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Research review

Could capsaicinoids help to support weight management? A systematic review and meta-analysis of energy intake data ☆

S. Whiting [a], E.J. Derbyshire [a,*], B. Tiwari [b]

[a] School of Healthcare Science, John Dalton East Building, Oxford Road, Manchester M1 5GD, United Kingdom
[b] Teagasc Food Research Centre, Ashtown, Dublin 15, Ireland

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ABSTRACT

Objective: Capsaicinoids are a group of chemicals naturally occurring in chilli peppers with bioactive properties that may help to support weight management. The aim of the present study was to conduct a meta-analysis investigating the potential effects of capsaicinoids on energy intake, to clarify previous observations and form evidence-based conclusions about possible weight management roles. *Methods:* Medical databases (Medline, Web of Knowledge and Scopus) were systematically searched for papers. Search terms were: 'capsaicin*' or 'red pepper' or 'chilli*' or 'chili*' with 'satiety' or 'energy intake'. Of the seventy-four clinical trials identified, 10 were included, 8 of which provided results suitable to be combined in analysis (191 participants). From the studies, 19 effect sizes were extracted and analysed using MIX meta-analysis software. *Results:* Data analysis showed that capsaicinoid ingestion prior to a meal reduced *ad libitum* energy intake by 309.9 kJ (74.0 kcal) $p < 0.001$ during the meal. Results, however, should be viewed with some caution as heterogeneity was high ($I^2 = 75.7\%$). Study findings suggest a minimum dose of 2 mg of capsaicinoids is needed to contribute to reductions in *ad libitum* energy intake, which appears to be attributed to an altered preference for carbohydrate-rich foods over foods with a higher fat content. *Conclusions:* Meta-anlysis findings suggest that daily consumption of capsaicinoids may contribute to weight management through reductions in energy intake. Subsequently, there may be potential for capsaicinoids to be used as long-term, natural weight-loss aids. Further long-term randomised trials are now needed to investigate these effects.

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Introduction

The plant of the genus capsicum produces a fruit (chilli pepper) with unique bioactive compounds (Kwon et al., 2011). The fruit contains a group of chemicals known as capsaicinoids, the most abundant and well known being capsaicin. Capsaicin, along with dihydrocapsaicin, makes up around 90% of capsaicinoids found in a typical chilli pepper (Meghvansi et al., 2010). These compounds are responsible for the fruit's 'pungent' flavour sensation that has

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* Corresponding author.
E-mail address: e.derbyshire@mmu.ac.uk (E.J. Derbyshire).

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made it popular in culinary cultures around the world (Hursel & Westerterp-Plantenga, 2010). This sensation occurs as capsaicinoids bind to the same group of nociceptors (namely the transient receptor potential cation channel subfamily V member 1 (TRPV1), also known as the 'capsaicin receptor') which lead to the sensation of pain from heat and acid (Sanatombi & Sharma, 2008).

In recent years, the fruit's bioactive effects have become of increasing interest within the field of health research (Luo, Peng, & Li, 2011). Clinical trials suggest capsaicinoids may have anti-cancer (Yang et al., 2010), anti-inflammatory (Choi et al., 2011) and antioxidant properties (Henning et al., 2011), while they have been used for pain relief for some time (Szallasi, Cruz, & Geppetti, 2006). Many of these effects are due to the actions of capsaicinoids on the TRPV1 which is found in tissues throughout the body and is the subject of current research (Gunthorpe & Szallasi, 2008). There is also accumulating evidence that capsaicinoid compounds may help to support weight loss (Ludy, Moore, & Mattes, 2012).

Evidence from intervention trials in humans suggests daily consumption of capsaicinoids may increase energy expenditure by around 30 per cent for an hour (Yoshioka et al., 1995) and lipid oxidation by around 20% (Lejeune, Kovacs, & Westerterp-Plantenga, 2003). A number of human intervention trials have also investigated capsaicinoids' ability to regulate energy intake, although findings have generally been contradictory (Whiting, Derbyshire, & Tiwari, 2012). For example, one study found significant reductions in *ad libitum* energy intake of 24 subjects after consuming a capsaicinoid invention prior to a meal, compared to a placebo (Westerterp-Plantenga, Smeets, & Lejeune, 2005). However, another trial found no reduction in energy intake in 36 participants during a 4-week intervention with fresh chillies compared with a control diet (Ahuja, Robertson, Geraghty, & Ball, 2007).

As the effects of capsaicinoids on energy intakes can be difficult to establish from one meal, one trial investigated the effects of hot spices on energy intake and appetite after participants received five meals of fixed portion sizes, served with or without five hot spices followed by a buffet (Reinbach, Martinussen, & Moller, 2010). While hot spices were not found to significantly affect energy intake, the ingestion of hot spices appeared to induce changes in sensory specific desires e.g. an increased desire for sweet foods after ingesting chilli.

While pharmacological solutions have been created to help people control appetite, a number of medications (such as sibutramine, fenfluramine and dexfenfluramine) have been withdrawn from the market due to harmful cardiovascular side-effects and the options for treatment with drugs are currently limited (McGavigan & Murphy, 2012). Capsaicinoids have therefore the potential to be an innovative approach in terms of helping people trying to manage their weight; however, patent legislation provides little monetary incentive for the pharmaceutical industry to develop a plant compound for a medical application. Thus this present article sets out to combine findings from studies investigating inter-relationships between capsaicinoid ingestion and energy intake using a meta-analytical approach and form evidence-based conclusions about possible weight management roles.

Methods

Identification of relevant studies

Studies were identified by searching Web of Knowledge, PubMed and Scopus (1990-Present). The initial search was performed in June 2012 and updated in May 2013. The following search terms were used in all databases: '*capsaicin**' 'red pepper'', '*chilli**', '*chili**'. These four terms were each combined (using Boolean 'AND') with '*energy intake*' and '*satiety*'. Trials were initially selected based on their abstract; full content was then reviewed to determine final inclusion.

Inclusion and exclusion criteria

Inclusion was based on the following criteria: Human, randomised, intervention trials, in English using 'healthy' volunteers, compared to themselves or to a matched control group. Healthy meant participants were free of disease, but included overweight and obese participants. Duplicate results were removed, along with studies that did not investigate capsaicinoids' effect on appetite and those where the intervention included other bioactive ingredients (such as green tea and caffeine). The remaining studies were reviewed to establish an appropriate effect size that could be extracted and analysed. The most commonly occurring measure (change in energy intake) was chosen and studies that did not feature this measure were excluded.

Data extraction

Data extracted from the papers included: number of participants, gender, age, BMI, ethnicity, study type, dosage, the intervention used and study duration (Table 1). The studies' authors and year of publication were also recorded. Effect sizes were then extracted for analysis, including mean energy intakes (in kJ) for control and intervention groups, along with standard deviations.

Statistical analysis

Both random and fixed effects models were used to estimate combined mean differences, although the random effects model is theoretically preferable in this case. The fixed effects model assumes the effect size is the same for each study (Borenstein, 2009). However, due to differences in study design (such as dosage, timing of intervention and population size) this is unlikely to be the case for the trials used in this analysis. All statistical analyses were performed using MIX software version 2.0 (Bax, Yu, Ikeda, Tsuruta, & Moons, 2006). The analysis was carried out according to PRISMA guidelines (Moher, Liberati, Tetzlaff, & Altman, 2010).

Results

A total of 74 clinical trials were identified from the database searches. Fifty-five trials were excluded for being duplicates and a further 9 were excluded for methodological reasons (as listed in Fig. 1), leaving a total of 10 trials. The 10 studies investigated the role of capsaicinoids on weight management in relation to effects on energy intake, hunger and hormone levels. Studies assessing *ad libitum* energy intake after a capsaicinoid intervention were most common, and were therefore used in the main analysis. Two papers were then excluded as they did not measure energy intake (see Fig. 1), leaving a final total of 8 studies (with 191 participants) which were included in the meta-analysis (see Table 2 for assessment of risk of bias).

Most of the selected studies followed this design: after randomisation, participants would consume a capsaicinoid intervention or placebo, followed by a test meal consumed at a research site. The participants would consume food *ad libitum* until full and the remaining food would then be weighed to calculate energy intake. The only exception to this was one study which used 4 weeks of chilli supplementation (added to meal by the participant at home) in addition to participants' normal diet and 4 weeks of a control diet (Ahuja et al., 2007).

Two trials investigated capsaicinoids effects on over and under eating; one featured 3 weeks of positive energy balance and 3 weeks of negative energy balance, prior to each test meal (Reinbach, Smeets, Martinussen, Moller, & Westerterp-Plantenga, 2009). The other trial simulated these conditions by using high fat or high