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High consumption increases sensitivity to after-flavor of canned coffee beverages

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ABSTRACT

Background: Consumers' dietary habits affect perception of flavor attributes of common foods. One such flavor attribute is after-taste, but the definition of this term in the context of flavor perception is not consistent among studies. To address this issue, we refer collectively to the complex sensation perceived after swallowing or spitting out foods as "after-flavor", and considered each flavor attribute (for example, bitterness and retronasal aroma) as a component of after-flavor. In this study, we examined how consumption of canned coffee beverages in daily life affects sensitivity to the after-flavor of these beverages. We performed time–intensity evaluation of bitterness and retronasal aroma after participants swallowed three different canned coffee beverages. We classified participants into two groups based on their consumption of canned coffee beverages in daily life: the relatively high-consumption group, who consumed at least one canned coffee beverages per week, and the relatively low-consumption group, who consumed less than one canned coffee beverages per week. We compared the time courses of perceived intensity of bitterness and retronasal aroma between these two groups.

Results: Time courses of perceived intensity of bitterness in two of the canned coffee beverages, and retronasal aroma in all three canned coffee beverages were significantly higher in the relatively high-consumption group.

Conclusions: Familiarization with canned coffee beverages due to increased consumption in daily life might significantly promote sensitivity to the after-flavor of such beverages.

1. Introduction

Consumers' dietary habits affect their perception of the flavor attributes of common foods. Several researchers have described psychological aspects affected by dietary habits such as preference and acceptability, whereas few researchers have focused on psychophysical aspects such as perceived intensity or threshold.

Applying a cross-cultural perspective, some researchers have examined how consumers from different food cultures perceive flavor attributes of common foods such as drinkable yogurt (Thompson, Lopetcharat, & Drake, 2007), chocolate milk (Thompson, Gerard, & Drake, 2007), wine (Yoo, Saliba, Prenzler, & Ryan, 2012), and apples (Galmarini, Symoneaux, Chollet, & Zamora, 2013). Although it is widely known that food preparation and diet differ among countries, few studies have investigated the influence of cultural factors on psychophysical aspects of taste and aroma (Doty, 1986). In previous studies that measured perceived intensities of inosine monophosphate (IMP), NaCl, and sodium saccharin, threshold for IMP, and response times for NaCl and sodium saccharin (Saito, Hübener, Kobayakawa, Laska, & Gotow, 2002), no significant differences were observed between Japanese and German participants, consistent with the findings of Yamaguchi (1991). According to olfaction, Hoshika et al. (1993) measured detection thresholds of six odorants (hydrogen sulfide, phenol, styrene, *m*-xylene, toluene, and tetrachloroethylene) in Japanese and Dutch participants, and showed that the thresholds for five of the odorants (excluding *m*-xylene) were similar between individuals from the two countries, whereas Dutch participants demonstrated obviously higher detection thresholds for *m*-xylene. The authors of these previous studies pointed out that it is not easy to determine the causes underlying such differences. To address this issue, researchers devised stimuli that differed in familiarity among cultures and countries (e.g., Ayabe-Kanamura et al., 1998;

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Distel et al., 1999). Ayabe-Kanamura and colleagues (1998) performed evaluations of perceived intensity, pleasantness, similarity, and edibility in Japanese and German participants using odorants familiar to Japanese people, odorants familiar to Europeans, and odorants familiar to both cultures. The results showed a positive correlation between the evaluation values of pleasantness and edibility, and also revealed significant differences in perceived intensities of some odorants, such as dried fish, beer, and cheese, between the Japanese and German participants. Additionally, Distel and colleagues (1999) reported that familiarity and intensity were significantly correlated. It is reasonable to assume that more frequent consumptions of certain foods would increase familiarity with this food. Based on the findings described above, we predicted that perceived intensities of flavor of common foods might be altered, and probably increased, by the living environment, including various aspects of food culture.

Does evaluation of the flavor of common foods differ among consumers who live in regions with the same food culture? Mahar and Duizer (2007) indicated that consumers who consumed high levels of sweetened beverages preferred sweeter orange juice more strongly than consumers who consumed low levels of such beverages. Additionally, Liem and de Graaf (2004), who allowed children aged 6–11 years to ingest orangeade with added sucrose for 8 days, reported that preference for orangeade significantly increased after the period of ingestion. As described above, perception of flavor attributes of common foods is influenced not only by global aspects such as food culture, but also by personal aspects such as history and frequency of consumption.

Psychophysical aspects of flavor perception also affect consumption of common foods. Previous studies (Mattes, 1994; Tanimura & Mattes, 1993) examined the relationship between consumption of caffeine in coffee beverages and perception of bitterness. Tanimura and Mattes (1993) asked participants about their consumption of caffeine in daily life, reported that the no-consumption group had a significantly higher detection threshold for caffeine than the moderate- and heavy-consumption groups. These results imply that consumption of coffee beverages that contain caffeine can change consumers' perception of the bitterness of such beverages.

In considering flavor attributes of coffee beverages, aroma is an important attribute (Aceña, Vera, Guasch, Busto, & Mestres, 2011; Akiyama et al., 2008; Caprioli et al., 2012). The specific aroma of coffee is produced by roasting green coffee beans (Majcher, Klensporf-Pawlik, Dziadas, & Jeleń, 2013). At least 800 volatile components contribute to the aroma of coffee (López-Galilea, Fournier, Cid, & Guichard, 2006). In studies that performed chemical analysis (Akiyama et al., 2009) or sensory evaluation (Barron et al., 2012) of coffee aroma, some researchers have made a clear distinction between orthonasal aroma, which is inhaled through the nose before the coffee is taken into the oral cavity, and retronasal aroma, which is exhaled through the nose while the coffee is held in the mouth or after it is swallowed.

After-taste is one of the important evaluation items frequently used in sensory evaluations of flavor attributes of common foods (Aidoo, Sakyi-Dawson, Abbey, Tano-Debrah, & Saalia, 2012; Fernández-Fernández, Romero-Rodríguez, & Vázquez-Odériz, 2005; Guerra, Sanz, Valenciano, & Casquero, 2011; Phillips et al., 2010; Pérez, Escalona, & Guerrero, 1998). However, the flavor attributes defined by the technical term "after-taste" differ among researchers. In other words, although in one study after-taste was defined as the remaining bitterness and pungency 10 min after ingestion of a sample (Wie et al., 2007), in other reports the term was not concretely defined (e.g., Aidoo et al., 2012). In particular, retronasal aroma was included in after-taste in one report (Fernández-Fernández, Vázquez-Odériz, & Romero-Rodríguez, 2002), described as an olfactory component of after-taste in another report (Lasekan, 2013), and referred to as 'after-odor' or 'after-smell' in another report (Buettner, 2004). Based on these previous studies, we collectively refer to the complex sensory perceptions that occur after food is swallowed or spit out as "after-flavor", and we defined individual flavor attributes (e.g., bitterness and retronasal aroma) as components of after-flavor.

Perceived intensity and durability are more frequently measured in evaluations of after-flavor (Fernández-Fernández et al., 2002, 2005). Investigations of temporal dependency of flavor attributes often employ time–intensity evaluation (Lee & Pangborn, 1986; Pineau et al., 2009), as also described in ASTM E1909-13 (The American Society for Testing and Materials, 2013). Previous studies have conducted time–intensity evaluation of taste qualities of common foods such as bitterness of beer (Guinard et al., 1996; King & Moreau, 1996; Techakriengkrai, Paterson, Taidi, & Piggott, 2004), sweetness of beer (Techakriengkrai, Paterson, & Piggott, 2004), bitterness of white wine (Sokolowsky & Fischer, 2012), sweetness of red wine (Ishikawa & Noble, 1995), and sweetness of whisky (Piggott, Hunter, & Margomenou, 2000), and of retronasal aromas of common foods such as the vanilla odor of ice cream (Li, Marshall, Heymann, & Fernando, 1997), strawberry odor of ice cream (Hyvönen, Linna, Tuorila, & Dijksterhuis, 2003), banana odor of gelled candy (Leclercq & Blancher, 2012), and cinnamon odor of chewing gum (Potineni & Peterson, 2008).

In this study, we investigated how consumption of canned coffee beverages in daily life affects perception of the flavor attributes of canned coffee beverages. Among several flavor attributes, we focused on the temporal change of after-flavor. To evaluate this change, we performed time–intensity evaluation of bitterness and retronasal aroma. Furthermore, after classifying participants into relatively high- and low-consumption groups on the basis of their consumption of canned coffee beverages in daily life, we compared time courses of perceived intensity of bitterness and retronasal aroma between the two consumption groups. Additionally, we investigated whether preference for canned coffee beverages is changed by the amount of consumption of such beverages in daily life.

2. Materials and methods

2.1. Participants

This study was conducted in accordance with the revised version of the Helsinki Declaration. All procedures in this study were approved by the ethical committee for ergonomic experiments of the National Institute of Advanced Industrial Science and Technology, Japan. When we recruited participants, we informed potential volunteers that in order to use canned coffee and salt-free cracker as experimental materials, individuals with food allergies to any ingredient of these materials would be ineligible to participate. Before starting the experiment, we reconfirmed that no participant had food allergies to any ingredient of the experimental materials. Furthermore, we informed them of their right to cease participation even after their initial agreement to participate. Informed written consent was acquired from all participants. Eighty-five students from the University of Tsukuba (41 women and 44 men) between the ages of 20 and 25 years old (mean age ± standard deviation = 21.3 ± 1.3 years) participated in the experiments; volunteers contacted us after seeing our recruitment announcement on the campus bulletin board. Participants received compensation for participation in the experiment.

2.2. Materials

If coffee beverages of the same brand are produced under controlled conditions, they should have the same quality. Based on this