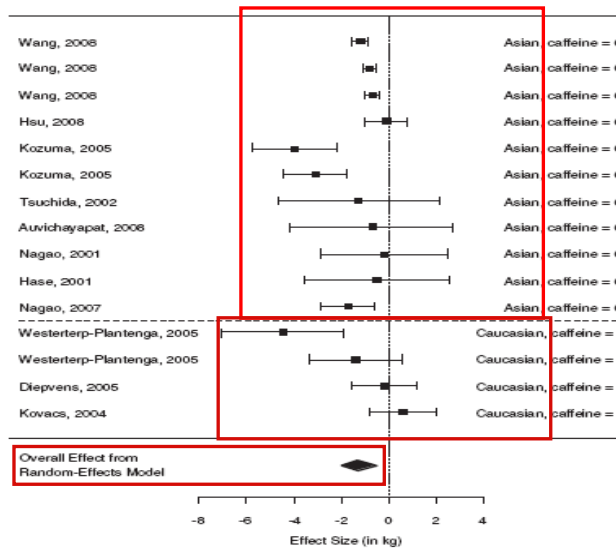


Figure 2 Forestplot of the individual effect size estimates (mean weight change within the treatment group minus mean weight change within the control group) with corresponding 95% confidence intervals (caffeine = 0/1 for low (0) or moderate-to-high (1) regular caffeine intake).

COMBINATIONS OF BIOACTIVE COMPONENTS



POTENTIAL MECHANISMS FOR EFFECTS OF COMBINATIONS OF BC'S

Study by Belza et al., IJO 2007;31:121-130:

- Bioactive supplement consisted of capsaicin, catechins, caffeine and tyrosine
- Bioactive supplement increased DIT by 90 kJ/4-hr
- Effect was maintained after 8-weeks supplementation
- Proposed mechanism shown in the figure

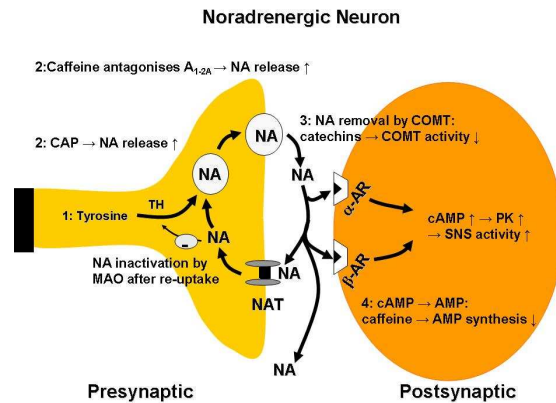


Figure: Potential mechanisms, whereby BC's can stimulate noradrenergic neurons – and thereby thermogenesis

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SIDE EFFECTS OF BC'S

Statement:

- All components can be harmful and have side effects if consumed in too large amounts
- In other words – there are side effects to everything – even "healthy" components such as vitamins

Side effects of BC's:

- Effects on blood pressure and heart rate
 - Capsaicin has been shown to increase BP (Patanè et al., Int. J Cardiol., 2009)
- Some case studies have reported hepatotoxicity following consumption of GTE – but not green tea as a beverage
 - Most likely a dosing issue!
- There may be side effects on other endpoints as well – but so far this has not been reported

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SUMMARY

Current evidence:

- **Some BC's may have positive effects on energy balance**
 - Currently, capsaicin is the best example
 - In order to increase the effect size focus should be to find BC's with either additive or synergistic effects
- **Effect sizes**
 - Approx. 1-2 %
 - Thus only relevant for weight maintenance – and not weight loss
- **Side effects**
 - Increases in BP and/or HR
 - Mouth/Gastrointestinal discomfort – BUT pungency not necessary for an effect on energy balance!!!
 - Hepatotoxicity?

Hypothetical mechanisms:

- Input from (some) BC's → through specific cranial nerves → hypothalamus → increased SNS-activity → increased NA → increased activity of different mechanisms → effects on EE and EI

Future research

- More combination treatments
- New ingredients
- More long-term studies
- Side effects – especially for dietary supplements/isolated components



THANKS FOR YOUR ATTENTION!



RELEVANT REVIEWS WITHIN THE FIELD

Spices & green tea:

- 1) Kovacs EMR & Mela D. "Metabolically active functional food ingredients for weight control", *Obesity Reviews* 7;59-78:2006
- 2) Westerterp-Plantenga M, Diepvens K, Joosen AMCP, Bérubé-Parent S, Tremblay A. "Metabolic effects of spices, teas, and caffeine", *Physiology & Behaviour* 89;85-91:2006
- 3) Hursel R, Westerterp-Plantenga MS. "Thermogenic ingredients and body weight regulation", *International Journal of Obesity* 2010, Feb 9 [Epub ahead of print].

Green tea:

- 4) Hursel R, Viechtbauer W, Westerterp-Plantenga MS. "The effects of green tea on weight loss and weight maintenance: A meta-analysis", *International Journal of Obesity* 33(9);956-961:2009
- 5) Grove KA, Lambert JD. "Laboratory, epidemiological, and human intervention studies show that tea (*camellia sinensis*) may be useful in the prevention of obesity", *Journal of Nutrition* 140;446-453, 2010

