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CH-19 Sweet, a Non-Pungent Cultivar of Red Pepper, Increased Body Temperature and Oxygen Consumption in Humans

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We investigated the effect of CH-19 Sweet, a non-pungent cultivar of red pepper, on body temperature and oxygen consumption in humans. CH-19 Sweet was given to 11 healthy volunteers, and core body temperature, body surface temperature and oxygen consumption were measured. The control group ingested California-Wandar, which contained neither capsaicin nor capsiate. The core body temperature in the CH-19 Sweet group was significantly higher than that in the control group ($P<0.01$). The forehead temperature measured by infrared thermography in the CH-19 Sweet group was significantly higher than that in the control group. The body surface temperature was increased for about 20 min after consumption of CH-19 Sweet intake, and the neck temperature was significantly higher ($P<0.001$) than when the subjects consumed California-Wandar. We also measured respiratory gas by indirect calorimetry while subjects wore a face mask. A significant difference was detected in oxygen consumption between the two groups, and the value was significantly higher in the CH-19 Sweet group ($P<0.03$). These results suggest that CH-19 Sweet increased thermogenesis and energy consumption.

Key words: CH-19 Sweet; capsiate; capsaicin; body temperature; oxygen consumption

Capsium species, hot peppers, are important plants and have been used world wide as food, spices, and medicines. Capsaicin, (E)-N-[(4-hydroxy-3-methoxyphenyl)methyl]-8-methyl-6-nonenamide, the major pungent component in fruits of *Capsium*, has been reported to enhance the catecholamine secretion[1] and energy expenditure[2] and suppress the body fat accumulation by long-term treatment[3] in experimental animal studies. Although hot peppers and capsaicin may be used in a diet therapy for obesity, their usage as a food additive or a drug is limited by its strong pungency and nociceptive activity for humans.

Among many capsaicin analogs reported as components of hot red peppers, that with a C14 to C20 side alkyl chain had no pungency. Furthermore, Watanabe *et al.*[1] reported that these long-chain non-pungent capsaicin analogs stimulated adrenalin release. Indeed, the chemically synthesized C18 long-chain capsaicin analog did not show any pungency and increased fat metabolism.[4] Unfortunately, these long-chain non-pungent capsaicin analogs are minor components in natural hot pepper fruits and substantially hard to isolate from hot capsaicin. Many species of low-pungent hot red peppers have been analyzed but a fruit body with a higher ratio of the long-chain capsaicin analogs has not been found.

Yazawa *et al.*[5] reported that the fruit of a non-pungent cultivar of pepper, named CH-19 Sweet, contains only a small amount of capsaicinoids but a considerable amount of capsaicinoid-like substances (CLSs). Kobata *et al.*[6] characterized one of the CLSs and found a non-pungent capsaicin analog, named capsiate. They also reported that capsiate has a structure similar to capsaicin and no pungency orally.

In this study, we measured body temperature and oxygen consumption to determine whether CH-19 Sweet has a thermogenetic effect in humans.

Methods

Subjects and settings. Data were collected from healthy, normotensive Japanese volunteers, seven males and four females, ranging in age from 21 to 32 years (mean, 24.5 years). The subjects were required to get up before 0800 h on the days of the experiment. Informed consent was obtained from all subjects according to the guidelines established by the Declaration of Helsinki. Measurements were made in a quiet room with about 50% humidity and temperature of 22 ± 1°C. The subjects abstained from food,

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drink, and exercise for the previous 3 hours. They wore oridinary clothing, shirt with long sleeves and trousers or skirt. Before measurements, the subjects were instructed to wear a face mask for respiratory gas sampling with electrodes attached for temperature measurement in a quiet and relaxing atmosphere for more than 15 min in the sitting position. After body temperature and oxygen consumption were stabilized for at least 5 munites, the subjects ingested a pepper, CH-19 Sweet or California-Wandar.

Materials. The control group was given California-Wandar, which contained neither capsaicin nor capsiate. CH-19 Sweet and California-Wandar were cultivated by the Laboratory of Vegetable and Ornamental Horticulture in Kyoto, Japan. They were frozen and stored at −20°C immediately after harvest. They were given to the volunteers at the rate of 0.1 g/kg body weight.

Equipment and data analysis. Temperature of tympanic membrane in the ear was taken as the core body temperature with an infrared ear thermometer (S-10, Morisita Jintan Co., Osaka, Japan). The core body temperature was measured every 10 minutes by the volunteers themselves. The facial temperature was measured by infrared thermography (Avionics Co., Tokyo, Japan). The temperature at the neck and wrist was measured with an electronic thermometer (NR-1000, Keyence, Tokyo, Japan). The electrodes of the thermometer were attached to the skin under clothing. The respiratory gas was measured by indirect calorimetry with a mass spectrum analyzer (RL-600, AlcoSystem, Tiba, Japan). Because basal body temperature and oxygen consumption differ among individuals, the mean values of temperature before intake was set as the base line value (0°C) and the mean values of oxygen consumption before intake was standardized as 100%, and relative values after intake of the fruits were compared.

Statistical Analysis. Data are expressed as means ± SE. The effects of time, treatment, and time × treatment ware evaluated by two-way repeated measures ANOVA; for comparison between the two groups at certain times, Student's *t* test was used. Statistics were calculated with the Stat View software package (Macintosh Version J 5.0, Abacus Concepts, Berkeley, CA). Probability levels of <0.05 were considered to indicate significance.

Results

The core body temperature of CH-19 Sweet intake group was slightly increased from the base line value (Fig. 1). The core body temperature was higher in the CH-19 Sweet group than in the control group (time × treatment effect, $P<0.01$; Fig. 1), the difference being significant at 10–60 min after intake. The core and neck temperature in the California-Wandar group was slightly decrease with time. The reason for this decrease was suspected to be the subjects were at rest in a quiet room, because the temperature of the subjects at rest was gradually decreased with time and did not differ from the California-Wandar group in our preliminary experiment (data not shown).

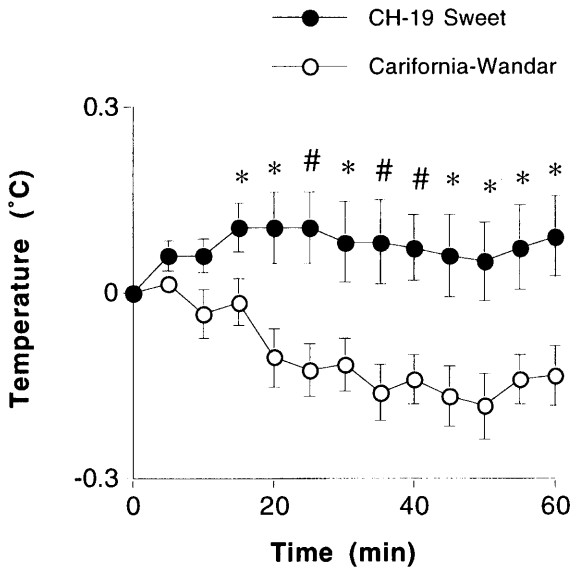

Fig 1. The Core Body Temperature in CH-19 Sweet and California- Wandar Groups.

Values are means ± SEM (n = 10–11). Body temperature was significantly higher in the CH-19 Sweet group than in the California-Wandar group (time × treatment effect, $P<0.01$ by two-way repeated measures ANOVA). *Significantly different from control group (*$P<0.05$, #$P<0.01$ by unpaired Student's *t* test).

The forehead temperature measured by infrared thermography in the CH-19 Sweet group was increased from the base line value and was significantly different from that in the California-Wandar group at 20 min after intake (Fig. 2). The surface temperature at the wrist and the neck after CH-19 intake was increased from the base line (Fig. 3). Significant differences were detected in the wrist temperature at 10 and 15 min after intake (Fig. 3-A). The neck temperature in the CH-19 Sweet group was significantly higher than that in the California-Wandar group (time × treatment effect, $P<0.001$; Fig. 3-B), the difference being significant at 10–60 min after intake.

The oxygen consumption in the CH-19 Sweet group was significantly higher than that in the California-Wandar group (time × treatment effect, $P<0.03$; Fig. 4), the difference being significant at 40 min after intake. There was no difference in respiratory quotient between the two groups (data not shown).

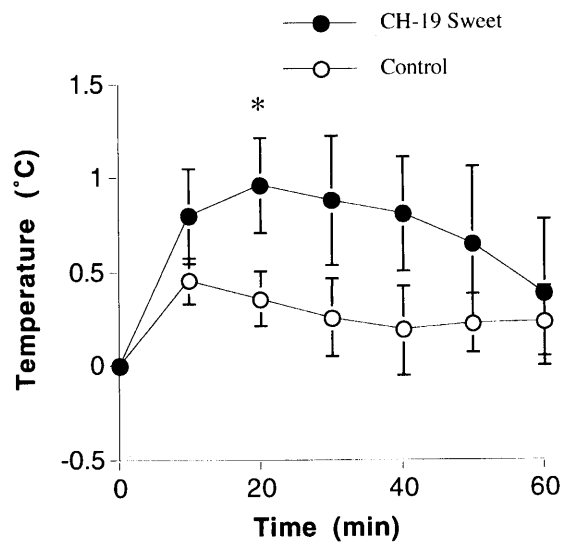

Fig 2. The Forehead Temperature After Intake of CH-19 Sweet or California-Wandar.

Values are means ± SEM (n = 5). *Significantly different between the two groups ($P < 0.05$ by unpaired Student's t test).

Discussion

This study demonstrated that body temperature and oxygen consumption were increased by a single intake of CH-19 Sweet. These results suggest that CH-19 Sweet increases thermogenesis and energy expenditure, and daily intake of this pepper may be used as a therapeutic tool for obesity.

We measured the temperature of the tympanic membrane in the ear to evaluate core body temperature, because this method is easy to perfom and is stress-free for the subjects. The core body temperature was increased by CH-19 Sweet intake, and this suggests that energy substrates were burned and heat was generated in the body. We measured the face temperature by infrared thermography and used forehead temperature in which there was a rapid response after intake. There were significant differences at the forehead and wrist in body surface temperature. These results suggest that CH-19 Sweet ingestion stimulate vasodilation in human.

The respiratory gas was analyzed by indirect calorimetry with a mass spectrum analyzer. This system can measure oxygen consumption and carbon dioxide production accurately, even in small experimental animals.[7] Oxygen consumption was increased by CH-19 Sweet, but the respiratory quotient in the CH-19 Sweet group was similar to that in the California-Wandar group. This suggests that CH-19 Sweet has an effect not on fat or carbohydrate metabolism but on only energy expenditure.

Because body temperature and oxygen consumption was thought to be affected by mastication or behavior when the voluteers were ingesting, we use California-Wandar, which has components similar to

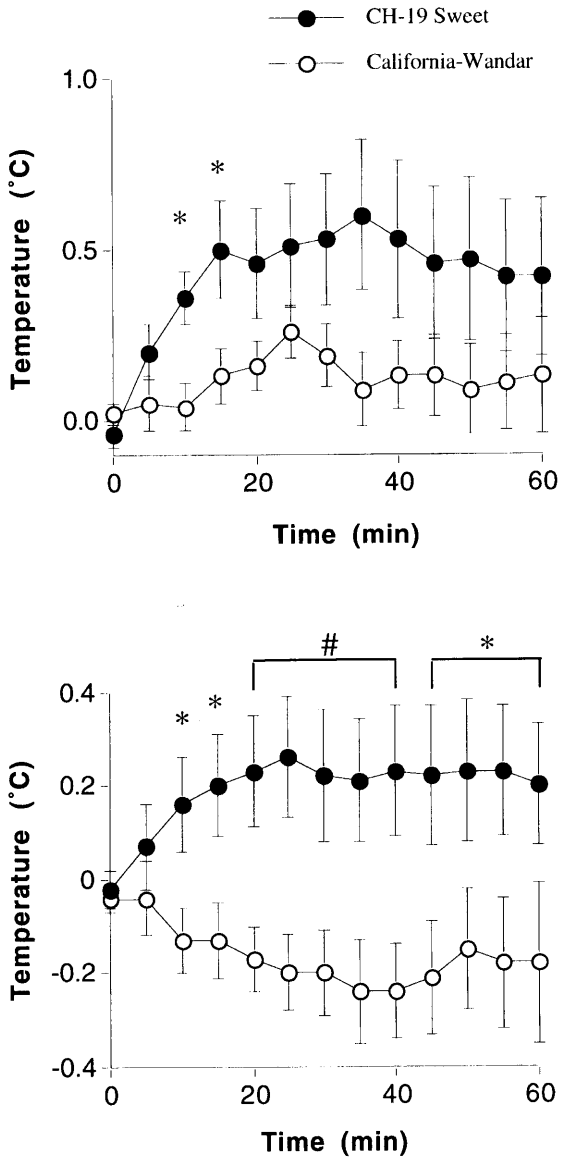

Fig 3. The Surface Temperature at the Wrist (Upper Panel) and the Neck (Lower Panel) in CH-19 Sweet and California-Wandar Group.

Values are means ± SEM (n = 10–11). The neck temperature was significantly higher in the CH-19 Sweet group than in the California-Wandar group (time × treatment effect, $P < 0.001$ by two-way repeated measures ANOVA). Significantly different from control group (*$P < 0.05$, #$P < 0.01$ by unpaired Student's t test).

CH-19 Sweet, as a control. The core and wrist temperature in the California-Wandar group was gradually decreased with time, and significant deferences were detected 20 munites after ingestion compared to base line value. Similary, the core and wrist temperature was decreased with time in the subject sitting at rest in our preliminary experiment (data not shown). The other parameters, oxygen consumption and forehead and wrist temperature, in the California-Wandar group were also similar to those in the subjects at rest. These results suggest that mastication or behavior when the voluteers were ingesting have no

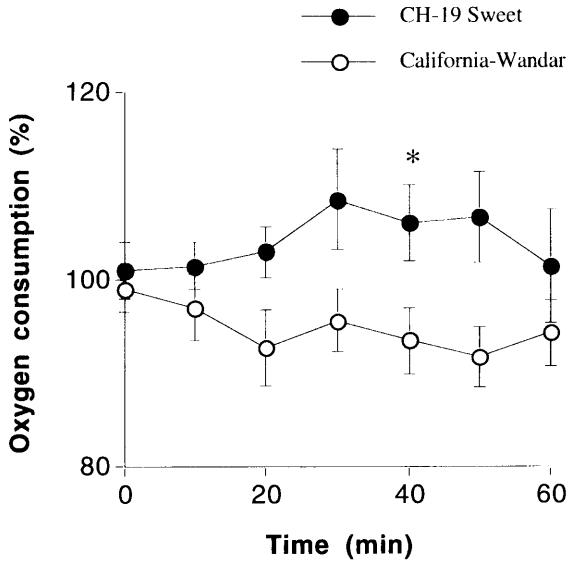

Fig 4. Oxygen Consumption in CH-19 Sweet and California-Wandar Group.

Values are means ± SEM (n = 10–11). Oxygen consumption was significantly higher in the CH-19 Sweet group than in the California-Wandar group (time × treatment effect, $P < 0.001$ by two-way repeated measures ANOVA). Significantly different from control group ($P < 0.05$ by unpaired Student's *t* test).

effect on body temperature or oxygen consumption.

Hot red pepper has also been reported to increase oxygen consumption in humans.[8] The dose of hot red pepper was almost the same weight as that of CH-19 Sweet on the weight basis in this study, and there are no differences between hot red pepper and CH-19 Sweet in the increase of oxygen consumption. This suggests that CH-19 Sweet has the same effect as hot red pepper on energy consumption.

The effect of CH-19 Sweet on body temperature and oxygen consumption is thought to be caused by capsiate, an ingredient of this pepper, because the major difference between CH-19 Sweet and California-Wandar is its presence. Capsiate has a structure similar to capsaicin but no pungency.[1] We found that capsiate and capsaicin increase thermogenesis and suppress body fat accumulation in laboratory animals (unpublished results). These results suggested that capsiate can be used as a component in diet foods.

Capsaicin was reported to suppress body fat accumulation in experimental animals.[2] In humans, however, suppression of body fat accumulation by capsaicin has not been observed, mainly because only a limited amount of capsaicin can be ingested because of its strong pungency. The amount of capsiate contained in CH-19 Sweet was about from 0.3 to 1.0 mg/g fruit (data not shown). This amount of capsiate is similar to the amount of capsaicin in hot chilli peppers. Although the subjects ingested a considerable amount of capsiate, they felt little or no pungency and could eat it easily. This is the first report on the physiological effect of a natural product that contain a considerable amount of non-pungent capsaicin analog, and it may be applied as a therapeutic tool for obesity.

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