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Using Check-All-That-Apply (CATA) method for determining product temperature-dependent sensory-attribute variations: A case study of cooked rice☆

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ABSTRACT

Temperatures of most hot or cold meal items change over the period of consumption, possibly influencing sensory perception of those items. Unlike temporal variations in sensory attributes, product temperature-induced variations have not received much attention. Using a Check-All-That-Apply (CATA) method, this study aimed to characterize variations in sensory attributes over a wide range of temperatures at which hot or cold foods and beverages may be consumed. Cooked milled rice, typically consumed at temperatures between 70 and 30 °C in many rice-eating countries, was used as a target sample in this study. Two brands of long-grain milled rice were cooked and randomly presented at 70, 60, 50, 40, and 30 °C. Thirty-five CATA terms for cooked milled rice were generated. Eighty-eight untrained panelists were asked to quickly select all the CATA terms that they considered appropriate to characterize sensory attributes of cooked rice samples presented at each temperature. Proportions of selection by panelists for 13 attributes significantly differed among the five temperature conditions. "Product temperature-dependent sensory-attribute variations" differed with two brands of milled rice grains. Such variations in sensory attributes, resulted from both product temperature and rice brand, were more pronounced among panelists who more frequently consumed rice. In conclusion, the CATA method can be useful for characterizing "product temperature-dependent sensory attribute variations" in cooked milled-rice samples. Further study is needed to examine whether the CATA method is also effective in capturing "product temperature-dependent sensory-attribute variations" in other hot or cold foods and beverages.

1. Introduction

Consumer acceptance of foods or beverages often varies with their serving temperatures (Brown & Diller, 2008; Cardello & Maller, 1982; Lee & O'Mahony, 2002). In general, consumers' hedonic ratings for certain foods or beverages are the highest in the temperature ranges in which they are usually consumed (Cardello & Maller, 1982). Serving temperatures have been also found to influence taste intensities. More specifically, psychophysical studies have demonstrated that taste intensities of basic taste solutions change with serving temperatures (Bartoshuk, Rennert, Rodin, & Stevens, 1982; Lipscomb, Rieck, & Dawson, 2016; Moskowitz, 1973; Pangborn, Chrisp, & Bertolero, 1970), while those results have been inconsistent. Moreover, the effect of serving temperatures on taste intensities has been observed in food or beverage products (Drake, Yates, & Gerard, 2005; Kim, Samant, Seo, & Seo, 2015; Ross & Weller, 2008; Yau & Huang, 1996).

People generally have their meals over a period of 10 to 60 min (Bell & Pliner, 2003). In other words, when people consume hot or cold meal-products, people may experience their meals over a wide range of product temperatures since those temperatures change over time. Such temperature variations of hot or cold foods and beverages can be more pronounced when those are consumed concurrently with other activities, such as performing office work or engaging in social conversations. These observations suggest that sensory professionals should consider potential variations in sensory attributes of hot or cold foods and beverages over a wider range of product temperatures that consumers typically encounter in daily life (Seo, Lee, Jung, & Hwang, 2009). However, in most sensory studies of hot or cold food/beverage products, the products have been evaluated at specific serving temperatures, but not at a range of product temperatures in which those are usually consumed.

Serving temperatures have been found to affect intensities of sensory attributes in food or beverage products. In most sensory studies regarding the effect of serving temperatures, food or beverage samples

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have been compared with respect to attribute intensities between two (Francis et al., 2005; Yau & Huang, 1996) or among three serving-temperature conditions (Cliff & King, 2009; Drake et al., 2005; Kähkönen, Tuorila, & Hyvönen, 1995; Ross & Weller, 2008). However, there has only been a limited number of studies that focused on such temperature-dependent changes in sensory attributes over a wider range of product temperatures, i.e., among four or more serving-temperatures. For example, Kim et al. (2015) instructed both 8 trained and 62 consumer panelists to evaluate saltiness intensities of salt water, chicken broth, and miso soup at 5 different serving temperatures: 80, 70, 60, 50, and 40 °C. In another study by Stokes, O'Sullivan, and Kerry (2016), 10 panelists were asked to rate intensities of 14 sensory attributes of brewed coffee presented at 7 different serving temperatures: 77, 75, 70, 60, 50, 40, and 30 °C. In a recent study conducted by Steen, Waehrens, Petersen, Münchow, and Bredie (2017), 8 panelists were asked to rate intensities of 8 sensory attributes for brewed coffee served at 6 different serving temperatures: 62, 56, 50, 44, 37, and 31 °C. Intensities of four sensory attributes, i.e., overall intensity, sweet note, bitter note, and roasted flavor, were found to differ as a function of serving temperature. In particular, brewed coffee samples evaluated at 50 °C or higher temperatures were more associated with "overall intensity", "bitter note", and "roasted flavor" attributes, while those evaluated at 44 °C or lower temperatures were more associated with "sour note", "sweet note", and "tobacco flavor" attributes.

Since the temperatures of hot food or beverage products quickly change over time, the number of sensory attributes evaluated at specific serving temperatures has been limited in the aforementioned studies. Due to the limited number of sensory attributes used in the scoring-based traditional methods, a "rapid sensory profiling technique" seems to be more suitable for capturing dynamics of temperature-dependent sensory attributes in hot or cold foods and beverages. Using one of the rapid sensory profiling techniques, i.e., the projective mapping (Napping) method (Pagès, 2005), Ross, Weller, and Alldredge (2012) demonstrated serving temperature-dependent variations in sensory attributes of red wine products. More specifically, 12 trained panelists were asked to evaluate and sort six wine samples simultaneously presented at each three serving-temperatures: 10, 16, and 22 °C, based on sensory similarities. Subsequently, panelists were asked to characterize their sorted clusters of wine samples using sensory attribute terms. Such testing was replicated at each serving-temperature and the formation of clusters was compared between the two replications. Wine samples evaluated at lower temperatures (10 and 16 °C) showed greater variations between the replications with respect to the sorted clusters of wine samples than did those evaluated at higher temperature (22 °C). In addition, clusters of wine samples served at 22 °C were characterized more frequently as having "leather" and "low astringent" attributes, while those served at 10 or 16 °C were described more frequently as having "bitter", "smooth", and "high astringent" attributes.

The Napping method, however, seems inapplicable to sensory studies aiming at characterizing variations in sensory attributes of hot food or beverage products due to following reasons. First, panelists may have a difficulty in simultaneously evaluating hot food or beverage samples served at different temperatures, especially when there are many samples to be evaluated. Second, it seems difficult to control the temperature of the tongue during a Napping task of hot food or beverage samples, simultaneously presented, at different temperatures. The temperature of the tongue has been found to play an important role in modulating the associations between sample temperature and sensory perception (Green & Frankmann, 1987; Mony et al., 2013).

Using another rapid sensory profiling technique, i.e., Check-All-That-Apply (CATA) questions (Adams, Williams, Lancaster, & Foley, 2007), this study aimed to characterize variations in sensory attributes with changing temperatures of hot or cold food/beverage products. CATA questions consist of a list of sensory attributes (in the form of words or phrases) from which trained or untrained panelists can select all the attributes that they consider appropriate to characterize each sample (Valentin, Chollet, Lelièvre, & Abdi, 2012). Even though CATA questions yield only binary outcomes (checked or unchecked data), the use of CATA questions on naïve consumer panelists has been found not only to demonstrate high discriminative capability among test samples, but also to produce results similar to those obtained from descriptive sensory analysis (Ares, Barreiro, Deliza, Giménez, & Gámbaro, 2010; Bruzzone, Ares, & Giménez, 2012; Cadena et al., 2014). Moreover, CATA questions have been considered consumer-friendly, easy to understand, and highly reproducible, making this methodology applicable to a large number of consumer panelists (Jaeger et al., 2013). Building on these methodological merits of the CATA questions, the CATA method permits panelists to quickly select all the attributes they consider appropriate to characterize each sample over a temperature range in which the test products can be consumed (e.g., for cooked rice, 70 to 30 °C). In this way, results from the CATA method may draw a "big picture" view as to how sensory attributes can change with temperatures of hot or cold foods and beverages.

Cooked rice serves as a particularly apt example for illustrating variations in temperature-dependent sensory attributes during eating. In many Asian countries, cooked rice presented at hot temperatures (e.g., 70 °C) is consumed while its temperature decreases over the period of eating. Moreover, cooked rice is often consumed at near or even below room temperature (20 °C) in some countries. Nevertheless, there is limited information on the potential influence of temperature changes on sensory attributes of cooked rice during eating. In addition, since sensory perception of certain foods or beverages is modulated by dietary habit and familiarity (Kim et al., 2015; Ludy & Mattes, 2012), it is worth examining as to whether the effect of temperature changes on sensory attributes of cooked rice varies with dietary habit and familiarity, particularly the frequency of rice consumption. Therefore, the primary objectives of this study are to characterize "product temperature-dependent sensory-attribute variations" of cooked rice using the CATA method, and to determine whether such attribute-variations can be affected by frequency of rice consumption.

2. Materials and methods

This study was conducted according to the Declaration of Helsinki for studies on human subjects. The protocol used in this study was approved by the Institutional Review Board of the University of Arkansas (Fayetteville, AR, USA). A written informed consent was obtained from each participant prior to participation.

2.1. Panelists

Eighty eight rice-consumers (65 females, 23 males) ranging in age from 18 to 75 [mean ± standard deviation (SD) = 37 ± 14] were recruited through the consumer profile database of the University of Arkansas Sensory Service Center (Fayetteville, AR, USA). That database contains profiles of > 6200 Northwest Arkansas residents. More than half the panelists were Caucasians (N = 46), followed by 35 Asians, 6 Latino-Americans, and 1 Native American. Each panelist self-reported having no clinical history of major diseases such as cardiovascular disease, diabetes, cancer, or renal diseases. In addition, all panelists reported that they had purchased rice-grain products for their consumption sometime during the three months prior to study participation. Finally, panelists were asked to answer on 7 category scales how frequently they eat rice grain-based products: 1 = never, 2 = < 1 per month, 3 = 2–3 times per month, 4 = 1–2 times per week, 5 = 3–4 times per week, 6 = 5–6 times per week, and 7 = every day. Based on their frequency of rice consumption, panelists were classified into two groups: 1) "frequent consumption group" (≥ 3 times per week; N = 65) and 2) "non-frequent consumption group" (≤ 2 times per week; N = 23).

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