2-1-2012

Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users

Mary-Jon Ludy
Bowling Green State University, mludy@bgsu.edu

Richard D. Mattes
Purdue University

Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users

Mary-Jon Ludy [a,b], Richard D. Mattes [a,*]

[a] Department of Foods and Nutrition, Purdue University, 212 Stone Hall, 700 West State Street, West Lafayette, IN 47907-2059, USA

[b] Current affiliation: School of Family and Consumer Sciences, Bowling Green State University, Johnston Hall, Bowling Green, OH 43403-0059, USA

[*] Corresponding author.

E-mail address: mattes@purdue.edu (R.D. Mattes).

Telephone: +1765 494 0662; fax: +1765 494 0674 (not for publication).

Abstract

Some individuals savor spicy foods, while others avoid them. Reasons underlying this range of hedonic responses are unknown. The purpose of this study was to explore the basis for individual differences in preference for spicy foods. Regular spicy food users (n = 13) and non-users (n = 12) were characterized for selected sensory, physiological, personality, and cultural attributes. Individual differences between users and non-users were primarily related to sensory and cultural attributes (i.e., a higher proportion of users reported consuming spicy foods since childhood and users rated spicy foods as more palatable and were better able to discriminate this burn than non-users). Users and non-users exhibited comparable responsiveness to noxious pressure pain, oral tactile sensitivity, and auditory sensitivity, varying only in responsiveness to oral thermal heat (i.e., users were more sensitive to increases than non-users). Studied personality traits did not vary between users and non-users. These findings suggest that prior experience, rather than physiological adaptation or personality differences, may best predict preference for spicy foods. These findings are of public health interest, given that spicy food consumption is reported to confer weight management and food safety benefits.

Key Words

Burn; Capsaicin; Food preference; Human; Nociception; Oral irritation; Palatability; Pungency; Spices

Introduction

Hedonic responses to spicy foods are extraordinarily varied, ranging from high desirability to aversions (Tepper, Keller, & Ullrich, 2003). The frequency of consumption and customary concentration are equally divergent. Spicy food is described as a primary and essential component of the Korean diet (Kim, Kil, Yoon, & Cho, 2003), with a mean per capita consumption of ~ 7 g hot red pepper (RP) per day (Ku & Choi, 1990). In contrast, only 10.5% of the United States population consumes any kind of pepper on a daily basis (Smiciklas-Wright, Mitchell, Mickle, Cook, & Goldman, 2002), with a mean preference for ~ 1 g of hot RP in spicy food-containing meals (Ludy & Mattes, 2011). Reasons underlying these diverse preferences are unclear, but may be hypothesized to include differences in sensory, physiological, personality, and/or cultural attributes. Spicy foods are reported to increase energy expenditure (Ludy & Mattes, 2011; Matsumoto, et al., 2000; Yoshioka, et al., 2004; Yoshioka, et al., 1995; Yoshioka, et al., 1999; Yoshioka, St-Pierre, Suzuki, & Tremblay, 1998), alter substrate oxidation (Lejeune, Kovacs, & Westerterp-Plantenga, 2003; Lim, et al., 1997; Yoshioka, et al., 1995; Yoshioka, et al., 1998), suppress orexigenic sensations (Ludy & Mattes, 2011; Westerterp-Plantenga, Smeets, & Lejeune, 2005; Yoshioka, et al., 2004; Yoshioka, et al., 1999), and protect against foodborne illnesses by exerting antimicrobial effects (Cichewicz & Thorpe, 1996; Sherman, 2002), but these benefits are realized only by those who consume spicy foods. Therefore, an improved understanding of the potential mechanisms by which certain individuals develop a preference for spicy foods, while others reject them, holds substantial public health merit, especially in weight management.

One mechanism that may account for variations in spicy food preference is that experience may alter the sensory responses elicited by spicy foods, leading to more favorable evaluations and increased consumption frequency. Repeated experience with spicy solutions over a 2-week period reduces ratings of burn intensity (Stevenson & Prescott, 1994). This apparent adaptation is not unique to spicy stimuli. The acute elevations in blood pressure and plasma catecholamines observed following caffeine consumption subside after three days in caffeine non-users following repeated coffee consumption (250 mg caffeine/day) (Robertson, Wade, Workman, Woosley, & Oates, 1981) and after five days in regular users following increased coffee consumption (504 mg caffeine/day) (Ammon, Bieck, Mandalaz, & Verspohl, 1983). Likewise, repeated exposure to extremely hot or cold climates induces metabolic adaptations, such as an altered rate of thermogenesis and redistribution of body heat, enabling individuals to perform physical tasks more efficiently at temperature extremes (Sawka, Castellani, Pandolf, & Young, 2002). Thus, it is conceivable that adaptations induced with regular, repeated exposure, however initiated, may allow individuals to more easily tolerate the pungency of spicy foods. The hypothesis was that regular spice use would be associated with reduced intensity and increased palatability ratings in regular users.

An additional possibility for varied spicy food preferences is divergent physiological responsiveness to noxious stimuli. Previous studies report that regular users rate the burn of spicy stimuli as less intense than non-users (Cowart, 1987; H. Lawless, et al., 1985; Stevenson & Prescott, 1994; Stevenson & Yeomans, 1993). The relationship between oral somatosensory sensitivity and spicy food perception is not well characterized, but some evidence suggests the genetically-determined sensitivity to the bitter compound 6-*n*-propythiouracil (PROP) is associated with hedonic ratings of foods (Duffy, 2007), as well as tactile and pain responsiveness (Duffy & Bartoshuk, 2000). Compared to PROP non-tasters, tasters and supertasters report greater oral tactile sensation following stimulation with high-fat dairy products (Duffy, Bartoshuk, Lucchina, Snyder, & Tym, 1996), high-fat salad dressings (Tepper & Nurse, 1997), and commercial thickeners (Prutkin, Fast, Lucchina, & Bartoshuk, 1999), in addition to von Frey hairs (Yackinous & Guinard, 2001). Similarly, oral pain may be heightened in PROP tasters and supertasters following ingestion of both spicy and non-spicy oral irritants (Bartoshuk, 2000), with tasters rating the burn of pungent foods more intensely than non-tasters (Karrer & Bartoshuk, 1991; Tepper & Nurse, 1997). It is proposed that differences in oral somatosensory sensitivity between PROP tasters and non-tasters are due to greater trigeminal innervation of the tongue (Duffy, 2007). Thus, it is plausible that physiological differences in chemesthesis between regular spicy food users and non-users are driving their dissimilar preferences for and intake of spicy foods. It was hypothesized that non-users of spicy foods would be more sensitive to oral tactile, oral thermal, and pressure pain, compared with regular users. Since audition encompasses a different sensory domain, it was not expected to vary between groups and was measured as a test performance control.

Varied reactions to spicy foods may also be related to personality traits. Consuming spicy foods may appeal to thrill-seekers, who enjoy the body's feeling of imminent danger (Rozin & Schiller, 1980). Early works from the 1970s (Kish & Donnenwerth, 1972) and 1980s

(Logue & Smith, 1986) reported positive correlations between sensation seeking behavior and the consumption of "unusual spices (for Americans)," suggesting that sensation seekers require more stimulation from foods with respect to taste (flavor) and texture, as well as perceived danger. In a more recent study, where subjects were asked to envision a party environment and complete a consumer choice survey with options for low- and high-arousal objects, introverts opted for comfort food cookbooks whereas extraverts preferred spicy food cookbooks (Wheeler & Berger, 2007). Since sensation seeking behavior, extraversion, and openness to experiences are related (Aluja, García, & García, 2003), it was posited greater extraversion and sensation seeking behavior, and less finickiness would be observed in regular users of spicy foods compared to non-users.

Another potential explanation for discordant responses to spicy foods is that cultural beliefs facilitate hedonic shifts leading to greater pleasure from their consumption. Attempts to induce preferences for spicy foods in animal models have had limited success (e.g., mice (Simons, Dessirier, Jinks, & Carstens, 2001) and rats (Rozin, Grass, & Berk, 1979)) except under conditions where there is social induction via forming close personal relationships with humans (e.g., chimpanzees (Rozin & Kennel, 1983)) or repeated exposure to same-species-peers consuming piquant foods (e.g., rats (Galef, 1989)). This suggests that social interactions may contribute to the acquisition of a preference for spicy foods, as has been demonstrated for other facets of the diet (Kikuchi & Watanabe, 2000; van den Bree, Przybeck, & Robert Cloninger, 2006). In humans, it is well established that repeated experience with unfamiliar foods increases both liking (Pliner, 1982) and preference (L. Birch & Marlin, 1982) for those foods. Regular users, compared to non-users, report that spicy stimuli are more palatable (H. Lawless, et al., 1985; Stevenson & Yeomans, 1993) and gradual introduction of increasingly spicy foods has been demonstrated to reverse the initial dislike and induce strong preferences for the burn, flavor, and aroma of spicy foods in cultures where hot spices are part of the regional/ethnic identity (Rozin & Schiller, 1980). The beneficial effects attributed to chili peppers in extreme climates illustrate culture's dynamic impact on food choice. The sweating induced by chili peppers is viewed as a cooling mechanism in hot weather (Nabhan, 2004), whereas chili peppers are perceived to provide a warming effect in cold environments (Rozin & Schiller, 1980). Given the potential role of cultural beliefs in shaping perceptions of spicy foods, it was hypothesized that non-users would report no early exposure to spicy foods, whereas regular spicy food users would report consuming spicy foods since childhood.

Methods

Experimental protocol

This study investigated individual differences in sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users using a parallel group design. It was part of a larger study investigating the effects of red pepper (RP) on thermogenesis and appetite (Ludy & Mattes, 2011). Subjects completed a screening session where sensory perception and experience with spicy foods were characterized. For those meeting preset eligibility criteria, six study visits were conducted in random order at least one week apart. During each study visit, two to three standardized personality questionnaires and/or one perceived intensity assessment of non-spicy noxious stimuli was completed. Each evaluation was executed one time. Findings on thermogenesis and appetite are reported elsewhere (Ludy & Mattes, 2011).

Subjects

Subjects were recruited using public advertisements. They completed questionnaires concerning their spicy food perception and experience (H. Lawless, et al., 1985), in addition to their weight, diet, physical activity, and medical history. A screening visit was scheduled for those meeting preset criteria: 18 to 65 years old, body mass index (BMI) of 18.5 to 27 kg/m^2, weight stable (≤ 5 kg change over the past 6 months), consistent habitual diet and activity patterns over the past 3 months, regular spicy food user (≥ 3 times/week) or non-user (< 1 time/month), no allergies to study foods, in good health, taking no medications likely to influence appetite or energy metabolism, and non-smokers (≥ 1 year). Screening included assessment of height, weight, 6-*n*-propylthiouracil (PROP) taster status (Bartoshuk, Duffy, & Miller, 1994), physical activity level (Johansson & Westerterp, 2008), and oral burn palatability/intensity. Equal numbers of PROP tasters and non-tasters, as well as regular spicy food users and non-users were desired. After screening, potential subjects were excluded if their PROP taster or spicy food use category was fully recruited; if they rated plain tomato soup, which was later presented with spicy stimuli to scale palatability/intensity, as unpalatable; or their measured BMI was not between 18.5 and 27 kg/m^2. All subjects signed an informed consent form approved by the Biomedical Institutional Review Board at Purdue University and received monetary compensation.

Sensory perception and experience with spicy foods

Spicy food perception and experience with spicy foods was characterized using the "Hedonics of Capsaicin Containing Foods Questionnaire" (H. Lawless, et al., 1985). Preferred spicy and bland food eating frequency (Food Action Rating Scale (Schutz, 1965)) was also assessed. The spicy foods selected for scaling were targeted in previous studies (Ahuja, Robertson, Geraghty, & Ball, 2007; H. Lawless, et al., 1985), while bland items were selected from the foods commonly eaten in the United States (Smiciklas-Wright, et al., 2002). Burn intensity was assessed by asking subjects to taste tomato soup containing ascending concentrations of RP (0, 0.5, 1, 1.5, 2, 2.5, and 3 g per 290 g serving; RP: 1995 ug/g capsaicin, 247 ug/g nordihydrocapsaicin, and 1350 ug/g dihydrocapsaicin equivalent to 53,800 Scoville Heat Units). Tomato soup was prepared with 150 g Campbells Condensed Tomato Soup, 125 g Lactaid whole milk, and 15 g Market Pantry heavy cream. Soup, milk, cream, and RP were mixed at room temperature (~ 22 °C); refrigerated (~ 3 °C, minimum overnight and maximum 3 days); and heated to a constant temperature (~ 60 °C) before serving. Subjects swished 10 ml soup samples in their mouth for 3-seconds, expectorated, rinsed with room temperature water, and rested for 10-seconds before evaluating the burn intensity and palatability. They rated each concentration's burn intensity on a 100 mm visual analog scale (VAS) and palatability on a 200 mm labeled affective magnitude (LAM) scale (Schutz & Cardello, 2001). When the soup became unpalatable (< -33 on a LAM scale), the questioning ended (prior to reaching the highest concentration in 1 user (1 at 2.5 g) and 6 non-users (2 at 0.5 g, 1 at 1 g, and 3 at 2 g)).

Physiological responsiveness to noxious stimuli

Psychophysical testing was conducted to determine individual differences in cutaneous pressure, oral thermal sensation, oral tactile sensitivity, and auditory intensity. Pressure intensity was assessed using a dolorimeter (Force Ten™ FDX, Wagner Instruments, Greenwich CT). Subjects themselves pressed the head of the dolorimeter on the tip of their middle finger, on the side opposite the nail, of their non-dominant hand (Özcan, Tulum, Pinar, & Baskurt, 2004). Pressure was applied until their self-assessed intensity reached a rating of "very strong" on a general labeled magnitude scale (gLMS). This procedure was repeated three times. The mean of the last two trials was recorded as the pressure intensity value. Oral thermal intensity was assessed through subject ratings for water samples of 26.7 (80), 35 (95), 43.3 (110), 51.7 (125), and 60 (140) °C (°F). Samples of 10 ml were swished in the mouth for 3-seconds and expectorated. Subjects then rinsed with room temperature water and rested for 10-seconds before rating heat intensity on a VAS. Oral tactile sensitivity was evaluated by applying von Frey hairs with five levels of force (i.e., 2.83, 3.84, 4.31, 4.93, and 5.46 mN) in random order to the tip of the tongue. Subjects rated the touch intensity on a VAS. Audition was included as a check for malingering, with no expectation that hearing would be related to spicy food use. It was assessed through intensity ratings for five decibel levels (i.e., 30, 45, 60, 75 and 90 db) of white noise administered binaurally in random order on an audiometer (Model MA40, Maico, Minneapolis MN). Subjects rated the sound intensity on a VAS. A computerized system was used to collect data (Compusense® *five*, version 4.6, Compusense Inc., Guelph ON, Canada).

Personality and cultural attributes

Standardized questionnaires were administered to characterize participants on selected personality traits. Extraversion-introversion (Eysenck Personality Questionnaire – Revised (Eysenck, Eysenck, & Barrett, 1985)); finickiness (Food Attitudes Survey (Raudenbush, Van Der Klaauw, & Ra, 1995)); and sensation seeking (Brief Sensation Seeking Scale (Stephenson, Hoyle, Palmgreen, & Slater, 2003)) were assessed. Hedonic eating (Power of Food Scale (Cappelleri, et al., 2009; Lowe, et al., 2009)) was included to detect malingering, as responses were not expected to differ by user status. This was based on the assumption that individuals with the resources to select from an array of foods will select the ones they deem palatable (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998), irrespective of spicy food preference. Cultural practices were assessed by asking subjects when, if at all, spicy foods were introduced.

Statistical analysis

Repeated measures analysis of variance (ANOVA), with user status, time course of spicy food introduction, and sex as between-subjects factors, were performed for oral thermal sensation, oral tactile sensitivity, auditory intensity, and burn sensitivity assessments, as well as palatability. When appropriate, the Bonferroni adjustment was applied for multiple comparisons. For extraversion, finickiness, sensation seeking, hedonic eating, and food preference questionnaires, as well as pressure pain: (1) two-way ANOVA, with user status, sex, and/or median splits for personality as fixed factors, were conducted to test interactions between spice use and sex, in addition to spice use and personality; and (2) independent samples t-tests were used to determine inter-individual differences between users and non-users, in addition to users who reported consuming spicy food since childhood and those with a later introduction. Analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 17.0 for Windows (SPSS Inc., Chicago IL). The criterion for statistical significance was $p < 0.05$, two-tailed. Data are reported as mean ± standard error of the mean (SEM).

Results

Subject characteristics

Thirteen regular spicy food users, who were accustomed to eating spicy foods at least 3 times per week for a minimum of 3 months (69% since childhood), and 12 non-users, who ate spicy foods less than once per month, completed the study. Users included 10 men and 3 women, aged 23.2 ± 0.8 years with a mean body mass index (BMI) of 22.9 ± 0.6 kg/m^2. Seven users were Caucasian and 6 were Asian. Non-users included 4 men and 8 women, aged 22.8 ± 0.5 years with a mean BMI of 22.3 ± 0.4 kg/m^2. Ten non-users were Caucasian, 1 was Asian, and 1 was African American.

Sensory perception and experience with spicy foods

Compared to non-users, users had higher ($t(23) = 13.275$, $p < 0.001$) composite scores on the "Hedonics of Capsaicin Containing Foods Questionnaire" (H. Lawless, et al., 1985), with greater scores in users consuming spicy foods since childhood than those introduced later ($t(11) = 3.074$, $p = 0.001$). Users also had an increased frequency of chili pepper consumption, liking of chili pepper taste in food, and liking of chili pepper burn (all $p < 0.001$). Further, they reported that chili pepper makes food taste better; that without hot spices, food tastes too bland (childhood users more than those introduced later); and that they did not find it hard to appreciate the flavors of food when food contains hot spices (all $p \leq 0.001$). Figure 1 shows that users preferred the taste of spicy foods, including: Mexican, Indian, Chinese, wasabi, horseradish, and spices ($t(22) = 4.574$, $p < 0.001$; $t(22) = 3.890$, $p = 0.001$; $t(22) = 3.838$, $p = 0.001$; $t(17) = 4.795$, $p < 0.001$; $t(20) = 2.235$, $p = 0.037$; $t(23) = 2.067$, $p = 0.050$; respectively). In contrast, bland food preference ratings did not vary significantly by user status. There were no significant differences by sex.

There was a user status x concentration interaction for tomato soup palatability ratings ($F(6, 138) = 3.823$, $p = 0.001$). Figure 2 shows that palatability ratings of tomato soup with RP were greater in users than non-users, specifically at 1, 1.5, 2, 2.5 and 3 g concentrations, but did not vary by user status for tomato soup without RP. Tomato soup without RP was rated as most palatable in non-users and least palatable in users. While users perceived all tomato soup concentrations to be of approximately equal palatability (i.e., mean range = 32 to 39.7), ratings fell with increasing concentrations in non-users, and the difference between user and non-user ratings was greatest at high concentrations (i.e., mean difference = 43.4 and 38.4 arbitrary units greater in users at 2 and 3 g RP, respectively). Palatability ratings did not differ by time course of spicy food introduction or sex.

There was a user status x concentration interaction for perceived burn intensity ratings ($F(6,138) = 6.517$, $p < 0.001$). Figure 3 shows that non-users discriminated poorly between the spicy stimuli, only differentiating non-spicy (0 g) and spicy (0.5, 1, 1.5, 2, and 3 g) RP concentrations. In contrast, users monotonically scaled the stimuli. Users perceived tomato soup to be significantly spicier than non-users at concentrations of 2.5 and 3 g ($t(23) = 2.861$, $p < 0.01$) and $t(23) = 2.343$, $p < 0.05$, respectively). Burn intensity ratings did not differ by time course of spicy food introduction or sex.

Physiological responsiveness to noxious stimuli

There was a user status x temperature interaction for heat intensity ratings ($F(4, 84) = 2.572$, $p < 0.05$). Figure 4 shows that users reported a more rapid rise of heat intensity with exposure to increasing water temperature. Perceived pressure, oral tactile sensation, and hearing intensity did not vary significantly by user status. Physiological responsiveness to noxious stimuli did not differ by time course of spicy food introduction or sex.

Personality and cultural attributes

A higher proportion of users reported consuming foods containing chili peppers from childhood ($t(23) = 3.800$, $p = 0.001$). Sensation seeking was greater in users consuming spicy foods since childhood than those introduced later ($t(11) = 2.650$, $p < 0.05$). In addition, there was a user status x sex interaction for extraversion ($F(3, 21) = 5.176$, $p < 0.05$) with higher extraversion in female users and male non-users. No other personality traits varied significantly by user status, time course of spicy food introduction, or sex. Furthermore, there were no interactions between user status and personality traits.

Discussion

Despite the ubiquitous global presence of spicy foods (Palevitch & Craker, 1996) and their reported weight management (Cichewicz & Thorpe, 1996; Ludy & Mattes, 2011; Sherman, 2002; Westerterp-Plantenga, et al., 2005; Yoshioka, et al., 2004; Yoshioka, et al., 1995; Yoshioka, et al., 1999; Yoshioka, et al., 1998) and food safety (Cichewicz & Thorpe, 1996; Sherman, 2002) benefits, patterns of acceptance are widely divergent both across countries (e.g., average daily chili pepper consumption of 2.5-8 g in Asian nations compared to 0.05-0.5 g in the United States and Europe) (Gonlachanvit, 2010) and within countries (e.g., preferred quantity of red pepper (RP) per spicy food-containing meal of 1.8 g in regular users and 0.3 g in non-users in the United States (Ludy & Mattes, 2011)). Trends in spicy food consumption are burgeoning in the United States at rates far surpassing population growth (i.e., 25% increase from early to mid-1990's (Reineccius, 1998)). Thus, understanding the mechanisms underlying the acquisition of spicy food preferences is of public health interest. To evaluate potential mechanisms, it was hypothesized that (1) regular spicy food users would be less sensitive to oral tactile, oral thermal, and pressure pain than non-users; (2) users would demonstrate greater extraversion and sensation seeking behavior, and less finickiness, than non-users; (3) users would rate spicy stimuli as having lower burn intensity and greater palatability than non-users; and (4) users would report consuming spicy foods since childhood, while non-users would report no early exposure to spicy foods.

Sensory perception

In agreement with previous studies (H. Lawless, et al., 1985; Stevenson & Yeomans, 1993), regular users rated the palatability of spicy foods more favorably and preferred eating them more frequently than non-users. However, a novel finding was that while users maintained discriminatory abilities across a range of burn intensities, non-users could only distinguish between spicy and non-spicy. Users rated the highest concentrations (2.5 and 3 g RP per 290 g tomato soup serving) as spicier than non-users, whereas earlier studies (Cowart, 1987; H. Lawless, et al., 1985; Stevenson & Prescott, 1994; Stevenson & Yeomans, 1993) noted that users reported weaker burn intensity. One potential reason for this varied interpretation of burn intensity is that non-users experience more rapid fatigue within a testing session than users. Desensitization, or an attenuation in sensory response, may occur following a single application of capsaicin after time delays of 2.5 to 5 minutes (Green, 1989) and can persist for days, though there is marked individual variability (Karrer & Bartoshuk, 1991). A longer term effect is also possible. Repeated exposure to spicy stimuli over a 2-week period reduces burn intensity ratings (Stevenson & Prescott, 1994). These changes in food perception with routine exposure are not isolated to spicy foods. Level of alcohol (R. D. Mattes, 1994) and caffeine (D.J. Mela, et al., 1992; Tanimura & Mattes, 1993) intake have also been associated with increased taste detection thresholds. Furthermore, abstinence from alcohol has been shown to decrease taste detection thresholds in alcoholics (Settle, 1978). These findings imply that level of spicy food experience may be a primary determinant of the sensory interpretation of burn.

A number of methodological issues may account for the lack of sensory effects between groups. The first concerns the physical mixture of irritant stimuli tested. Previous studies mixed stock solutions of capsaicin with tomato juice (Stevenson & Prescott, 1994; Stevenson & Yeomans, 1993) (tomato juice = ~ 2.1% fat, 82.9% carbohydrate, 14.9% protein (Gebhardt, et al., 2009)), or used deionized water combined with ethanol as the solvent (H. Lawless, et al., 1985). In the present study, RP (1995 ug/g capsaicin) was mixed with a fat-containing tomato soup (36% fat, 52.5% carbohydrate, 11.5% protein). This distinction is pertinent because capsaicin's perceived intensity is inversely related to fat content of the vehicle (Carden, Penfield, & Saxton, 1999). Further, both capsaicin's detection thresholds and intensity ratings decrease with oil- versus water-based stimuli (H. T. Lawless, Hartono, & Hernandez, 2000).

Second, the discrepant burn intensity findings noted in this study and others reported in the literature may relate to the time courses of capsaicin desensitization and burn recovery. Compared to 15- and 30-second exposure times with spicy stimuli in prior studies ((H. Lawless, et al., 1985; Stevenson & Prescott, 1994), respectively), our subjects were exposed for only 3-seconds. Similarly, although subjects in a previous study (Stevenson & Prescott, 1994) rested 15-seconds before providing intensity ratings for spicy stimuli, our subjects rested only 10-seconds. These small time differences are relevant because, in the case of desensitization, longer exposure and rest times do not equate to better burn recovery and may promote desensitization. Shorter exposure and rest periods may be hypothesized to reduce the potential for desensitization (i.e., our entire 7-solution procedure was completed in less than 2.5 minutes).

Third, rinse solution may affect burn perception. Sucrose, which has a hedonically positive character, is reported to produce faster reductions in irritation than water, which is hedonically neutral (Stevens & Lawless, 1986). A previous study (Stevenson & Yeomans, 1993) required subjects to rinse their mouths with a sucrose solution for 6-seconds, while our subjects' water rinse was untimed, but likely shorter than 6-seconds. The shorter water rinse in our trial may have decreased the potential for burn recovery, especially among non-users who experience an early loss in the ability to discriminate spicy stimuli.

Finally, in an earlier study (Stevenson & Yeomans, 1993), subjects were informed that subsequent solutions would increase in intensity. Although we also provided spicy stimuli in ascending order, and ceased questioning when subjects rated stimuli as unpalatable or sampled all stimuli, our subjects did not have overt knowledge of the testing order. Familiarity with the testing order may produce response bias by leading subjects to provide socially desirable responses (i.e., increases in intensity because they are supposed to exist rather than are perceived). These findings underscore the importance of using consistent timing, rinse solutions, and subject instructions, as well as controlled irritant stimuli to characterize burn perception.

Physiological responsiveness to noxious stimuli

Contrary to our hypothesis, physiological responsiveness to an array of non-spicy noxious stimuli was similar between regular spicy food users and non-users, varying only in responsiveness to oral thermal heat. The assumption that non-users would express greater sensitivity to noxious stimuli hinged on the belief that altered physiology was driving varied hedonic responses to foods, a phenomenon that has been reported with the bitter compound 6-*n*-propythiouracil (PROP) (Duffy, 2007; Duffy & Bartoshuk, 2000). One possibility for our observation is that although previous literature suggests that PROP tasters perceive the burn from pungent foods as more intense than non-tasters (Karrer & Bartoshuk, 1991; Tepper & Nurse, 1997) due to greater oral lingual trigeminal innervation (Bartoshuk, 2000), spicy food preference is likely predominantly culturally-driven. This is highlighted by the widespread consumption of RP in countries with a higher prevalence of PROP tasters. For example, in parts of China and East Africa (Kenya) where chili peppers are accepted as a basic component of the diet (Rozin & Schiller, 1980), the prevalence of PROP tasters may be 89% to 92% (R. D. Mattes & Beauchamp, 2000). Furthermore, equal proportions of PROP tasters and non-tasters were screened in both user groups (i.e., 83% PROP tasters in both user groups).

A less likely explanation for our finding is that current methods were insufficient to identify the variation. Not all reports have demonstrated greater sensitivity to noxious stimuli in PROP tasters than non-tasters. For example, some studies have reported no correlation between PROP taster status and oral thermal sensitivity (Prutkin, et al., 1999), bitterness/irritation perceived in beer (D. J. Mela, 1990) and wine (Noble, 1994), reported intake of cruciferous vegetables (Jerzsa-Latta, Krondl, & Coleman, 1990) or goitrogen-containing foods (R.D. Mattes & Labov, 1989), or sensory perception and hedonic responses to foods and model solutions with varying degrees of fat (Drewnowski, Henderson, & Barratt-Fornell, 1998; Yackinous & Guinard, 2001), sweetness (Drewnowski, et al., 1998; Horne, Lawless, Speirs, & Sposato, 2002; Yackinous & Guinard, 2001), saltiness (Schifferstein & Frijters, 1991; Smagghe & Louis-Sylvestre, 1998; Yackinous & Guinard, 2001), and caffeine (Smagghe & Louis-Sylvestre, 1998). Together, these findings indicate that culture may be more important that physiological sensitivity in driving the desire to consume spicy foods.

A caveat of the current study is that differences in habitual consumption of high-temperature foods and beverages were not assessed and may confound comparisons between users and non-users. This is relevant given that “thermal taster status,” the ability to experience taste by altering tongue temperature alone in the absence of taste compounds, has been newly identified as a source of individual variation in taste/flavor perception (Cruz & Green, 2000) that is independent of PROP taster status (Bajec & Pickering, 2008), genetically-based (Talavera, et al., 2005), and is present in approximately 50% of the population (Green & George, 2004). Additionally, thermal taster status has been positively associated with intensity of sweet, salty, sour, bitter, and umami tastes (Green & George, 2004). However, burning, stinging, and prickling sensations evoked by capsaicin have not been demonstrated to differ between thermal tasters and non-tasters (Green, Alvarez-Reeves, George, & Akirav, 2005). Oral thermal heat preferences should be considered in the design of future studies.

Personality and cultural attributes

It was hypothesized that personality characteristics would differ between spice users and non-users. Weak correlations have been reported between sensation seeking and the preference for spicy foods compared to bland foods ($r = 0.36$) (Kish & Donnenwerth, 1972), specifically chili pepper ($r = 0.20$), Mexican food ($r = 0.20$), and black pepper ($r = 0.15$) (Logue & Smith, 1986). Additionally, limited research suggests that introverts, compared to extraverts, prefer comfort versus spicy foods when given a cookbook choice (Wheeler & Berger, 2007). We found greater sensation seeking in childhood users of spicy foods than those introduced later, as well as higher levels of extraversion in female users and male non-users. There was no association between personality traits, or sex, and spicy food preferences when all users were compared to non-users, nor a heightened bland food preference in non-users. However, these data should be extrapolated with caution as the distribution of the sample was distorted (i.e., very limited numbers of users introduced to spicy foods after childhood (n = 4), female users (n = 3), and male non-users (n = 4) in a total sample size of 25). Individual differences in scale usage can be discounted since subjects scored similarly in their assessments of hedonic eating, which was included to identify malingering. Although the data identify isolated personality and sex differences, a possible explanation for the lack of systematic differences between users and non-users in this study is that, perhaps, cultural values supersede individual personality and sex characteristics in the development of spicy food preferences.

There are examples of cultural facilitation of spicy food preferences by conferring social benefits. Historically, eating spicy foods served as a symbol of high social status (Schivelbusch, 2005). Children frequently begin consuming spicy foods to emulate the behavior of respected adults and/or to conform to the pressure of their peers (Rozin & Schiller, 1980). Eating spicy foods is also a part of religious and ceremonial practices in many societies (Yamamoto & Nawata, 2009). Additionally, individuals may derive extra-sensory enjoyment from the burn elicited by the spicy foods they initially perceive as harmful, through exploitation of cultural ideals, such as being strong and "macho." However, evidence is also available that culture can promote spice aversions by inculcating perceptions of danger, social inappropriateness with their use. For example, abstention from chili peppers was recommended in the Victorian era due to fears of sexual stimulation (Jones, 2007), and other populations believe that overconsumption of spicy foods is responsible for poor eyesight (Yamamoto & Nawata, 2009). Similarly, RP is rubbed on the breast as an infant weaning practice in some indigenous cultures (Jelliffee, 1962; Osuhor, 1980). A potential confound in this study is that more Asians were in the user group (n = 6), than the non-user group (n = 1). Thus, varied reactions to spicy foods among users and non-users may be related to either cultural influences or just differences in level and length of spice use. Previous studies (Laing, et al., 1993; Prescott & Bell, 1995; Sand, 2005; Yeh, et al., 1998) indicate that variations in flavor preferences among cultures are likely attributable to varied dietary experiences, rather than genetically-based differences in chemosensory function.

It may be that an interaction between personality traits and culture is the best predictor of use. Neophobia is a pervasive, general trait of humans (L. L. Birch, 1999), but can be extinguished for selected items with adequate exposure and absence of reinforcing aversive associations. Culture determines the pattern of exposure to foods, the flavoring of foods, and the preparation of foods (Rozin & Schiller, 1980), so provides a medium for facilitating spice acceptance. In a study linking sensation seeking behavior to spicy food preferences (Logue & Smith, 1986), a minority of subjects consumed characteristically spicy cuisines during childhood (2.4% Spanish and 2% Oriental, compared to 64.2% American, 15.7% Italian, 4.4% Jewish, 3.1% Polish-German, and 8.2% other), suggesting the possible influence of personality traits in shaping food preferences developed during adulthood. In contrast, our study found that regular spicy food users, the majority (69%) consuming these foods since childhood, scored comparably to non-users on sensation seeking. These divergent outcomes suggest that cultural values prompting a comparatively early introduction of spicy foods may serve as a more potent influence on lifelong food preferences than underlying personality characteristics.

Collectively, these data suggest that exposure is a stronger determinant of the preference for spicy foods than inherent sensory responsiveness or personality traits and is the primary feature distinguishing regular users from non-users. However, these data generate new questions concerning the time course and social influences required to promote induction of a hedonic shift in spicy food preference, as well as strategies for overcoming the initial neophobia, for instance early introduction, role models, gradual low-dose exposure, and pairing spicy with fat- and/or sucrose-containing foods/beverages. Investigating such approaches will highlight mechanisms by which spicy foods can be most successfully added to the diet. While there is evidence for weight management (Cichewicz & Thorpe, 1996; Ludy & Mattes, 2011; Sherman, 2002; Westerterp-Plantenga, et al., 2005; Yoshioka, et al., 2004; Yoshioka, et al., 1995; Yoshioka, et al., 1999; Yoshioka, et al., 1998) and food safety (Cichewicz & Thorpe, 1996; Sherman, 2002) benefits of spicy foods, there are also reports of increased gut permeability (Jensen-Jarolim, et al., 1998) and gastric cancer prevalence (Gajalakshmi & Shanta, 1996; Lee, Park, Yoo, & Ahn, 1995; Lopez-Carrillo, Hernandez-Avila, & Dubrow, 1994; Lopez-Carrillo, et al., 2003) at high intake levels. Exploration of these areas is crucial before public health recommendations to markedly increase spicy food consumption can be made.

Acknowledgements

This work was supported by the McCormick Science Institute (MSI) and the National Institutes of Health (NIH) under Ruth L. Kirschstein National Research Service Award (5T32DK076540). Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the MSI or the NIH. The authors thank Sze-Yen Tan for comments on the manuscript.

References

Ahuja, K. D. K., Robertson, I. K., Geraghty, D. P., & Ball, M. J. (2007). The effect of 4-week chilli supplementation on metabolic and arterial function in humans. *European Journal of Clinical Nutrition, 61*, 326-333.

Aluja, A., García, Ó., & García, L. (2003). Relationships among extraversion, openness to experience, and sensation seeking. *Personality and Individual Differences, 35*, 671-680.

Ammon, H. P., Bieck, P. R., Mandalaz, D., & Verspohl, E. J. (1983). Adaptation of blood pressure to continuous heavy coffee drinking in young volunteers. a double-blind crossover study. *British Journal of Clinical Pharmacology, 15*, 701-706.

Bajec, M. R., & Pickering, G. J. (2008). Thermal taste, PROP responsiveness, and perception of oral sensations. *Physiology & Behavior, 95*, 581-590.

Bartoshuk, L. M. (2000). Comparing sensory experiences across individuals: recent psychophysical advances illuminate genetic variation in taste perception. *Chemical Senses, 25*, 447-460.

Bartoshuk, L. M., Duffy, V. B., & Miller, I. J. (1994). PTC/PROP tasting: anatomy, psychophysics, and sex effects. *Physiology & Behavior, 56*, 1165-1171.

Birch, L., & Marlin, D. (1982). I don't like it; I never tried it: effects of exposure on two-year-old children's food preferences. *Appetite, 3*, 353-360.

Birch, L. L. (1999). Development of food preferences. *Annual Review of Nutrition, 19*, 41-62.

Cappelleri, J. C., Bushmakin, A. G., Gerber, R. A., Leidy, N. K., Sexton, C. C., Karlsson, J., & Lowe, M. R. (2009). Evaluating the Power of Food Scale in obese subjects and a general sample of individuals: development and measurement properties. *International Journal of Obesity, 33*, 913-922.

Carden, L. A., Penfield, M. P., & Saxton, A. M. (1999). Perception of heat in cheese sauces as affected by capsaicin concentration, fat level, fat mimetic and time. *Journal of Food Science, 64*, 175-179.

Cichewicz, R. H., & Thorpe, P. A. (1996). The antimicrobial properties of chile peppers (Capsicum species) and their uses in Mayan medicine. *Journal of Ethnopharmacology, 52*, 61-70.

Cowart, B. (1987). Oral chemical irritation: does it reduce perceived taste intensity? *Chemical Senses, 12*, 467-479.

Cruz, A., & Green, B. G. (2000). Thermal stimulation of taste. *Nature, 403*, 889-892.

Drewnowski, A., Henderson, S. A., & Barratt-Fornell, A. (1998). Genetic sensitivity to 6-n-propylthiouracil and sensory responses to sugar and fat mixtures. *Physiology & Behavior, 63*, 771-777.

Duffy, V. B. (2007). Variation in oral sensation: implications for diet and health. *Current Opinion in Gastroenterology, 23*, 171-177.

Duffy, V. B., & Bartoshuk, L. M. (2000). Food acceptance and genetic variation in taste. *Journal of the American Dietetic Association, 100*, 647-654.

Duffy, V. B., Bartoshuk, L. M., Lucchina, L. A., Snyder, D. J., & Tym, A. (1996). Supertasters of PROP (6-n-propylthiouracil) rate the highest creaminess to high-fat milk products. *Chemical Senses, 21*, 598 (abstract).

Eysenck, S. B. G., Eysenck, H. J., & Barrett, P. (1985). A revised version of the psychoticism scale. *Personality and Individual Differences, 6*, 21-29.

Gajalakshmi, C. K., & Shanta, V. (1996). Diet and risk of stomach cancer: a case-control study in Madras, India. *Cancer Prevention International, 2*, 97-109.

Galef, B. G. (1989). Enduring social enhancement of rats' preferences for the palatable and the piquant. *Appetite, 13*, 81-92.

Gebhardt, S. E., Lemar, L. E., Pehrsson, P. R., Exler, J., Haytowitz, D. B., Patterson, K. K., Nickle, M. S., Thormas, R. G., Showell, B. A., & Holden, J. M. (2009). USDA National Nutrient Database for Standard Reference, Release 22.

Glanz, K., Basil, M., Maibach, E., Goldberg, J., & Snyder, D. (1998). Why Americans eat what they do: taste, nutrition, cost, convenience, and weight control concerns as influences on food consumption. *Journal of the American Dietetic Association, 98*, 1118-1126.

Gonlachanvit, S. (2010). Are rice and spicy diet good for functional gastrointestinal disorders? *Journal of Neurogastroenterology and Motility, 16*, 131-138.

Green, B. G. (1989). Capsaicin sensitization and desensitization on the tongue produced by brief exposures to a low concentration. *Neuroscience Letters, 107*, 173-178.

Green, B. G., Alvarez-Reeves, M., George, P., & Akirav, C. (2005). Chemesthesis and taste: evidence of independent processing of sensation intensity. *Physiology & Behavior, 86*.

Green, B. G., & George, P. (2004). 'Thermal taste' predicts higher responsiveness to chemical taste and flavor. *Chemical Senses, 29*, 617-628.

Horne, J., Lawless, H. T., Speirs, W., & Sposato, D. (2002). Bitter taste of saccharin and acesulfame-k. *Chemical Senses, 27*, 31-38.

Jelliffee, D. B. (1962). Culture, social change, and infant feeding: current trends in tropical regions. *American Journal of Clinical Nutrition, 10*, 19-45.

Jensen-Jarolim, E., Gajdzik, L., Haberl, I., Kraft, D., Scheiner, O., & Graf, J. (1998). Hot spices influence permeability of human intestinal epithelial monolayers. *Journal of Nutrition, 128*, 577-581.

Jerzsa-Latta, M., Krondl, M., & Coleman, P. (1990). Use and perceived attributes of cruciferous vegetables in terms of genetically-mediated taste sensitivity. *Appetite, 15*, 127-134.

Johansson, G., & Westerterp, K. R. (2008). Assessment of the physical activity level with two questions: validation with doubly labeled water. *International Journal of Obesity, 32*, 1031-1033.

Jones, M. O. (2007). Food choice, symbolism, and identity: bread-and-butter issues for folkloristics and nutrition studies. *Journal of American Folklore, 120*, 129-177.

Karrer, T., & Bartoshuk, L. (1991). Capsaicin desensitization and recovery on the human tongue. *Physiology & Behavior, 49*, 757-764.

Kikuchi, Y., & Watanabe, S. (2000). Personality and dietary habits. *Journal of Epidemiology, 10*, 191-198.

Kim, W. O., Kil, H. K., Yoon, D. M., & Cho, M. J. (2003). Treatment of compensatory gustatory hyperhidrosis with topical glycopyrrolate. *Yonsei Medical Journal, 44*, 579-582.

Kish, G. B., & Donnenwerth, G. V. (1972). Sex differences in the correlates of stimulus seeking. *Journal of Consulting and Clinical Psychology, 38*, 42-49.

Ku, Y., & Choi, S. (1990). The composition of foods. In *The Scientific Technology of Kimchi* (pp. 33–34). Seoul, Korea: Korean Institute of Food Development.

Laing, D., Prescott, J., Bell, G., Gillmore, R., James, C., Best, D., Allen, S., Yoshida, M., & Yamazaki, K. (1993). A cross-cultural study of taste discrimination with Australians and Japanese. *Chemical Senses, 18*, 161-168.

Lawless, H., Rozin, P., & Shenker, J. (1985). Effects of oral capsaicin on gustatory, olfactory, and irritant sensations and flavor identification in humans who regularly or rarely consume chili pepper. *Chemical Senses, 10*, 579-589.

Lawless, H. T., Hartono, C., & Hernandez, S. (2000). Thresholds and suprathreshold intensity functions for capsaicin in oil and aqueous based carriers. *Journal of Sensory Studies, 15*, 437-477.

Lee, J. K., Park, B. J., Yoo, K. Y., & Ahn, Y. O. (1995). Dietary factors and stomach cancer: a case-control study in Korea. *International Journal of Epidemiology, 24*, 33-41.

Lejeune, M. P. G. M., Kovacs, E. M. R., & Westerterp-Plantenga, M. S. (2003). Effect of capsaicin on substrate oxidation and weight maintenance after modest body-weight loss in human subjects. *British Journal of Nutrition, 90*, 651-659.

Lim, K., Yoshioka, M., Kikuzato, S., Kiyonaga, A., Tanaka, H., Shindo, M., & Suzuki, M. (1997). Dietary red pepper ingestion increases carbohydrate oxidation at rest and during exercise in runners. *Medicine & Science in Sports & Exercise, 29*, 355-361.

Logue, A. W., & Smith, M. E. (1986). Predictors of food preferences in adult humans. *Appetite, 7*, 109-125.

Lopez-Carrillo, L., Hernandez-Avila, M., & Dubrow, R. (1994). Chili pepper consumption and gastric cancer in Mexico: a case-control study. *American Journal of Epidemiology, 139*, 263-271.

Lopez-Carrillo, L., Lopez-Cervantes, M., Robles-Diaz, G., Ramirez-Espitia, A., Mohar-Betancourt, A., Meneses-Garcia, A., Lopez-Vidal, Y., & Blair, A. (2003). Capsaicin consumption, Helicobacter pylori positivity and gastric cancer in Mexico. *International Journal of Cancer, 106*, 277-282.

Lowe, M. R., Butryn, M. L., Didie, E. R., Annunziato, R. A., Thomas, J. G., Crerand, C. E., Ochner, C. N., Coletta, M. C., Bellace, D., & Wallaert, M. (2009). The Power of Food Scale. A new measure of the psychological influence of the food environment. *Appetite, 53*, 114-118.

Ludy, M. J., & Mattes, R. D. (2011). The effects of hedonically acceptable red pepper doses on thermogenesis and appetite. *Physiology & Behavior, 102*, 251-258.

Matsumoto, T., Miyawaki, C., Ue, H., Yuasa, T., Miyatsuji, A., & Moritani, T. (2000). Effects of capsaicin-containing yellow curry sauce on sympathetic nervous system activity and diet-induced thermogenesis in lean and obese young women. *Journal of Nutritional Science and Vitaminology, 46*, 309-315.

Mattes, R. D. (1994). Influences on acceptance of bitter foods and beverages. *Physiology & Behavior, 56*, 1229-1236.

Mattes, R. D., & Beauchamp, G. K. (2000). Individual differences in bitter taste. In R. G. Kunzendorf & B. Wallace (Eds.), *Individual Differences in Conscious Experience* (Vol. 20, pp. 99-123). Philadelphia: John Benjamins Publishing Company.

Mattes, R. D., & Labov, J. (1989). Bitter taste responses to phenylthiocarbamide are not related to dietary goitrogen intake in human beings. *Journal of the American Dietetic Association, 89*, 692-694.

Mela, D. J. (1990). Gustatory perception of isohumulones: influence of sex and thiourea taster status. *Chemical Senses, 15*, 485-490.

Mela, D. J., Mattes, R. D., Tanimura, S., & Garcia-Medina, M. R. (1992). Relationships between ingestion and gustatory perception of caffeine. *Pharmacology Biochemistry & Behavior, 43*, 513-521.

Nabhan, G. P. (2004). *Why Some Like It Hot: Food, Genes, and Cultural Diversity*. Washington DC: Shearwater Books.

Noble, A. C. (1994). Bitterness in wine. *Physiology & Behavior, 56*, 1251-1255.

Osuhor, P. C. (1980). Weaning practices amongst the Hausas. *International Journal of Food Sciences & Nutrition, 34*, 273-280.

Özcan, A., Tulum, Z., Pinar, L., & Baskurt, F. (2004). Comparison of pressure pain threshold, grip strength, dexterity, and touch pressure of dominant and non-dominant hands within and between right-and left-handed subjects. *Journal of Korean Medical Science, 19*, 874–878.

Palevitch, D., & Craker, L. E. (1996). Nutritional and medical importance of red pepper (Capsicum spp.). *Journal of Herbs, Spices & Medicinal Plants, 3*, 55-83.

Pliner, P. (1982). The effects of mere exposure on liking for edible substances. *Appetite, 3*, 283-290.

Prescott, J., & Bell, G. (1995). Cross-cultural determinants of food acceptability: recent research on sensory perceptions and preferences. *Trends in Food Science & Technology, 6*, 201-205.

Prutkin, J. M., Fast, K., Lucchina, L. A., & Bartoshuk, L. M. (1999). PROP (6-n-propylthiouracil) genetics and trigeminal innervation of fungiform papillae. *Chemical Senses, 24*, 243 (abstract).

Raudenbush, B., Van Der Klaauw, N. J., & Ra, F. (1995). The contribution of psychological and sensory factors to food preference patterns as measured by the Food Attitudes Survey (FAS). *Appetite, 25*, 1-15.

Reineccius, G. (1998). *Source Book of Flavors* (2 ed.). New York, NY: Aspen Publishers.

Robertson, D., Wade, D., Workman, R., Woosley, R. L., & Oates, J. A. (1981). Tolerance to the humoral and hemodynamic effects of caffeine in man. *Journal of Clinical Investigation, 67*, 1111-1117.

Rozin, P., Grass, L., & Berk, G. (1979). Reversal of innate aversions: attempts to induce a preference for chili peppers in rats. *Journal of Comparative & Physiological Psychology, 93*, 1001-1014.

Rozin, P., & Kennel, K. (1983). Acquired preferences for piquant foods by chimpanzees. *Appetite, 4*, 69-77.

Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion, 4*, 77-101.

Sand, J. (2005). A short history of MSG: good science, bad science, and taste cultures. *Gastronomica, 5*, 38-49.

Sawka, M., Castellani, J., Pandolf, K., & Young, A. (2002). Human Adaptations to Heat and Cold Stress. In *Blowing Hot and Cold: Protecting Against Climatic Extremes*. Dresden, Germany.

Schifferstein, H. N. J., & Frijters, J. E. R. (1991). The perception of the taste of KCl, NaCl and quinine HCl is not related to PROP-sensitivity. *Chemical Senses, 16*, 303-317.

Schivelbusch, W. (2005). Spices: tastes of paradise. In C. Korsmeyer (Ed.), *The Taste Culture Reader: Experiencing Food and Drink* (pp. 123-130). New York, NY: Berg.

Schutz, H. G. (1965). A food action rating scale for measuring food acceptance. *Journal of Food Science, 30*, 365-374.

Schutz, H. G., & Cardello, A. V. (2001). A labeled affective magnitude (LAM) scale for assessing food liking/disliking. *Journal of Sensory Studies, 16*, 117-159.

Settle, R. G. (1978). The alcoholic's taste perception of alcohol: preliminary findings. In M. Galanter (Ed.), *Currents in Alcoholism* (Vol. 15, pp. 257-267). New York: Grune and Stratten.

Sherman, P. W. (2002). Why we use spices. *Foods & Food Ingredients Journal of Japan, 198*, 56-69.

Simons, C. T., Dessirier, J. M., Jinks, S. L., & Carstens, E. (2001). An animal model to assess aversion to intra-oral capsaicin: increased threshold in mice lacking substance P. *Chemical Senses, 26*, 491-497.

Smagghe, K., & Louis-Sylvestre, J. (1998). Influence of PROP-sensitivity on taste perceptions and hedonics in French women. A study performed without retronasal olfaction. *Appetite, 30*, 325-339.

Smiciklas-Wright, H., Mitchell, D. C., Mickle, S. J., Cook, A. J., & Goldman, J. D. (2002). Foods commonly eaten in the United States: quantities consumed per eating occasion and in a day, 1994–1996. *US Department of Agriculture NFS Report No. 96-5*.

Stephenson, M., Hoyle, R., Palmgreen, P., & Slater, M. (2003). Brief measures of sensation seeking for screening and large-scale surveys. *Drug and Alcohol Dependence, 72*, 279-286.

Stevens, D. A., & Lawless, H. T. (1986). Putting out the fire: effects of tastants on oral chemical irritation. *Perception & Psychophysics, 39*, 346-350.

Stevenson, R. J., & Prescott, J. (1994). The effects of prior experience with capsaicin on ratings of its burn. *Chemical Senses, 19*, 651-656.

Stevenson, R. J., & Yeomans, M. R. (1993). Differences in ratings of intensity and pleasantness for the capsaicin burn between chili likers and non-likers: implications for liking development. *Chemical Senses, 18*, 471-482.

Talavera, K., Yasumatsu, K., Voets, T., Droogmans, G., Shigemura, N., Ninomiya, Y., Margolskee, R. F., & Nilius, B. (2005). Heat activation of TRPM5 underlies thermal sensitivity of sweet taste. *Nature, 438*, 1022-1025.

Tanimura, S., & Mattes, R. D. (1993). Relationships between bitter taste sensitivity and consumption of bitter substances. *Journal of Sensory Studies, 8*, 31-41.

Tepper, B. J., Keller, K. L., & Ullrich, N. V. (2003). Genetic variation in taste and preferences for bitter and pungent foods: implications for chronic disease risk. In *Challenges in Taste Chemistry and Biology* (Vol. 867, pp. 60-74). Washington, DC: ACS Publications.

Tepper, B. J., & Nurse, R. J. (1997). Fat perception is related to PROP taster status. *Physiology & Behavior, 61*, 949-954.

van den Bree, M., Przybeck, T., & Robert Cloninger, C. (2006). Diet and personality: associations in a population-based sample. *Appetite, 46*, 177-188.

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

Wheeler, S. C., & Berger, J. A. (2007). When the same prime leads to different effects. *Journal of Consumer Research, 34*, 357–368.

Yackinous, C. A., & Guinard, J.-X. (2001). Relation between PROP taster status and fat perception, touch, and olfaction. *Physiology & Behavior, 72*, 427-437.

Yamamoto, S., & Nawata, E. (2009). Use of *Capsicum frutescens* L. by the indigenous peoples of Taiwan and the Batanes Islands. *Economic Botany, 63*, 43-59.

Yeh, L., Kim, K., Chompreeda, P., Rimkeeree, H., Yau, N., & Lundahl, D. (1998). Comparison in use of the 9-point hedonic scale between Americans, Chinese, Koreans, and Thai. *Food Quality and Preference, 9*, 413-419.

Yoshioka, M., Imanaga, M., Ueyama, H., Yamane, M., Kubo, Y., Boivin, A., St-Amand, J., Tanaka, H., & Kiyonaga, A. (2004). Maximum tolerable dose of red pepper decreases fat intake independently of spicy sensation in the mouth. *British Journal of Nutrition, 91*, 991-995.

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.

Figure Legends

Figure 1. Mean (± SEM) preferred eating frequency of spicy (a) and bland foods (b) evaluated using the Food Action Rating Scale (Schutz, 1965) (n = 25). Comparisons are based on independent samples t-tests. *$p \leq 0.05$, ***$p \leq 0.001$

Figure 2. Palatability of tomato soup with ascending RP concentrations. Subjects (n = 25) swished tomato soup for 3-seconds, expectorated, rinsed with water, and rested for 10-seconds before evaluating palatability. Mean (± SEM) palatability of tomato soup was greater in users than non-users. Comparisons are based on one-way repeated measures ANOVA with Bonferroni adjustment. *$p < 0.05$, ***$p < 0.001$

Figure 3. Mean (± SEM) perceived burn intensity of tomato soup with ascending RP concentrations in regular spicy food users (n = 13) (a) and non-users (n = 12) (b). Subjects swished tomato soup for 3-seconds, expectorated, rinsed with water, and rested for 10-seconds before evaluating burn intensity. Bars with dissimilar letters are significantly different ($p < 0.05$). Comparisons are based on one-way repeated measures ANOVA with Bonferroni adjustment.

Figure 4. Heat intensity ratings of water with increasing temperatures. Subjects (n = 25) swished water for 3-seconds, expectorated, rinsed with water, and rested for 10-seconds before evaluating heat intensity. Mean (± SEM) heat intensity ratings of water increased

more rapidly in users than non-users ($p < 0.05$). Comparisons are based on one-way repeated measures ANOVA with Bonferroni adjustment.

Figure 1 Eating Frequency - Black and White

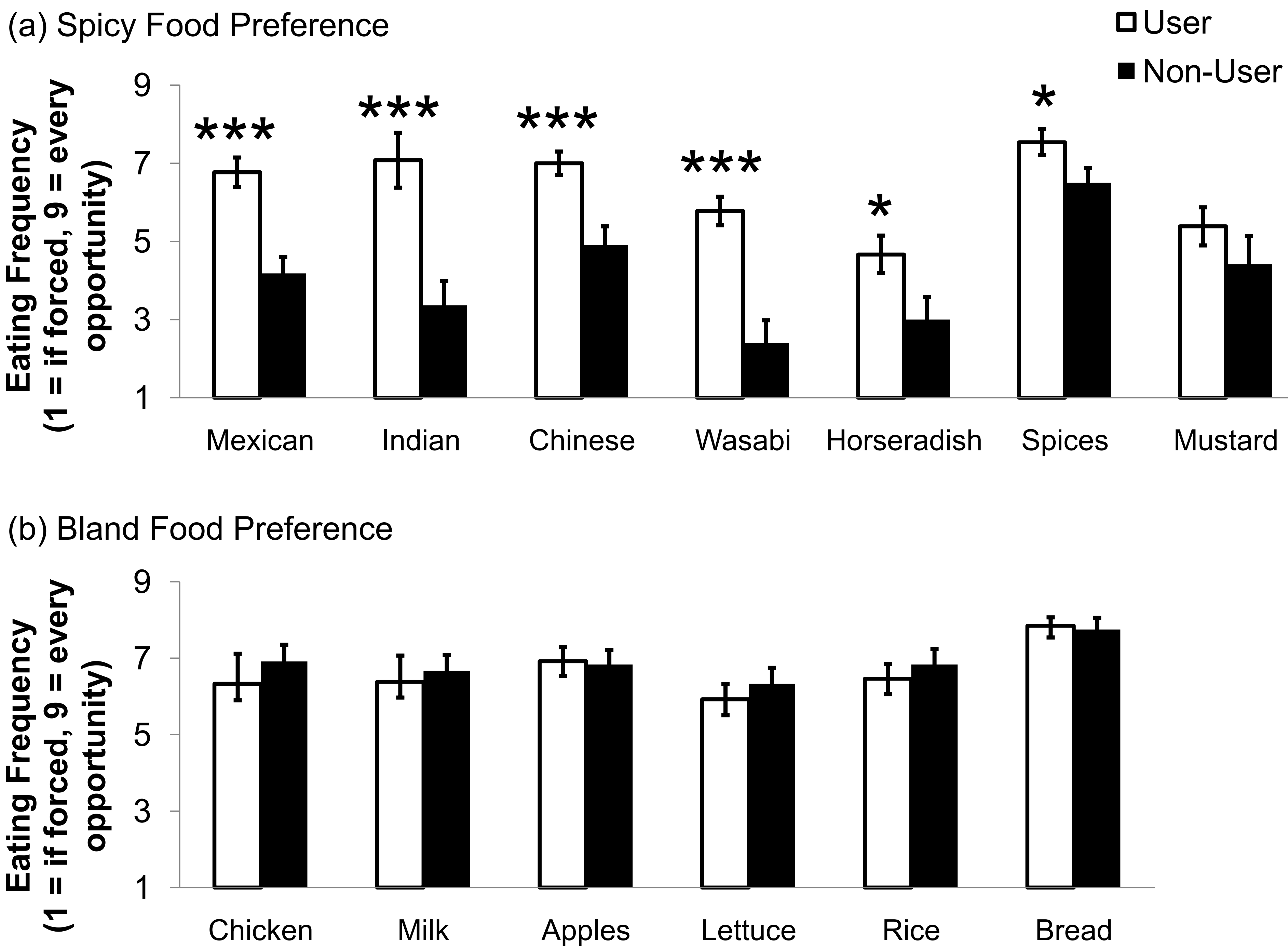


Figure 1 Palatability - Black and White

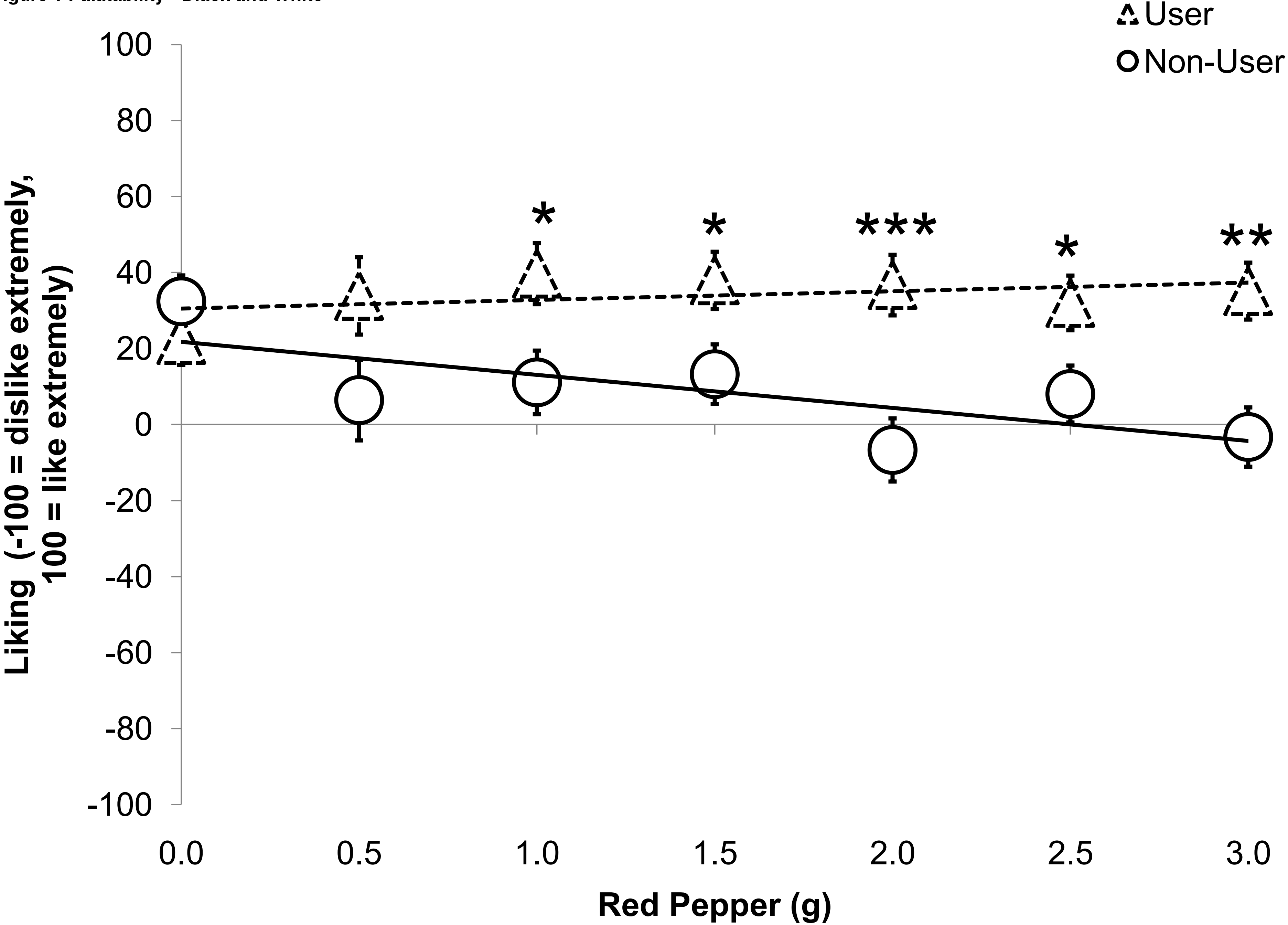
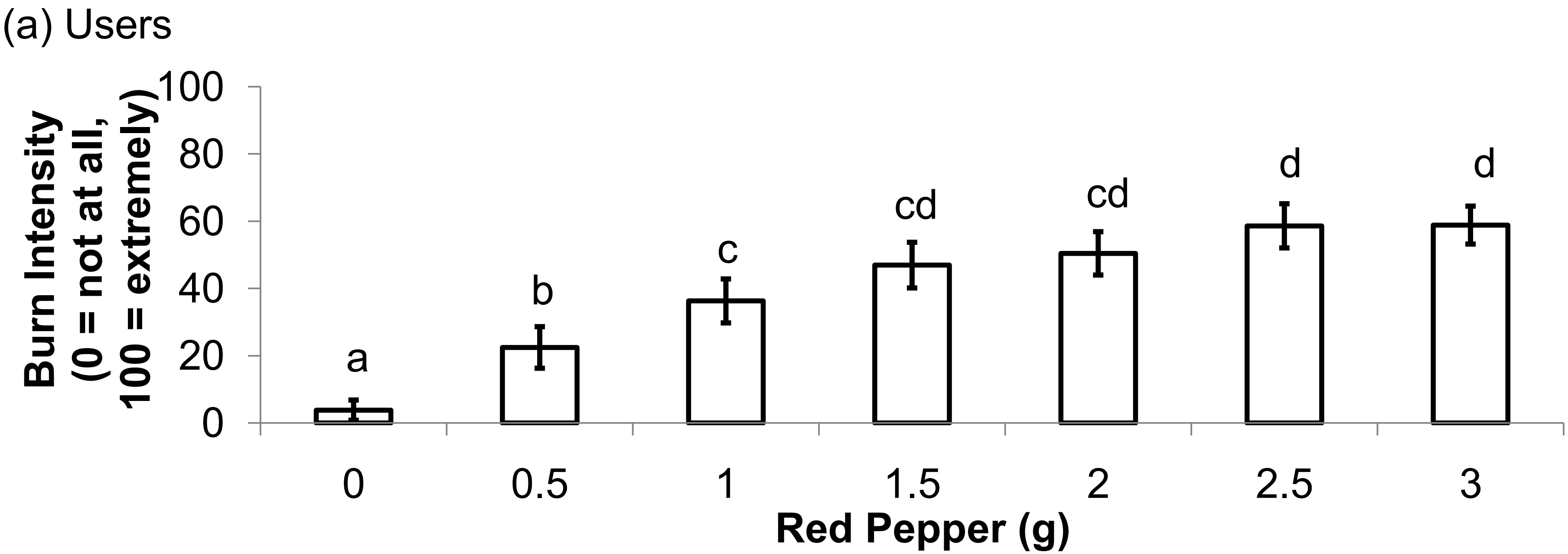


Figure 3 Burn Intensity - Black and White



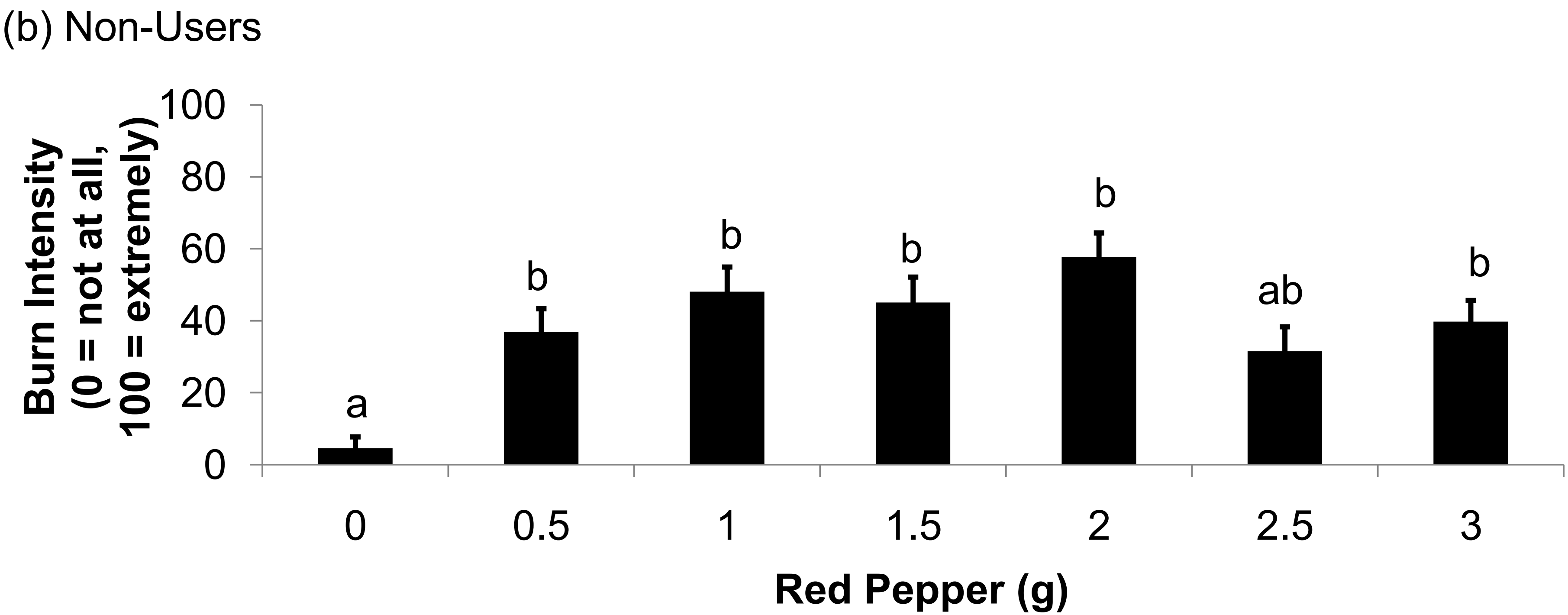


Figure 4 Heat Intensity - Black and White