Effect of capsaicin on satiety and diet-induced thermogenesis

Mishra S[1] and Megan Pratt[2]
[1]The New Zealand Institute for Plant & Food Research Ltd, Private Bag 11600, Palmerston North 4442
[2] Oxford Brookes University, School of Life Sciences, Gipsy Lane, Oxford 0X3 0BP, UK

ABSTRACT

Background: One way to reduce net energy intake is by using bioactives, such as capsaicin, which has both satiating effects and can also increase energy expenditure through diet-induced thermogenesis (DIT). In terms of energy stored as body fat, and over a prolonged period, an increase in thermogenesis can have a substantial impact on obesity.
Objectives: To determine the effect of capsaicin on satiety and diet-induced thermogenesis.
Design: Rice and rice plus tabasco sauce was fed to 10 subjects using a two-way cross over design. Height, weight, waist and hip circumference and, body fat content of the subjects were measured together with blood pressure, heart rate, energy expenditure (thermogenesis), and satiety which was measured using visual analogue scale.
Outcomes: Using the area under the curve of thermogenesis versus time, DIT was greater but not significantly so when the subjects consumed rice+Tabasco sauce (treatment containing capsaicin) rather than rice only. Scores for feeling full/not hungry/having less desire to eat 2.5 h after the meal were significantly higher for rice+tabasco sauce than for rice alone. Changes in blood pressure and heart rate were not significantly different in subjects eating the diets.
Conclusion: Capsaicin increased DIT and had a significant satiating effect, but because of inter-subject variability measurement of DIT needs to be more highly powered to reach statistical significance.

INTRODUCTION

Obesity, no matter how it is caused, always involves an imbalance between energy consumed and energy expenditure (EE). Weight loss can be achieved by reducing energy intake and/or increasing EE (Smeets & Westerterp-Plantenga, 2009). There are three main forms of EE: (1) basal metabolic rate (BMR) which is about 65% of daily energy intake (DEI), (2) physical activity (20-30% DEI) and (3) DIT which is about 10% of DEI (Frayn, 2008). Even though, DIT is the smallest component of EE, it could play a role in weight maintenance (Westerterp, 2004).

There is growing eveidence that certain bioactive ingredients found in spicy foods or herbal drinks can lead to greater thermogenesis and in some cases to greater satiety (Westerterp-Plantenga *et al.*, 2006). Capsaicin, which gives pungency to hot red peppers (Smeets & Westerterp-Plantenga, 2009), is one such compound that has been reported to increase EE and fat oxidation, and reduce appetite (Kawada *et al.*, 1986; Yoshioka *et al.*, 1998; Kawabata *et al.*, 2006). Increase in activity of the sympathetic nervous sytem caused by capsaicin seems to be associated with energy and lipid metabolism (Yoshioka *et al.*, 1998; Yoshioka *et al.*, 1999). In the experiment reported here, we present the results of a pilot study in which .we tried to replicate previous studies and test experimental protocol prior to more detailed research.

METHODS

Subjects and Experimental Design

Ten volunteers between the age 24 and 60 were recruited. The subjects were fed rice and rice plus Tabasco sauce (source of capsaicin in this study) in a 2 way cross over design. The subjects were asked not to eat anything after 10pm the night before the experiment and were asked to arrive by 8am on the day. After resting for 30min, body measurements including height, weight, waist and hip circumference, body fat content, blood pressure, heart rate were measured. Then they were fed the test meal consisting of either plain boiled white (66g) or the rice plus 3mL of Tabasco sauce estimated to deliver 3mg of capsaicin. DIT was measured using a Fitmate (COSMED Srl, Italy, C02874-02-91) for 30min prior to the meal and for 2.5hr after the meal with 10min breaks every 20min. Satiety profile was measured with the use of anchored 100mm visual analogue scale (VAS). On the test days the questionnaires were completed in fasting state, immediately after the consumption of the test meal and at 2.5h when the experiment stopped. The questions were (1) “How hungry do you feel (0 not hunfry at all and 10 being extremely hungry)?”, (2) “How full do you feel (0 being not at all full and 10 being extremely full)?”, (3) “How strong is your desire to eat (0 being not at all strong and 10 being extremely strong)?”, (4) “How much food do you think you can eat (0 being a large amt and 10 being nothing at all)?”. Statistical analysis – the data are presented as mean ± Standard error of the mean (SEM)

RESULTS

Figure 1 shows the changes in metabolic rate over 2.5hr after consuming the test meals. The curves are quite typical of this type of study but because of the large inter individual variation there was no statistically significant difference between the treatments.

VAS rating (Table 1) of hunger, fullness, desire to eat and satiety showed no significant difference between the treatments during fasting and immediately after food consumption. However, 2.5h later a significant decrease in feeling of

hunger and desire to eat was observed in the treatment containing capsaicin, and an increased feeling of fullness and satiety.

No significant differences were observed in the haemodynamic functions.

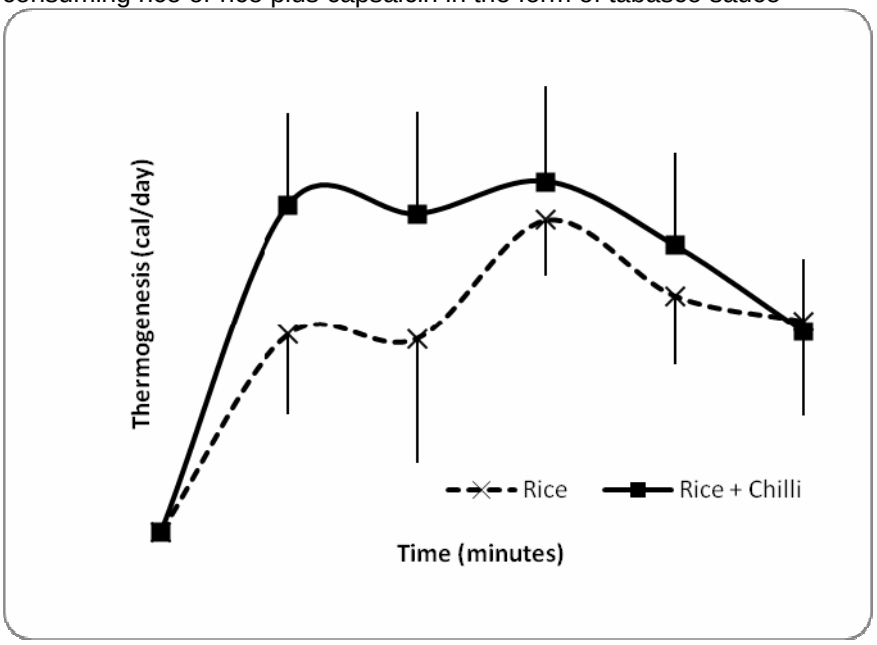
Table 1: VASmm rating at fasting and 2.5hrs after feeding by the subjects

Satiety profile	Rice ± SEM	Rice + Tabasco sauce ± SEM
Hunger (1):		
Fasting	64.8 ± 6	66.3 ± 8
Immediately after eating	24.3 ± 4	24.4 ± 5
2.5 hrs after eating	65 ± 8*	49.1 ± 9*
Fullness (2):		
Fasting	16.8 ± 4	17.6 ± 3
Immediately after eating	68.7 ± 3	74.7 ± 6
2.5 hrs after eating	24 ± 6*	41.8 ± 8*
Desire to eat (3):		
Fasting	69.8 ± 5	72.2 ± 7
Immediately after eating	25.7 ± 3	23.7 ± 6
2.5 hrs after eating	69.2 ± 9*	51.7 ± 9*
Prospective consumption of food (4):		
Fasting	31.8 ± 6	26.6 ± 6
Immediately after eating	60.2 ± 8	66.2 ± 9
2.5 hrs after eating	26.4 ± 8*	45.6 ± 9*

** Significant difference p<0.05*

(1),(2), (3), (4) – meaning of terms given in METHODS

Figure 1: Rate of post prandial thermogenesis measured for 2.5h after consuming rice or rice plus capsaicin in the form of tabasco sauce



DISCUSSION

No significant effect of capsaicin was observed on DIT probably because of the low dosage used (3mg) combined with inter-subject variability. Other studies that used low dosage of capsaicin such as 0.03g, 0.06g have also observed no increase in EE (Snitker *et al.*, 2009; Galgani *et al.*, 2010). The sensitivity of subjects in this study to capsaicin limited the dose that could be given. Another reason for non significant result could be due to the small sample size. Given that intra-individual variability in DIT is 6 to 30% (Segal *et al.*, 1992; Westerterp, 1993) and within-subject variability is 43-48% (Ravussin *et al.*, 1986; Tataranni *et al.*, 1995) , a higher powered test with more subjects might be needed to produce significant results. Studies done on Japanese population have shown an increase in EE of up to 30% upon consumption of capsaicin (Yoshioka *et al.*, 1995; Yoshioka *et al.*, 1998). Symapathomimetic compounds like capsaicin could potentially increase thermogenesis by approximately 300-400kJ daily which could lead to substantial weight loss (Hursel & Westerterp-Plantenga, 2010).

From the analysis of VAS, it seems capsaicin caused suppression of hunger, desire to eat less, feeling of fullness and increased satiety which could be

factors in successful weight loss. Exposure to capsaicin increased satiety in other studies as well (Westerterp-Plantenga *et al.*, 2005; Reinbach *et al.*, 2009). Because the capsaicin was able to significantly suppress appetite for 2.5h it may be useful to reduce food intake between meals in weight management.

The fact that measurements of satiety were more significant then the DIT measurements probably reflect the larger number of factors involved in appetite regulation then in DIT.

CONCLUSIONS

Capsaicin did not increase DIT but did affect satiety and appetite. Therefore, capsaicin and compounds of similar action may be helpful in reducing energy intake and might support weightloss/maintenance by sustaining satiety and suppressing hunger. However, testing compounds for their effects on DIT requires experimental designs with enough power to overcome inter-individual variability.

ACKNOWLEGEMENTS

This work was conducted while SM was supported by Oxford Brookes University Fellowship. The authors are grateful to Prof Jeya Henry for his support and the subjects for volunteering their time.

REFERENCES

Frayn KN (2008) *Metabolic regulation - A human perspective* 2nd ed. Oxford: Blackwell Science Ltd.

Galgani JE, Ryan DH & Ravussin E (2010) Effect of capsinoids on energy metabolism in human subjects. *British Journal of Nutrition* 103, 38-42.

Hursel R & Westerterp-Plantenga MS (2010) Thermogenic ingredients and body weight regulation. *International Journal of Obesity* 34, 659-669.

Kawabata F, Inoue N, Yazawa S, Kawada T, Inoue K & Fushiki T (2006) Effects of CH-19 sweet, a non-pungent cultivar of red pepper, in decreasing the body weight and suppressing body fat accumulation by sympathetic nerve activation in humans. *Bioscience Biotechnology and Biochemistry* 70, 2824-2835.

Kawada T, Watanabe T, Takaishi T, Tanaka T & Iwai K (1986) Capsaicin-induced beta-adrenergic action on energy metabolism in rats: influence of capsaicin on oxygen consumption, the respiratory quotient, and substrate utilization. *Proceeding of Society: Experimental Biollogy and Medicine* 183, 250-256.

Ravussin E, Lillioja S, Anderson TE, Christin L & Bogardus C (1986) Determinants of 24-hour energy-expenditure in man - methods and

results using a respiratory chamber. *Journal of Clinical Investigation* 78, 1568-1578.

Reinbach HC, Smeets A, Martinussen T, Moller P & Westerterp-Plantenga MS (2009) Effects of capsaicin, green tea and CH-19 sweet pepper on appetite and energy intake in humans in negative and positive energy balance. *Clinical Nutrition* 28, 260-265.

Segal KR, Chun A, Coronel P, Cruznoori A & Santos R (1992) Reliability of the measurement of postprandial thermogenesis in men of 3 levels of body fatness. *Metabolism-Clinical and Experimental* 41, 754-762.

Smeets AJ & Westerterp-Plantenga MS (2009) The acute effects of a lunch containing capsaicin on energy and substrate utilisation, hormones, and satiety. *European Journal of Nutrition* 48, 229-234.

Snitker S, Fujishima Y, Shen HQ, Ott S, Pi-Sunyer X, Furuhata Y, Sato H & Takahashi M (2009) Effects of novel capsinoid treatment on fatness and energy metabolism in humans: possible pharmacogenetic implications. *American Journal of Clinical Nutrition* 89, 45-50.

Tataranni PA, Larson DE, Snitker S & Ravussin E (1995) Thermal effect of food in humans - methods and results from use of a respiratory chamber. *American Journal of Clinical Nutrition* 61, 1013-1019.

Westerterp-Plantenga M, Diepvens K, Joosen A, Berube-Parent S & Tremblay A (2006) Metabolic effects of spices, teas, and caffeine. *Physiology & Behavior* 89, 85-91.

Westerterp-Plantenga MS, Smeets A & Lejeune MPG (2005) Sensory and gastrointestinal satiety effects of capsaicin on food intake. *International Journal of Obesity* 29, 682-688.

Westerterp KR (1993) Food quotient, respiratory quotient, and energy-balance. *American Journal of Clinical Nutrition* 57, S759-S765.

Westerterp KR (2004) Diet induced thermogenesis. *Nutrition & Metabolism* 1, (18 August 2004).

Yoshioka M, Lim K, Kikuzato S, Kiyonaga A, Tanaka H, Shindo M & Suzuki M (1995) Effects of red-pepper diet on the energy metabolism in men. *Journal of Nutritional Science and Vitaminology* 41, 647-656.

Yoshioka M, St-Pierre S, Drapeau V, Dionne I, Doucet E, Suzuki M & Tremblay A (1999) Effects of red pepper on appetite and energy intake. *British Journal of Nutrition* 82, 115-123.

Yoshioka M, St-Pierre S, Suzuki M & Tremblay A (1998) Effects of red pepper added to high-fat and high-carbohydrate meals on energy metabolism and substrate utilization in Japanese women. *British Journal of Nutrition* 80, 503-510.