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Dietary customs and food availability shape the preferences for basic tastes: A cross-cultural study among Polish, Tsimane' and Hadza societies

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ABSTRACT

Biological significance of food components suggests that preferences for basic tastes should be similar across cultures. On the other hand, cultural factors play an important role in diet and can consequently influence individual preference for food. To date, very few studies have compared basic tastes preferences among populations of very diverse environmental and cultural conditions, and research rather did not involve traditional populations for whom the biological significance of different food components might be the most pronounced. Hence, our study focused on basic taste preferences in three populations, covering a broad difference in diet due to environmental and cultural conditions, market availability, dietary habits and food acquirement: 1) a modern society (Poles, $n = 200$), 2) forager-horticulturalists from Amazon/Bolivia (Tsimane', $n = 138$), and 3) hunter-gatherers from Tanzania (Hadza, $n = 85$). The preferences for basic tastes were measured with sprays containing supra-threshold levels of sweet, sour, bitter, salty, and umami taste solutions. We observed several interesting differences between participating societies. We found that Tsimane' and Polish participants liked the sweet taste more than other tastes, while Hadza participants liked salty and sour tastes more than the remaining tastes. Further, Polish people found bitter taste particularly aversive, which was not observed in the traditional societies. Interestingly, no cross-cultural differences were observed for relative liking of umami taste – it was rated closely to neutral by members of all participating societies. Additionally, Hadza showed a pattern to like basic tastes that are more common to their current diet than societies with access to different food sources. These findings demonstrate the impact of diet and market availability on preference for basic tastes.

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1. Introduction

The sense of taste has evolved to serve as a dominant regulator and driver of feeding behavior and physiologically, taste is separated into five basic tastes, each associated with different biological significance; the sweet, salty, bitter, sour and umami ("savory") tastes guide the intake of energy (calories), electrolytes, possibly dangerous stimuli, acids and ions, and protein consumption, respectively (Lindemann, 2001). There is evidence to suggest that hedonic responses to tastes, particularly sweetness and bitterness, are present at birth and may be innate (Beauchamp, Cowart, & Schmidt, 1991). Further, biological significance of taste is indicated by evidence for certain, universal food preferences – for example, in most cultures there is a liking for sweet items, though the most liked level of sweetness varies greatly from person to person (Pangborn, 1970).

However, food plays an important part in cultures, not just for

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nourishment, but for establishing traditions (Bessiere, 1998), providing barter for trade, and establishing societal status (Sorokowski, Sorokowska, & Danel, 2013). Additionally, the availability of food plays a role in which food becomes customary to the culture and used for these purposes. For example, people in cultures with access to international trade have a broader diet than societies that have to rely on foods sourced locally or traded regionally (Rosinger, Tanner, & Leonard, 2013). Several implications from these food pressures can not only shape what is eaten in a society, but also the preferences and familiarity for components that make up the flavor of complex food products such as the smell, taste and texture of the food. These preferences might further change the overall perception of the food and contribute to consumption patterns. Generally, food items traditionally consumed in the culture of origin are preferred over other foods (Logue & Smith, 1986; Rozin, 1982). So far, however, only few studies have reported cross-cultural differences in basic taste preferences. An early study by Moskowitz et al. (1975) showed that Indian laborers from the Karnataka region in India who commonly chew on tamarind (a highly sour, but slightly sweet fruit) enjoy sour taste over Western cultures (Moskowitz, Kumaraiah, Sharma, Jacobs, & Sharma, 1975). Later, Prescott and colleagues in a series of studies comparing Australian and Japanese cultures, showed little differences between the societies with regard to taste discrimination or intensities, but varying taste hedonics (Prescott, 1998). The Japanese showed a higher preference for sour and umami than the Australians, reflecting dietary patterns in the cultures. Similarly, this research group showed that domestic products were preferred among the cultures (Laing et al., 1993, 1994).

Overall, biological significance of different food components suggests that preferences for five basic tastes should be similar across cultures. On the other hand, cultural factors play an important role in diet and can consequently influence individual preference for food. To date, very few studies have compared five basic tastes preferences among populations of diverse environmental conditions and dietary customs – research has rather focused on comparing developed societies that have access to foods outside of their culture (Prescott, 1998), or on describing dietary habits of different groups (Berbesque & Marlowe, 2009; Murray, Schoeninger, Bunn, Pickering, & Marlett, 2001). Also, studies rather did not involve traditional populations for whom the biological significance of different food components might be the most pronounced. Hence, it is difficult to draw definite conclusions on cross-cultural basic taste preference patterns and determinants. Thus, this exploratory study looked at differences in basic taste preferences and similarity of these tastes to current diets among three types of populations: 1) a modern society (i.e. Poles), 2) forager-horticulturalists from Amazonia/Bolivia with limited access to modern food (Tsimane'), and 3) traditional hunter-gatherers from Tanzania (Hadza).

2. Materials and methods

The study was conducted according to the Declaration of Helsinki. The study protocol and consent procedure received ethical approval from the Institutional Review Board (IRB) of the University of Wroclaw (Wroclaw, Poland), from the Great Tsimane' Council (the governing body of the Tsimane'), and approved by the Commission for Science and Technology of Republic of Tanzania for Hadza. The participants received small gifts as a compensation for their participation. All participants provided informed consent before study inclusion, either orally (recorded on a portable recorder) or through a signed content form.

2.1. Participants

Our comparative study comprised three societies – Tsimane', Hadza and Polish. Tsimane' are a native Amazonian society of farmer-foragers from Bolivia with limited access to international trade (shops with basic foods such as oil, salt, and sugar in San Borja – a Bolivian town that lies between a few hours walk to a few days' canoe trip from Tsimane' settlements). Tsimane' practice domestic farming and agriculture, and several aspects of their culture (e.g. diet, foraging behaviors) have been covered extensively in the literature (Apaza et al., 2003; Foster et al., 2005; Vadez, Reyes-García, Godoy, & Apaza, 2004). Tsimane' tribe consists of roughly 8000 people, from approximately 100 villages located along the Maniqui River in the Beni area in northern Bolivia. This study included individuals from five villages – Campo Bello, Las Palmas, Uvasichi, Las Minas, and Alta Gracia. The Hadza are a traditional hunter-gatherer society from Tanzania who still consume a substantial proportion of traditional foods (95% of calories). They practice no cultivation or domestication of plants or animals, and their diet can be broken down into five major food categories: honey, meat, berries, baobab, and tubers (Marlowe, 2010; Schoeninger, Bunn, Murray, & Marlett, 2001; Vincent, 1985). Their population consists of 1000–1500 individuals who live in mobile camps of approximately 30 people. They live near Lake Eyasi, in northern part of Tanzania. For more information on traditions of this society, see e.g., (Marlowe, 2010). Polish individuals represented a Western society with full access to international trade.

One hundred and thirty-eight Tsimane' (70 women) with an age range from 18 to 72 (mean age ± SD–32.48 ± 12.12 years) participated in the study. Further, eighty-five (40 women) individuals from the Hadza society were included in the study with an age range from 18 to 70 (33.70 ± 14.15 years). The Polish sample consisted of 200 individuals (100 women) with an age range from 18 to 68 (32.63 ± 12.57 years).

2.2. Procedure

All tests among all the groups were carried out by a trained experimenter while an interpreter explained the procedure to all participants in their native language. Each participant was examined individually, and no major health issues were reported during testing. Participants from traditional societies had to confirm with the interpreter that they understood the procedure before moving forward with testing.

All five basic tastes were tested using sprays bottles containing each basic taste dissolved in water (up to 100 mL) at suprathreshold levels: sweet (10 g D-saccharose), sour (5 g citric acid), salty (7.5 g NaCl), bitter (0.05 g quinine hydrochloride), and umami (10 g monosodium glutamate; MSG). The participants were asked to open their mouth with their tongue extended while the administrator applied one spray (0.120 ml) over the tongue surface. The presentation order of basic tastes was the same for all participants (sweet, salty, sour, umami, bitter), and in between samples, participants were asked to rinse their mouth with clean water. After each taste spray, participants were asked three questions. First, they were asked if they were familiar with the taste (yes or no), and further – how good the taste was. Polish and Tsimane' participants were provided with the following response options: “I like it a lot”, “I like it”, “It is neutral”, “I do not like it”, or “I do not like it at all”; and Hadza answered this question on a following scale: “I like it”, “It is neutral”, or “I don't like it”. Finally, all groups were asked to rate similarity of a certain taste to their diet (“Do you eat food that tastes similar to this spray?” with the following response options: “No”, “Sometimes”, “Every day”, or “A few times a day”). The shorter scale was used for Hadza in the liking task since their ability

to memorize the response options and assess tastiness of stimuli on a longer scale was low. Hadza responses were later scaled up to the longer scale (5-point) for analysis (Cohen, Cohen, Aiken, & West, 1999).

2.3. Data analysis

The majority of the data analysis was performed with SPSS 21 (SPSS Inc., Chicago, IL, USA). The ratings for "liking" and "diet similarity" of all basic tastes were not normally distributed ($W < 0.05$) thus a generalized estimation equation (GEE) with an ordinal response was used. Here, the "liking" or "diet similarity" rating was set as the response while basic taste was set as the predictor with age and BMI set as covariates. BMI was adjusted since body mass can be related to taste thresholds (Donaldson, Bennett, Baic, & Melichar, 2009) and food choice (Cox, Perry, Moore, Vallis, & Mela, 1999). This factor showed a main effect among populations, $F(2, 412) = 33.46$, $p < 0.001$, and a post-hoc Tukey-Kramer HSD test revealed Hadza having significantly lower BMI than the other two groups ($p < 0.001$). Similarly, age was adjusted since studies have shown it to affect taste preference (Desor & Beauchamp, 1987; Hoffman, Salgado, Dresler, Faller, & Bartlett, 2016; Liem & Mennella, 2002). The main effect of basic taste was reported with a Wald's test. Separate models were made for each population, and non-parametric multiple comparisons were performed with the Steel-Dwass method (Neuhäuser & Bretz, 2001). Additionally, correlations were examined between questions concerning diet similarity with basic taste likings while adjusting for age and BMI using Spearman's rank-order partial correlations. These correlations were compared among societies with a *T*-test using a Fisher *Z* transformation with the program Concor (Diedenhofen & Musch, 2015).

3. Results

All descriptive statistics regarding assessments of taste likings and ratings of similarity of a certain taste to the diet are presented in Table 1.

3.1. Tsimane' ratings

An overall main effect was seen for both liking and diet similarity ratings among basic tastes ($\chi^2 = 134.41$, $p < 0.001$ and $\chi^2 = 55.84$, $p < 0.001$). Looking at the multiple comparisons, Tsimane' liked the taste of sweet more than salty ($Z = 8.55$, $p < 0.001$), sour ($Z = 8.77$, $p < 0.001$), umami ($Z = 8.22$, $p < 0.001$) and bitter ($Z = 10.14$, $p < 0.001$). Similarly, Tsimane' reported sweet taste composing more of their diet than other tastes ($p < 0.001$) besides salty ($Z = 0.4$, $p = 0.99$). Additionally, bitter taste was liked less than other tastes ($p < 0.001$) except sour ($Z = 2.68$, $p = 0.06$).

3.2. Polish ratings

Liking and diet similarity ratings significantly differed among basic tastes ($\chi^2 = 268.80$, $p < 0.001$ and $\chi^2 = 133.89$, $p < 0.001$). Multiple comparisons reveal that sweet and sour taste were liked more than salty ($Z = 9.63$, $p < 0.001$ and $Z = 5.67$, $p < 0.001$, respectively), umami ($Z = 7.14$, $p < 0.001$ and $Z = 4.25$, $p < 0.001$, respectively), and bitter ($Z = 15.08$, $p < 0.001$ and $Z = 11.72$, $p < 0.001$, respectively), while bitter was liked less than all other tastes ($p < 0.001$). Salty and umami were rated the similar ($Z = 0.86$, $p = 0.91$). Polish also reported that sweet ($Z = 9.45$, $p < 0.001$), salty ($Z = 9.61$, $p < 0.001$), sour ($Z = 11.3$, $p < 0.001$) and umami ($Z = 5.9$, $p < 0.001$) resembled their diet more than bitter taste.

3.3. Hadza ratings

An overall main effect was seen for both liking and diet similarity ratings among basic tastes ($\chi^2 = 22.32$, $p < 0.001$ and $\chi^2 = 40.09$, $p < 0.001$). The liking for salty taste was rated the higher then sweet ($Z = 4.04$, $p < 0.001$), umami ($Z = 3.7$, $p < 0.001$) and bitter ($Z = 3.49$, $p = 0.004$), but similar to the liking for sour ($Z = 1.85$, $p = 0.34$). The liking for sweet, sour, umami and bitter were not significantly different ($p < 0.05$). Additionally, Hadza reported that salty taste was the most frequent in their diet compared to all other tastes ($p < 0.001$).

The correlations between all basic taste likings with ratings of similarity of a certain taste to the diet revealed that Hadza have a higher preference for tastes common in their diets compared to Poles ($r_H = 0.85$ vs. $r_P = 0.66$, $Z = 7.75$, $p < 0.001$) and Tsimane' ($r_H = 0.85$ vs. $r_T = 0.61$, $Z = 8.64$, $p < 0.001$). Polish and Tsimane' societies showed no difference in the similarity of their diet as it relates to the liking of tastes.

4. Discussion

Dietary customs of societies may be shaped by the availability of food sources and communication with other cultures. Similarly, as foods become established in a culture and influence the diet, the preference for tastes that compose the foods may be affected. On the other hand, the biological significance of components associated with basic tastes suggests that at least the preferences for basic tastes should be similar across cultures. Nevertheless, the present study provides evidence for differences in basic taste preferences of three very different cultures: a Western one and two societies with either limited or no access to modern trade. Our results suggest that dietary habits and food availability shape the preferences for most basic tastes – only umami was rated closely to neutral by members of all participating societies. It seems thus that the basic tastes preferences are an effect of a complex interaction between biological and cultural influences, with the latter probably having a larger impact on taste perception.

Compared to Tsimane' and Poles, who represent societies with

Table 1
Tsimane', Polish and Hadza societies' basic taste preferences (like) and similarity to current diet (diet similarity).

	Tsimane'		Polish		Hadza	
	Liking	Diet similarity	Like	Diet similarity	Like	Diet similarity
Sweet	3.71 ± 0.77 a	1.62 ± 0.61 a	3.66 ± 0.81 a	2.06 ± 0.78 a	2.61 ± 1.95 b	1.48 ± 0.57 b
Salty	2.69 ± 0.97 b	1.61 ± 0.77 a	2.53 ± 1.19 b	2.10 ± 0.81 a	3.85 ± 1.81 a	2.10 ± 0.73 a
Sour	2.54 ± 1.06 bc	1.32 ± 0.50 b	3.27 ± 1.27 a	2.10 ± 0.62 a	3.27 ± 1.98 ab	1.67 ± 0.61 b
Umami	2.65 ± 1.01 b	1.26 ± 0.54 b	2.65 ± 1.29 b	1.94 ± 0.97 a	2.66 ± 1.98 b	1.55 ± 0.65 b
Bitter	2.19 ± 1.07 c	1.23 ± 0.52 b	1.62 ± 0.86 c	1.35 ± 0.60 b	2.76 ± 1.95 b	1.59 ± 0.68 b

Note: Higher numbers indicate higher liking and more frequent consumption of a certain taste. Columns represent mean ratings ± standard deviations. Mean ratings with different letters within the same column are significantly different ($p < 0.05$).

some to full access to modern trade respectively, Hadza showed a pattern to like basic tastes that were the most common to their current diet. This suggests an effect of trade and food availability on taste preference (Neumark-Sztainer, Story, Perry, & Casey, 1999). Hadza people forage or hunt only foods that are regionally available (Schoeninger et al., 2001); they also exchange these products for maize flour with local farmers, but they rarely use products from the local village shops (Marlowe, 2002). To this extent, tastes that are common to their diet could be more liked since other alternatives are highly limited; further, particular tastes in this society are introduced at an early age, which again seems to shape the preferences (Rozin & Schiller, 1980). Similarly, the lack of trade leaves villagers to less diverse diet (Kuhnlein & Receveur, 1996; Regmi, 2001), and food components are rarely transformed into complex food preparations, but rather eaten separately which may further illustrate certain basic tastes. Interestingly, our study shows that Hadza have a relatively lower liking for sweetness and that both traditional societies dislike bitterness less than their Western counterparts. Similarly, differences exist in salty and sour tastes preferences. Implications of these findings are discussed below.

As for the group differences, Poles and Tsimane' enjoyed sweet taste more than most other tastes, while this was not observed for Hadza. This finding is interesting as most research to date point to sweetness liking as universal (Drewnowski, 1997). Also, the sweet taste guides the intake of energy (Lindemann, 2001), so again this result is rather unexpected given the high level of daily physical activity in Hadza society. One explanation of the observed difference could be associative learning where cultures with access to refined sugar (and sugar-added foods) may increase their liking over repeated exposure (Liem & de Graaf, 2004), and experience with sweetness increases preferences and craving for sweet taste (Liem & de Graaf, 2004; Pepino & Mennella, 2005). For example, babies routinely fed sweetened water during the first months of life exhibited a greater preference for sweetness when tested several years later (Pepino & Mennella, 2005). Another contributing factor, especially for the Polish society, may be external to diet and relate to the heavy marketing put on sweet goods (Popkin & Nielsen, 2003). Sweets are an extremely popular and widely sold product, which could increase liking for refined sugar in populations having access to international trade. This conclusion is supported by our results showing that Polish and Tsimane' participants declared very frequent consumption of sweet taste in their diet, while Hadza did not consume it as often. However, the low concentration of the sweetness solution used in the study may point to another discussion. Hadza have been documented for their heavy reliance and high liking of honey from wild bees as main source of caloric intake (Murray et al., 2001). Thus, the low strength of sweetness from the solution may seem insufficient, unfamiliar or even disliked (Beauchamp & Cowart, 1985; Murray et al., 2001). Nevertheless, this result opens new interesting research questions regarding sweetness preferences that could be tested in further studies.

Although studies show that – similar to sweet taste – responses to bitter taste are innate, contrary to sweetness taste, this response is adverse (Drewnowski, 1997); however, through experience and childhood development the acceptance of bitterness may change (Wardle et al., 2008). In our study, Hadza and Tsimane' did not exhibit any special aversion to bitter, while Polish individuals assessed this taste as the least liked. Again, this might be explained by the differences in diet in these two societies compared to a Western one. For instance, it has been documented that both tribes often consume foods that are known to contain bitterness such as berries, leafy greens and tubers (Marlowe, 2010). In this case, bitterness is not considered unpleasant, like in Western societies, but similar to foods consumed on a daily basis. Further, exposure at an early age may reduce the rejection of similar tasting foods into adulthood (Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri, 2010; Pliner, 1982), thus this effect may be more evident for Hadza than Tsimane', whose preferences are shaped by a broader diet. Lack of aversion to bitter is also confirmed by a relatively high frequency of bitter food consumption declared by Hadza people. Finally, some studies suggest that a low sensitivity to bitter taste might be an effect of selection for malaria resistance (Krebs, 2009; Soranzo et al., 2005). It is hypothesized that certain bitter secondary compounds in plants are protective against malaria. Consequently, in areas with endemic malaria, like Eastern Africa, the protective benefit of consuming potentially dangerous bitter plants could outweigh the risks of poisoning.

The cross-cultural differences in salt and sour preferences are more difficult to explain. Only Hadza liked salty taste more than other tastes and they had reported it as a common taste in their diet, similar to Poles. Generally, although preference for salt may be considered innate, concentration levels of liking are learned, in which some infants do not start preferring higher levels until the first 4–6 months of age (Beauchamp, Cowart, & Moran, 1986; Leshem, 2009). Furthermore, mothers with salt deficiencies during pregnancy may foster children with higher initial liking of salt and increased intake into adulthood; similarly, infants with salt deficiency show this pattern of increased liking and intake, too (Crystal & Bernstein, 1995, 1998; Leshem, 1998). There are a few reasons as to why Hadza people could have learned to highly enjoy the salty taste. Similar to umami, salt is more palatable in the context of foods (Cowart & Beauchamp, 1986); however, natural saltiness in food is not common, as is usually added to enhance flavor. In the context of our research it is important to note that although Hadza have limited access to salt, they often use ash from some plants as salty meat seasoning (personal observation by MB). In addition, anthropological reports show that, for example, Aka and Baka Pygmies find salt a rare and prestigious commodity and hence, highly like its taste (Robbe & Hladik, 1994). Moreover, sodium-depleted individuals display a lower salt taste threshold than sodium-replete subjects and increased preference for high-salt diets (Beauchamp, Bertino, Burke, & Engelman, 1990). In other words, salt depletion may make Hadza more sensitive to salt and this could predispose them to enjoy salt more. Lastly, one more possible explanation of high preference for salt among Hadza is the important property of salt as a substance retaining water in human body, especially in humans exerting physical activity (Leshem, Arbutbul, & Eilon, 1999; Wald & Leshem, 2003). It is likely that people experiencing daily exercise and seasonal difficulties in finding water (i.e., Hadza living in Tanzanian bush) desire salt more than populations who do not normally lack drinking water (Poles and Tsimane'). As for the sour taste, similar to bitter, this taste is typically rejected at infancy yet acquired through experience (Beauchamp et al., 1991). For all groups, preference for sour should thus increase with increasing familiarity within their diets. Perhaps, the liking of sour for Hadza could be explained in the context of their diet that commonly involves consumption of Baobab Fruit (a fruit sour and tangy in taste) (Marlowe, 2010). This preference may be due to high amount of vitamin C in Baobab fruit pulp that is important for healthy subsistence (Chadare, Linnemann, Hounhouigan, Nout, & Van Boekel, 2008).

Interestingly, umami, which serves to signal the presence of protein and amino acids (Lindemann, 2001), was the only basic taste that was rated closely to neutral by members of all participating societies. This may not be surprising since the three societies under investigation are all carnivorous, each having meat as a large part of their diet and being accustomed to its taste. However, other studies have shown differences between two modern cultures in terms of preferences for this food component. For instance, Prescott et al. (1992) showed that at higher concentrations Japanese

preferred umami taste more than Australians. They concluded that differences may be due to the high umami-enhancing additives in Japanese cooking which include seaweed, shiitake mushrooms and bonito, and for this reason, Australians actually found lower concentrations of MSG more pleasant. However, the results from our study show that umami at low concentrations is a universally neutral taste, typical of diets of Western and non-Western societies.

There are certain limitations of our research. First, only one concentration of each taste was used. Meanwhile, studies show that preference-aversion curves for tastes differ (Pfaffmann, 1960), and differences in preference for concentration levels of basic tastes may exist among cultures (Prescott et al., 1992). Therefore, to better explore the issue of cross-cultural universality/variability in taste preferences, further studies should use different concentrations of basic tastes. For a full interpretation of such findings it would be also useful to know a place of every tested concentration in each aversion-preference curve. Another limitation are the small scales used in our study. In categorical scaling, it has been shown that scales below 5-points are less reliable, valid and show weaker discriminating ability (Leung, 2011), and increasing scale length to 7 or 9 points can yield higher mean correlation and validity (Hancock & Klockars, 1991). However, in our study we chose a 5-point scale for simplicity, to be better understood in all participating populations, which was meant to increase the possibility of obtaining comparable data in different cultures; however, Hadza had issues expressing taste with the applied scale, and thus even a shorter, a 3-point scale had to be used for them. Consequently, correlations among variables should be interpreted cautiously.

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References

Apaza, L., Godoy, R., Wilkie, D., Byron, E., Huanca, T., Leonard, W. R., … Vadez, V. (2003). Markets and the use of wild animals for traditional medicine: A case study among the Tsimane'Amerindians of the Bolivian rain forest. *Journal of Ethnobiology, 23*(1), 47–64. Retrieved from https://www.researchgate.net/profile/Victoria_Reyes-Garcia/publication/285065120_Markets_and_the_use_of_wild_animals_for_traditional_medicine_A_case_study_among_the_Tsimane'_Amerindians_of_the_Bolivian_rain_forest/links/56619bdc08ae4931cd59f2b8.pdf.

Beauchamp, G. K., Bertino, M., Burke, D., & Engelman, K. (1990). Experimental sodium depletion and salt taste in normal human volunteers. *The American Journal of Clinical Nutrition, 51*(5), 881–889. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2185626.

Beauchamp, G. K., & Cowart, B. J. (1985). Congenital and experiential factors in the development of human flavor preferences. *Appetite, 6*(4), 357–372. https://doi.org/10.1016/S0195-6663(85)80004-0.

Beauchamp, G. K., Cowart, B. J., & Moran, M. (1986). Developmental changes in salt acceptability in human infants. *Developmental Psychobiology, 19*(1), 17–25. https://doi.org/10.1002/dev.420190103.

Beauchamp, G. K., Cowart, B. J., & Schmidt, H. J. (1991). Development of chemosensory sensitivity and preference. In *Smell and taste in health and disease (pp. 405–416)*. Retrieved from https://scholar.google.com/scholar?cluster=15877006191352354443&hl=en&as_sdt=2005&sciodt=0,5.

Berbesque, J. C., & Marlowe, F. W. (2009). Sex differences in food preferences of Hadza hunter-gatherers. *Evolutionary Psychology, 7*(4), 147470490900700400 https://doi.org/10.1177/147470490900700409.

Bessiere, J. (1998). Local development and Heritage: Traditional food and cuisine as tourist attractions in rural areas. *Sociologia Ruralis, 38*(1), 21–34. https://doi.org/10.1111/1467-9523.00061.

Chadare, F. J., Linnemann, A. R., Hounhouigan, J. D., Nout, M. J. R., & Van Boekel, M. (2008). Baobab food products: A review on their composition and nutritional value. *Critical Reviews in Food Science and Nutrition, 49*(3), 254–274. https://doi.org/10.1080/10408390701856330.

Cohen, P., Cohen, J., Aiken, L. S., & West, S. G. (1999). The problem of units and the circumstance for POMP. *Multivariate Behavioral Research, 34*(3), 315–346. https://doi.org/10.1207/S15327906MBR3403_2.

Cowart, B. J., & Beauchamp, G. K. (1986). The importance of sensory context in young Children's acceptance of salty tastes. *Child Development, 57*(4), 1034 https://doi.org/10.2307/1130377.

Cox, D. N., Perry, L., Moore, P. B., Vallis, L., & Mela, D. J. (1999). Sensory and hedonic associations with macronutrient and energy intakes of lean and obese consumers. *International Journal of Obesity, 23*(4), 403–410. https://doi.org/10.1038/sj.ijo.0800836.

Crystal, S. R., & Bernstein, I. L. (1995). Morning Sickness: Impact on offspring salt preference. *Appetite, 25*(3), 231–240. https://doi.org/10.1006/appe.1995.0058.

Crystal, S. R., & Bernstein, I. L. (1998). Infant salt preference and Mother's morning sickness. *Appetite, 30*(3), 297–307. https://doi.org/10.1006/appe.1997.0144.

Desor, J. A., & Beauchamp, G. K. (1987). Longitudinal changes in sweet preferences in humans. *Physiology & Behavior, 39*(5), 639–641. https://doi.org/10.1016/0031-9384(87)90166-1.

Diedenhofen, B., & Musch, J. (2015). Cocor: A comprehensive solution for the statistical comparison of correlations. *PLoS One, 10*(3), e0121945. https://doi.org/10.1371/journal.pone.0121945.

Donaldson, L. F., Bennett, L., Baic, S., & Melichar, J. K. (2009). Taste and Weight: Is there a link? *The American Journal of Clinical Nutrition, 90*(3), 800S–803S. https://doi.org/10.3945/ajcn.2009.27462Q.

Drewnowski, A. (1997). Taste preference and food intake. *Annual Review of Nutrition, 17*(1), 237–253. https://doi.org/10.1146/annurev.nutr.17.1.237.

Foster, Z., Byron, E., Reyes-García, V., Huanca, T., Vadez, V., Apaza, L., … Leonard, W. R. (2005). Physical growth and nutritional status of Tsimane' Amerindian children of lowland Bolivia. *American Journal of Physical Anthropology, 126*(3), 343–351. https://doi.org/10.1002/ajpa.20098.

Hancock, G. R., & Klockars, A. J. (1991). The effect of scale manipulations on validity: Targetting frequency rating scales for anticipated performance levels. *Applied Ergonomics, 22*(3), 147–154. https://doi.org/10.1016/0003-6870(91)90153-9.

Hoffman, A. C., Salgado, R. V., Dresler, C., Faller, R. W., & Bartlett, C. (2016). Flavour preferences in youth versus adults: A review. *Tobacco Control, 25*, ii32–ii39. tobaccocontrol-2016–053192 https://doi.org/10.1136/tobaccocontrol-2016-053192.

Krebs, J. R. (2009). The gourmet ape: Evolution and human food preferences. *The American Journal of Clinical Nutrition, 90*(3), 707S–711S. https://doi.org/10.3945/ajcn.2009.27462B.

Kuhnlein, H. V., & Receveur, O. (1996). Dietary change and traditional food systems of indigenous peoples. *Annual Review of Nutrition, 16*(1), 417–442. https://doi.org/10.1146/annurev.nu.16.070196.002221.

Laing, D. G., Prescott, J., Bell, G. A., Gillmore, R., James, C., Best, D. J., … Yamazaki, K. (1993). A cross-cultural study of taste discrimination with Australians and Japanese. *Chemical Senses, 18*(2), 161–168. https://doi.org/10.1093/chemse/18.2.161.

Laing, D. G., Prescott, J., Bell, G. A., Gilmorre, R., Allen, S., Best, D. J., … Ishii, R. (1994). Responses of Japanese and Australians to sweetness in the context of different foods. *Journal of Sensory Studies, 9*(2), 131–155. https://doi.org/10.1111/j.1745-459X.1994.tb00237.x.

Lakkakula, A., Geaghan, J., Zanovec, M., Pierce, S., & Tuuri, G. (2010). Repeated taste exposure increases liking for vegetables by low-income elementary school children. *Appetite, 55*(2), 226–231. https://doi.org/10.1016/j.appet.2010.06.003.

Leshem, M. (1998). Salt preference in adolescence is predicted by common prenatal and infantile mineralofluid loss. *Physiology & Behavior, 63*(4), 699–704. https://doi.org/10.1016/S0031-9384(97)00525-8.

Leshem, M. (2009). Biobehavior of the human love of salt. *Neuroscience & Biobehavioral Reviews, 33*(1), 1–17. https://doi.org/10.1016/j.neubiorev.2008.07.007.

Leshem, M., Arbutbul, A., & Eilon, R. (1999). Exercise increases the preference for salt in humans. *Appetite, 32*(2), 251–260. https://doi.org/10.1006/appe.1999.0228.

Leung, S.-O. (2011). A comparison of psychometric properties and normality in 4-, 5-, 6-, and 11-point likert scales. *Journal of Social Service Research, 37*(4), 412–421. https://doi.org/10.1080/01488376.2011.580697.

Liem, D. G., & de Graaf, C. (2004). Sweet and sour preferences in young children and adults: Role of repeated exposure. *Physiology & Behavior, 83*(3), 421–429. https://doi.org/10.1016/j.physbeh.2004.08.028.

Liem, D. G., & Mennella, J. A. (2002). Sweet and sour preferences during childhood: Role of early experiences. *Developmental Psychobiology, 41*(4), 388–395. https://doi.org/10.1002/dev.10067.

Lindemann, B. (2001). Receptors and transduction in taste. *Nature, 413*(6852), 219–225. https://doi.org/10.1038/35093032.

Logue, A. W., & Smith, M. E. (1986). Predictors of food preferences in adult humans. *Appetite, 7*(2), 109–125. https://doi.org/10.1016/S0195-6663(86)80012-5.

Marlowe, F. (2002) (Sue Kent). In S. Kent (Ed.), *Why the Hadza are still hunter-gatherers. Ethnicity, huntergatherers, and the "Other"*. Washington D.C: Smithsonian Institution Press. Retrieved from http://web.mnstate.edu/robertsb/307/ANTH 307/hadzahuntergatherers.pdf.

Marlowe, F. (2010). *The Hadza: Hunter-gatherers of Tanzania*. University of California Press. Retrieved from https://books.google.com/books?hl=en&lr=&id=8p-AG8cqCJwC&pgis=1.

Moskowitz, H., Kumaraiah, V., Sharma, K., Jacobs, H., & Sharma, S. (1975). Cross-cultural differences in simple taste preferences. *Science, 190*(4220), 1217–1218. https://doi.org/10.1126/science.1198109.

Murray, S. S., Schoeninger, M. J., Bunn, H. T., Pickering, T. R., & Marlett, J. A. (2001). Nutritional composition of some wild plant foods and honey used by Hadza foragers of Tanzania. *Journal of Food Composition and Analysis, 14*(1), 3–13. https://doi.org/10.1006/jfca.2000.0960.

Neuhäuser, M., & Bretz, F. (2001). Nonparametric all-pairs multiple comparisons. *Biometrical Journal, 43*(5), 571–580. https://doi.org/10.1002/1521-4036(200109)43, 5<571::AID-BIMJ571>3.0.CO;2-N.

Neumark-Sztainer, D., Story, M., Perry, C., & Casey, M. A. (1999). Factors influencing food choices of Adolescents: Findings from focus-group discussions with adolescents. *Journal of the American Dietetic Association, 99*(8), 929–937. https://doi.org/10.1016/S0002-8223(99)00222-9.

Pangborn, R. M. (1970). Individual variation in affective responses to taste stimuli. *Psychonomic Science, 21*(2), 125–126. https://doi.org/10.3758/BF03335798.

Pepino, M. Y., & Mennella, J. A. (2005). Factors contributing to individual differences in sucrose preference. *Chemical Senses, 30*(suppl 1). i319–20 https://doi.org/10.1093/chemse/bjh243.

Pfaffmann, C. (1960). The pleasures of sensation. *Psychological Review, 67*(4), 253–268.

Pliner, P. (1982). The effects of mere exposure on liking for edible substances. *Appetite, 3*(3), 283–290. https://doi.org/10.1016/S0195-6663(82)80026-3.

Popkin, B. M., & Nielsen, S. J. (2003). The sweetening of the World's diet. *Obesity Research, 11*(11), 1325–1332. https://doi.org/10.1038/oby.2003.179.

Prescott, J. (1998). Comparisons of taste perceptions and preferences of Japanese and australian consumers: Overview and implications for cross-cultural sensory research. *Food Quality and Preference, 9*(6), 393–402. https://doi.org/10.1016/S0950-3293(98)00021-4.

Prescott, J., Laing, D., Bell, G., Yoshida, M., Gillmore, R., Allen, S., … Ishii, R. (1992). Hedonic responses to taste solutions: A cross-cultural study of Japanese and Australians. *Chemical Senses, 17*(6), 801–809. https://doi.org/10.1093/chemse/17.6.801.

Regmi, A. (2001). Changing structure of global food consumption and Trade: An introduction. In *changing structure of global food consumption and trade (p. 1)*. Retrieved from http://naldc.nal.usda.gov/download/34108/PDF#page=5.

Robbe, B., & Hladik, C. M. (1994). Taste responses, food choices and salt perception among the Inuit of Greenland. In *In selected proceedings of the XIVth congress of the international primatological society* (pp. 151–154). Strasbourg: Editions de l'Université Louis Pasteur.

Rosinger, A., Tanner, S., & Leonard, W. R. (2013). Precursors to overnutrition: The effects of household market food expenditures on measures of body composition among Tsimane' adults in lowland Bolivia. *Social Science & Medicine (1982), 92*, 53–60. https://doi.org/10.1016/j.socscimed.2013.05.022.

Rozin, P. (1982). *Human food selection: The interaction of biology, culture and individual experience. In the psychobiology of human food selection (pp. 225–254)*. Retrieved from https://scholar.google.com/scholar?cluster=12604175105146780574&hl=en&as_sdt=2005&sciodt=0,5.

Rozin, P., & Schiller, D. (1980). The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion, 4*(1), 77–101. https://doi.org/10.1007/BF00995932.

Schoeninger, M. J., Bunn, H. T., Murray, S. S., & Marlett, J. A. (2001). Composition of tubers used by Hadza foragers of Tanzania. *Journal of Food Composition and Analysis, 14*(1), 15–25. https://doi.org/10.1006/jfca.2000.0961.

Soranzo, N., Bufe, B., Sabeti, P. C., Wilson, J. F., Weale, M. E., Marguerie, R., … Goldstein, D. B. (2005). Positive selection on a high-sensitivity allele of the human bitter-taste receptor TAS2R16. *Current Biology, 15*(14), 1257–1265. https://doi.org/10.1016/j.cub.2005.06.042.

Sorokowski, P., Sorokowska, A., & Danel, D. P. (2013). Why pigs are important in Papua? Wealth, height and reproductive success among the Yali tribe of West Papua. *Economics & Human Biology, 11*(3), 382–390. https://doi.org/10.1016/j.ehb.2012.02.008.

Vadez, V., Reyes-García, V., Godoy, R., & Apaza, V. (2004). Does integration to the market threaten agricultural diversity? Panel and cross-sectional data from a horticultural-foraging society in the Bolivian Amazon. *Human Ecology, 32*(5), 635–646. Retrieved from http://www.jstor.org/stable/4603542.

Vincent, A. S. (1985). Plant foods in savanna environments: A preliminary report of tubers eaten by the Hadza of northern Tanzania. *World Archaeology, 17*(2), 131–148. https://doi.org/10.1080/00438243.1985.9979958.

Wald, N., & Leshem, M. (2003). Salt conditions a flavor preference or aversion after exercise depending on NaCl dose and sweat loss. *Appetite, 40*(3), 277–284. https://doi.org/10.1016/S0195-6663(03)00013-8.

Wardle, J., Cooke, L., Bellisle, F., Rolland-Cachera, M.-F., Skinner, J. D., Carruth, B. R., … Ryan, R. M. (2008). Genetic and environmental determinants of children's food preferences. *British Journal of Nutrition, 99*(S1), S15–S21. https://doi.org/10.1017/S000711450889246X.