

Battling human obesity: is there a role for thermogenic food ingredients?

Dr Natalie Luscombe-Marsh
ANZOS, Melbourne, October 23rd-25th 2009

Average weight gain per year for Australian men & women

Ball *et al.* (2003) *Public Health Nutr*; 6(3): 269-81

- 12,125 men and 17,674 women aged 35 to 69 years
- Self-reported weight, height and determinants of weight gain were collected in 1996, 1998 and 2001
- Av. weight gain was 0.5 kg per year (mean/SD of 1.58 ± 4.82 for men and 2.42 ± 5.17 kg for women, over 5 years)
- Equates to an energy imbalance of ~56 kJ/day (based on the assumption the cost of weight gain is ~ 40.7 kJ/g)

Thermogenic food ingredients



- Increase postprandial energy expenditure i.e. "energy wasters"
- May also stimulate satiety.

Hypothesis under investigation

"Some food ingredients are more useful than others in the prevention of human obesity, and in the maintenance of body weight after weight loss, because they stimulate postprandial energy expenditure (TEF) and satiety".

Outline of remaining presentation

➤ Acute Vs. chronic effects of:

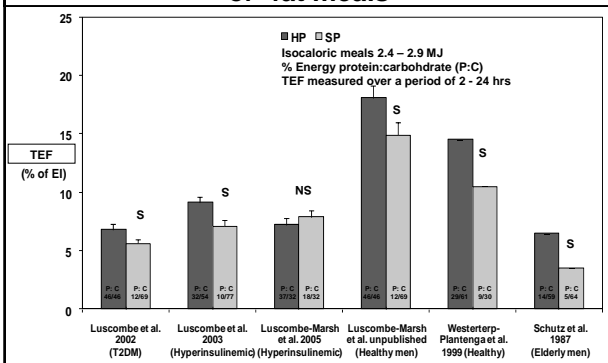
1. Dietary protein
2. Capsaicin
3. Caffeine
4. Green tea

on postprandial thermogenesis and satiety.

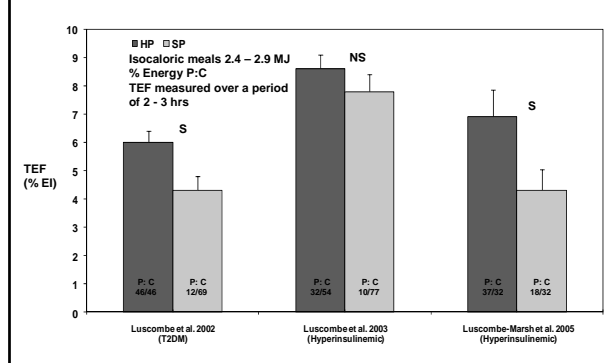
Mechanisms underlying protein-induced thermogenesis

1. Body has a limited storage capacity for protein- excess protein is immediately metabolised.
[Flatt JP (1995) *Am J Clin Nutr*]
2. Increased rate of ureagenesis and gluconeogenesis.
[Robinson SM *et al.* (1990) *Am J Clin Nutr*; van Milgen J (2002) *J Nutr*]
3. Increased protein synthesis is associated with high ATP cost.
[Robinson SM *et al.* (1990) *Am J Clin Nutr*; van Milgen J (2002) *J Nutr*]
4. Increased expression of uncoupling protein-2 in liver and uncoupling protein-1 in the brown adipose tissue.
[Nedergaard J *et al.* (2007) *Am J Physiol Endocrinol Metab*; Huttunen P *et al.* (1981) *Eur J Appl Physiol*]

Relative high protein meals are more thermogenic than high-carbohydrate or -fat meals



The greater thermogenic effect of relative high protein diets are maintained over 12-16 wks



The estimated energy cost of weight gain is greater when protein intake is low or high

Overfeeding studies	P:CHO (% En)	Cost weight gain (kJ/gram)
Ravussin et al. 1985	15/45	18.0
Roberts et al. 1990	10/50	36.0
Diaz et al. 1992	12/46	34.3
Jebb et al. 1996	15/50	17.1
Levine et al. 1999	20/40	49.77
Joosen et al. 2005	7/53	39.3
Miller & Mumford 1967	3/51	112.1
Servio et al. 2007	-12/44	19.2
		Av. 40.7

Protein induced thermogenesis may be associated with an increased satiety

Westerterp-Plantenga et al. (1999) Eur J Clin Nutr; 53: 495-502

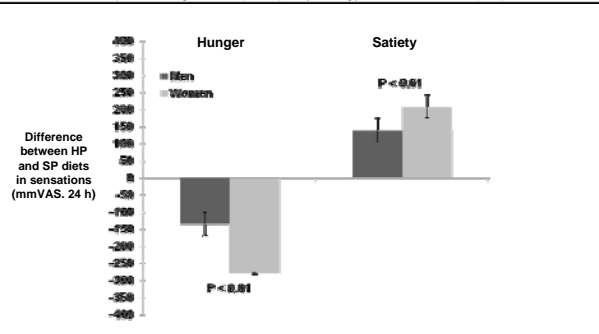
Diet induced thermogenesis and satiety (mean) responses in 8 healthy young females following isocaloric high protein and high fat diets for 24 hrs

	High Protein (P:C:F 29/61/10)	High Fat (P:C:F 9/30/61)	P value
24 hr TEF (kJ/d)	1295	931	P < 0.01
24 hr TEF (% EI)	14.6	10.5	P < 0.01
24 hr satiety (AUC mm.hrs)	886.4	788.8	P < 0.01

➤ The difference in TEF between the HP and HF diets correlated to the difference in satiety, $r = 0.8$, $P < 0.01$

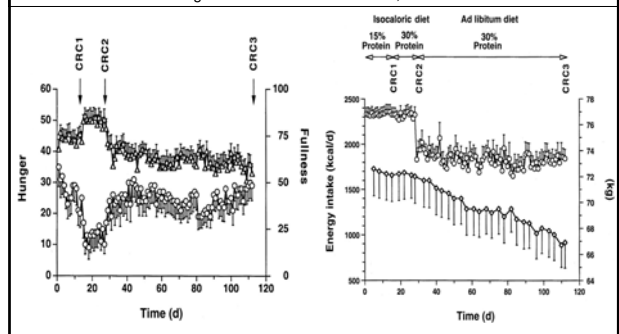
Changes in hunger and satiety after a high compared to standard protein diet were more pronounced in women than men

Westerterp-Plantenga et al. (2009) Physiology & Behaviour; 97(3-4):414-9



Suppression of appetite and energy intake by a high protein diet results in a 4.9 % greater weight loss

Weigle et al. Am J Clin Nutr 2005;82:41-48



Conclusions & implications for protein as a thermogenic food ingredient

- The thermogenic effect of protein is greater than for carbohydrate or fat, but it is still relatively small. Hence, its' effect on body weight regulation will be limited, but not of insignificance.
- Assuming an average post-obese female consumes 7500 kJ/day, we can calculate that a 2 % point greater TEF equates to wasting ~ 150 kJ/day which could theoretically prevent a weight regain of ~1.4 kg over 1 year.
- However, given daily fluctuations in energy intake and physical activity, it is more likely that this magnitude of protein-induced thermogenesis will, at the very least, prevent the average weight gain of 0.5 kg/year.
- Suppression of appetite and energy intake appears to be the major mechanism responsible for greater weight loss following high protein diet.

Other food ingredients of potential benefit for weight loss due to their thermogenic effect



Capsaicin



Caffeine



Green tea and oolong tea

[Diepvens K *et al.* (2007) *Am J Physiol Regul Integr Comp Physiol* 292:R77-R85; Kovac E & Mela D (2006) *Obesity reviews* 7:59-78]



Capsaicin

Food sources: Red pepper, mustard, ginger, tabasco sauce

Habitual intakes: unknown

➤ the average capsaicin content of various foods are:

Chilli powder	10 g; ~ 30 mg capsaicin
Mustard powder	?
Ginger powder	?
Tabasco sauce	?

➤ Blom S *et al.* (unpublished) reported increased gastrointestinal complaints at a low dose of capsaicin (1.1 mg) indicating some individuals are very sensitive to its' strong pungency.



Mechanism underlying capsaicin-induced thermogenesis

- Studies in rats have demonstrated that capsaicin stimulates thermogenesis in a dose-dependent manner by enhancing the secretion of catecholamines from the adrenal medulla.

[Kawada T *et al.* (1986) *Proc Soc Exp Biol Med* 183:250-56; Watanabe T *et al.* (1988) *Am J Physiol Endocrinol Metab* 255: E23-E27]



Thermogenic effects of capsaicin

Paper	Capsaicin dose	Duration (min/d) & subjects	Av. difference in TEF (kJ/day)	> Weight loss (compared to placebo)
Henry C & Emery B <i>Hum Nutr Clin Nutr</i> 1986	~ 9 mg to meal	150 min lean	25 % (~1625 kJ/d)	Not assessed
Yoshioka M. <i>et al.</i> <i>J Nutr Sci Vitaminol</i> 1995	~ 30 mg to meal	150 min lean	23 %	Not assessed
Yoshioka M. <i>et al.</i> <i>Br J Nutr</i> 1998	~ 30 mg to meal	210 min lean	20 kJ (if HC meal) vs. 60 kJ (if HF meal)	Not assessed
Lejeune M <i>et al.</i> <i>Br J Nutr</i> 2003	135 mg/d ¹	12 weeks 91 overweight	Sustained TEF and increased fat oxidation	No



Capsaicin as an appetite suppressant

- Addition of 18 mg capsaicin to a drink of tomato juice increased ratings of fullness and satiety (and reduced hunger) more than the control drink, and suppressed subsequent energy intake over the day by 791 kJ, in Caucasian men.

[Yoshioka M *et al.* (1999) *Br J Nutr*; 82: 115-123]

- In both men and women, 24 hr appetite and energy intake were significantly suppressed regardless of the route of administration (oral Vs. gastrointestinal), but the suppression was greater (by an av. 350 kJ) after oral ingestion indicating that the effect of capsaicin is independent of the spiciness in the mouth.

[Westerterp-Plantenga *et al.* (2004) *Int J Obes Relat Metab Disord*; 28: S25]



Caffeine

Plant sources: Coffee, tea, cola nuts (essential ingredient in cola drinks), cacao beans, mate, and guarana.

Habitual intakes: 0 - 1000 mg day⁻¹

➤ the average caffeine content of various drinks/foods are:

Coffee, drip	104-192 mg
Tea, brewed	20-90
Iced Tea	9-50
Soft Drinks	20-40
Cocoa Beverage	3-32
Milk Chocolate	1-15
Dark Chocolate	5-35

[The American Beverage Association; <http://www.coffeeqa.com/site/node/22>]

➤ estimated lethal dose is 5-10 g/d (i.e. 75/ 125/ 200 cups of coffee/tea/cola).

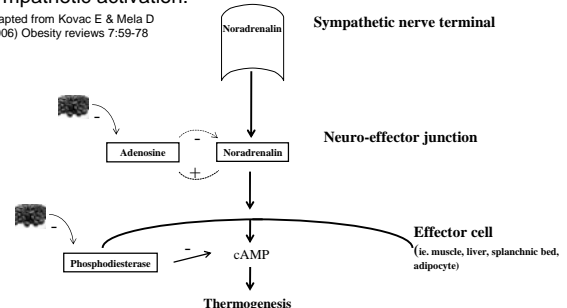
[Diepvens K *et al.* (2007) Am J Physiol Regul Integr Comp Physiol 292:R77-R85]



Mechanisms underlying caffeine-induced thermogenesis

Sympathetic activation:

Adapted from Kovac E & Mela D (2006) Obesity reviews 7:59-78



Thermogenic effects of caffeine

Paper	Caffeine dose	Duration (hrs/d) & subjects	Av. difference inTEF (kJ/day)	> Weight loss (compared to placebo)
Acheson KJ, <i>et al.</i> Am J Clin Nutr 1980	4 & 8 mg/kg	3 hrs lean & obese	9 % (~12 kJ/h)	Not assessed
Astrup A, <i>et al.</i> Am J Clin Nutr 1990	100, 200 & 400 mg	3 hrs healthy	37 - 134 kJ/h	Not assessed
Bracco D, <i>et al.</i> Am J Physiol Endocrinol Metab 1995	5 x 4 mg/kg	24 hrs lean & obese	209 kJ/d (in lean but no diff for obese)	Not assessed
Dullo AG, <i>et al.</i> 1989 Am J Clin Nutr	1 x 100 mg	12 hrs lean & post- obese	52 kJ/h in lean & 28 kJ/h in post- obese	Not assessed
Astrup A <i>et al.</i> 1992 Int J Obes	3 x 200 mg/d	24 weeks 180 obese	not sustained over 24 wks	No



Caffeine as an appetite suppressant

➤ Caffeine reduced energy intake in men but failed to produce the same effect in women.

[Tremblay *et al.* (1988) Nutr Res; 8: 553-558]



Green tea and oolong tea

➤ Catechin polyphenols, particularly *epigallocatechin gallate*, are the active ingredients of green and oolong tea.

➤ Catechins appear to modulate thermogenesis through the inhibition of catechol O-methyl-transferase (COMT), and consequent prolonged release of noradrenaline.

[Dullo *et al.* (1999) Am J Clin Nutr; 70: 1040-1045; Rumples *et al.* (2001) J Nutr; 131: 2848-2852]



Green tea and oolong tea

➤ Acute effects:

Catechin doses ranging from 375 – 902 mg day⁻¹ have been reported to stimulate 24 hr thermogenesis by 2.5 – 3.5 % and fat oxidation by 8 – 27 g, in humans.

[Dullo *et al.* (1999) Am J Clin Nutr; 70: 1040-1045; Rumples *et al.* (2001) J Nutr; 131: 2848-2852]

➤ Chronic effects:

Two of three studies have found that 12-week consumption of green tea catechins (375 -902 mg day⁻¹) reduced body weight and abdominal fat, in lean and obese men.

[Chantre & Lairon (2002) Phytomedicine; 9: 3-8; Nago *et al.* (2001) J Oleo Sci 50: 717-728; Kovacs *et al.* (2004) Br J Nutr 91: 431-437]

➤ No evidence that the weight reducing effect of green tea is modulated by an increased satiety

Conclusions & implications for capsaicin, caffeine & green tea as thermogenic food ingredients

- The acute thermogenic effects of caffeine and green tea are similar to that of protein, and therefore these food ingredients may also be useful foods to incorporate into a weight management program to prevent weight gain or regain after weight loss.
 - further long-term studies however are warranted.
- The acute effects of capsaicin indicate it also has potential as a thermogenic food ingredient for weight loss and maintenance, but chronic ingestion suggests it is not well tolerated and further research needs to be done to confirm its safety.
 - non-pungent capsaicin analogues i.e. the CH-19 Sweet may provide more promising results

