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Similar taste-nutrient relationships in commonly consumed Dutch and Malaysian foods

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ABSTRACT

Three recent studies showed that taste intensity signals nutrient content. However, current data reflects only the food patterns in Western societies. No study has yet been performed in Asian culture. The Malaysian cuisine represents a mixture of Malay, Chinese and Indian foods. This study aimed to investigate the associations between taste intensity and nutrient content in commonly consumed Dutch (NL) and Malaysian (MY) foods. Perceived intensities of sweetness, sourness, bitterness, umami, saltiness and fat sensation were assessed for 469 Dutch and 423 Malaysian commonly consumed foods representing about 83% and 88% of an individual's average daily energy intake in each respective country. We used a trained Dutch (n = 15) and Malaysian panel (n = 20) with quantitative sensory Spectrum™ 100-point rating scales and reference solutions, R1 (13-point), R2 (33-point) and R3 (67-point). Dutch and Malaysian foods had relatively low mean sourness and bitterness (<R1), but higher mean sweetness, saltiness and fat sensation (between R1 and R2). Mean umami taste intensity of Malaysian foods (15-point) was higher than that of Dutch foods (8-point). Positive associations were found between sweetness and mono- and disaccharides ($R^2 = 0.67$ (NL), 0.38 (MY)), between umami and protein ($R^2 = 0.29$ (NL), 0.26 (MY)), between saltiness and sodium ($R^2 = 0.48$ (NL), 0.27 (MY)), and between fat sensation and fat content ($R^2 = 0.56$ (NL), 0.17(MY)) in Dutch and Malaysian foods (all, $p < 0.001$). The associations between taste intensity and nutrient content are not different between different countries, except for fat sensation-fat content. The two dimensional basic taste-nutrient space, representing the variance and associations between tastes and nutrients, is similar between Dutch and Malaysian commonly consumed foods.

1. Introduction

The sense of taste plays a pivotal role in food choice and preference (Drewnowski, 1997). It has been hypothesized that taste has a nutrient-signaling function and is able to elicit expectations about foods concerning its macronutrient content (Rozin & Vollmecke, 1986; Temussi, 2009). Sweet taste, for example, may signal energy and carbohydrate content, umami and salty tastes may signal protein and sodium content, bitter taste may indicate toxic components, and sour taste may indicate ripeness of fruits (Temussi, 2009; Yarmolinsky, Zuker, & Ryba, 2009). This signaling function of taste has repeatedly been shown to affect the process of satiation, and meal termination (Bolhuis, Lakemond, de Wijk, Luning, & de Graaf, 2011; de Graaf & Kok, 2010; Weijzen, Smeets, & de Graaf, 2009). Taste signaling is therefore important in the regulation of food and energy intake (McCrickerd & Forde, 2016).

There is an enormous societal pressure both in middle and high income countries in the world to reduce salt, sugar and fat levels in foods (World Health Organization, 2013). However, attempts to reduce these levels face the challenge of keeping sensory perceptions of tastes at optimal levels (Zandstra, Lion, & Newson, 2016). From this perspective it is important to have insight in the relationships between the physical chemical or nutrient composition of commonly consumed foods and the sensory perception of taste.

Taste perception has also been implicated from an obesity perspective. A recent comprehensive review of Cox, Hendrie, and Carty (2016) suggested that lower sensitivity to fat taste and

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higher liking and preference for fat is related to an higher average BMI. There was little evidence of a relationship between sweet, salty, sour or bitter tastes sensitivities, preferences and weight status (Cox et al., 2016). Since taste plays a prominent role in potential nutrition-related health outcomes, it is important to assess the relationship between taste intensity and nutrient content of a wide range of foods representative of diets within and across population.

Only recently studies started to explore the taste-nutrient relationship of commonly consumed foods, in order to better understand the role that taste properties may play in food intake regulation. So far, three studies; originated from the Netherlands (van Dongen, van den Berg, Vink, Kok, & de Graaf, 2012), Australia (Lease, Hendrie, Poelman, Delahunty, & Cox, 2016) and United States (van Langeveld et al., 2017), have described the association of taste intensity and nutrient content within respectively 50, 377 and 237 consumed foods. The three studies consistently observed that sweet, salty, umami and fat sensation were positively associated with respectively mono- and disaccharides, sodium, protein and fat content. Moreover, energy content of consumed foods was positively associated with saltiness but not with sweet taste intensity in the Australian and American foods. However, these studies only investigated the nutrient-taste relationships in Western food patterns.

Food intake usually takes place within a range of familiar foods, which highly depend on cultural exposure and individual experience (Prescott, 1998; Rozin, 1996). The wide variety of regional cuisines makes the taste qualities in foods different all over the world. For instance, Western cuisines tend to pair foods that share flavors; whereas East Asian dishes does opposite and avoid combining similar flavors (Ahn, Ahnert, Bagrow, & Barabási, 2011). These cultural diversities of culinary practice and food patterns raise the question of whether these general patterns on taste-nutrient associations are similar across Western and Asian food patterns. However, up to now, no study has been performed to characterize the taste-nutrient relationships of commonly consumed foods in Asian culture.

In this paper, we investigate the association between taste intensity and nutrient content in commonly consumed Dutch and Malaysian foods. It was hypothesized that similar taste-nutrient relationships will exist in both Dutch and Malaysian foods regardless of different cultural backgrounds.

2. Material and methods

This study linked the taste profiles of commonly consumed foods in The Netherlands and Malaysia with the nutrient content of those foods. The commonly consumed foods have been selected using nation-wide food consumption data from each country.

2.1. Panelists

A Dutch (n = 15) and Malaysian trained sensory panel (n = 20) was used to describe a wide array of commonly consumed Dutch and Malaysian foods in terms of the intensity of five basic tastes (i.e. sweet, sour, bitter, umami, salt) and fat sensation. The Dutch panel consisted of 3 males and 12 females, with a mean age of 33 ± 12 years and a BMI of 23 ± 2 kg/m^2. The Malaysian panel consisted of 3 males and 17 females, with a mean age of 21 ± 3 years and a BMI of 22 ± 4 kg/m^2. Both panels were screened for good sensory ability and trained intensively (56–63 h, 6 months) using 100-point Spectrum™ inspired quantitative reference rating scales (Martin, Visalli, Lange, Schlich, & Issanchou, 2014; Muñoz & Civille, 1992; Teo et al., 2017).

All panelists signed an informed consent form and received financial compensation for participation in the study. The study has been approved by the Human Ethics Review Committee of Wageningen University (ABR number: **NL47315.081.13**) and Taylor's University (Ethics reference number: **HEC/2015/SBS/023**). The study was conducted according to the declaration of Helsinki and registered on ClinicalTrials.gov (**NCT03233503**).

2.1.1. Panel training

Both panels received an intensive training to evaluate the intensity of sweetness, sourness, bitterness, umami, saltiness and fat sensation. Panelists were trained using basic sapid taste solutions, followed by simple modified products and commercially available food products. Spectrum-based basic solutions were available with fixed reference points at 13.3 point (R1), 33.3 point (R2) and 66.7 point (R3) for each taste modality on a 100-point rating scale. For saltiness, the positions of R1 (16.7 point) and R3 (56.7 point) were different. Basic solutions contained increasing concentrations of sucrose for sweetness, sodium chloride (NaCl) for saltiness, monosodium glutamate (MSG) for umami, citric acid for sourness and caffeine for bitterness. The taste compounds were dissolved in mineral water (Evian®, Évian-les-Bains, France). The reference solutions on the rating scales were obtained from the Spectrum™ method (Muñoz & Civille, 1992). MSG concentrations for umami taste were adapted from the previous work of the Dijon group (Martin, Tavares, Schwartz, Nicklaus, & Issanchou, 2009). Next, panelists were trained using simple food matrices which were modified with varying concentrations of taste substances. For instance, NaCl and MSG were added to mashed potatoes and cooked rice for saltiness and umami; caffeine and citric acid were added to agar for bitterness and sourness; sucrose was added to gelatin for sweetness; and mascarpone was added to vanilla custard for fat sensation. This part of training was completed when the panels were able to discriminate different taste intensities and reproduce taste values in samples with different textural conditions.

Panelists then discussed, evaluated and rated perceived taste intensity of pre-selected commercially available reference foods on the line scales with the aid of the reference solutions. Foods with the largest variability between panelists were then excluded. Group discussions and individual training were repeated until consensus about taste and fat sensation of reference products was reached (i.e. each mean taste value was remained as non-statistically significantly different, and a coefficient of variation lower than 50% was obtained). The panels also received additional training sessions with regard to the taste attributes that appeared to be more difficult based on the results of the panel agreement, i.e. umami, bitter and fat sensation. At the end of training procedure, this resulted in 26 additional reference positions on the six rating scales, with the reference foods being specifically targeted for Dutch and Malaysian panel (see Table 1.) (Teo et al., 2017).

2.1.2. Panel performance

Both panels were instructed to evaluate an identical set of 19 control products in terms of six taste attributes to assess their performance. Panel performance measures (discriminative power, agreement, and reproducibility) were regularly monitored during training and profiling sessions. Oral feedback was given by the researcher to improve the panels' performance.

In general, the training procedure yielded two panels that were similar in panel performance but with a different cultural background. Both panels were able to discriminate between solutions and products, and the majority of the taste values could be reproduced. More importantly, two panels obtained similar taste profiles for a selection of 19 control foods (see Fig. 1).

The detailed training procedure and quantitative data regarding