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Nutrition and Dietetics

"Is there a link between taste and BMI?"

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WAGENINGEN UR

For quality of life

ΑΛΕΞΑΝΔΡΕΙΟ ΤΕΧΝΟΛΟΓΙΚΟ ΕΚΠΑΙΔΕΥΤΙΚΟ ΙΔΡΥΜΑ ΘΕΣΣΑΛΟΝΙΚΗΣ

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This thesis is dedicated to my parents, who supported me

and keep on supporting me in my every step.

Thank you.

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1. Acknowledgements

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2. Abstract

This project aims to examine if BMI (Body Mass Index) could be a valid indicator of people's food taste choices. The goal was to evaluate if there are existing differences between 2 groups of people with different BMI, Group 1 included people with BMI ≤ 25 kg/m² and Group 2 included people with BMI > 25 kg/m². Subjects involved were 20-55 years old (mean age = 28.03 years). This has been done by examining the food choices of 251 subjects, based on 24h dietary recalls. Upon examination of these factors, it became clear that there are significant differences between the two groups concerning the taste choices as well as the amount of consumption. Specifically, people with higher BMI consume more frequently salty foods ($p = 0.03$) while people with lower BMI consume more frequently sweet foods ($p = 0.01$). The amount of consumption though tended to be significantly higher for people with higher BMI, since they consume higher amounts of fat foods ($p = 0.053$), sweet foods ($p = 0.018$) and sour foods ($p = 0.027$). On the other hand, people with lower BMI consume higher amounts of bitter foods ($p = 0.011$). Based on our findings, people with lower BMI consume more frequently tea and in higher amounts, while people with higher BMI consumed mainly coffee. The amount of consumption of salty foods is similar for both groups. Specific food products consumed more frequently by the total population are milk semi-fat, coffee, banana, apple, multi grain bread and soup with vegetables which are included in dominant taste categories of fat, bitter, sweet, salty and umami respectively. The relationship of frequency of choice and taste intensity differs as well. The relationship between the amount of consumption the dominant taste is also different for the two groups, as mentioned before. Our findings suggest that the relationship of frequency of choice and dominant taste, is different for people with BMI ≤ 25 kg/m² and BMI > 25 kg/m². In conclusion, to answer to the aim of this research, BMI is a valid indicator of people's food taste choices.

Keywords: BMI, taste, food choices, taste preferences, Dutch population, commonly consumed products, nutrition

3. Introduction

Sensory Science is the field of the future, while people are facing countless food products with multiple flavors and ingredients, which may cause confusion. In 1975 the number of food products in an average supermarket was 8.948 and in 2010 the number was 5 times higher, 38.718 according to the Food Marketing Institute. On the other hand, the average Body Mass Index (BMI) according to World Health Organization is rising and a need for further investigation concerning the connection of taste preferences between different BMI groups of people is remaining a controversial subject. A different approach of understanding if the relationship between the amount of consumption, the taste intensity preference and the dominant food taste preference, is affected by the BMI, is by researching the food choices of people with different BMI in combination with their taste properties.

By convention, most researchers believe that human taste perceptions can be categorized into one or more combinations of five taste qualities, each of which is associated with a particular biologically relevant class of compounds. Sweet sensations are associated with the presence of simple carbohydrates; umami taste is generated by amino acids and small peptides; salt taste is associated with the presence of sodium and sometimes other ions; sour taste is generated by acids; and bitter taste sensations arise from stimuli that are potential toxins, such as various plant alkaloids (Breslin & Spector, 2008). All the above suggest that there is a clear relationship between food taste and nutrient content, but does this fact affect the taste preferences for people with different BMI?

As mentioned, the BMI of people in developed countries is dangerously elevating, based on World Health Organization, the worldwide prevalence of obesity nearly doubled between 1980 and 2008, while the need to investigate the root of the problem is remaining imperative. It is well known that elevated BMI is associated with multiple diseases. A new study reveals that obese and morbidly obese subjects were proven to be in a greater risk of primary hyperparathyroidism (Glenn, Yen, Javorsky, & Rose, 2016). A 10-year research, is pointing that the incidence of diabetes, gallstones, hypertension, heart disease, colon cancer, and stroke (men only) increased with degree of overweight in both men and women. Adults who were overweight but not obese ($25.0 \leq BMI \leq 29.9$) were at significantly increased risk of developing numerous health conditions. Moreover, the dose-response relationship between BMI and the risk of developing chronic diseases was evident even among adults in the upper half of the healthy weight range (BMI of 22.0-24.9), suggesting that adults should try to maintain a BMI between 18.5 and 21.9 to minimize their risk of disease (Field, Coakley, & Must, 2001).

Humans have a relatively narrow range of unlearned likes (hedonic responses that are biologically predestined and clearly present independent of any previous exposure), the most apparent of which is a liking for sweetness (Mela, 1997;

Mennella & Beauchamp, 1996). Extensive evidence from experiments with animals and growing evidence from human studies support the view that our liking for particular combinations of sensory attributes in foods is primarily acquired as a result of their repeated pairing with other positive or negative stimuli or events, via associative conditioning (Gearhardt, Rizk, & Treat, 2014). BMI has been positively related to consumption of a diet characterized by higher intakes of meats, eggs, fats, and oils, while dietary patterns with a higher contribution from vegetables, beans, or fruits and grains had negative associations with BMI (Maskarinec, Novotny, & Tasaki, 2000). This seems consistent with the experimental data linking obesity with greater selection of more energy-dense, savory foods (Cox, Perry, Moore, & Vallis, 1999; Westerterp-Plantenga & Pasman, 1996). Therefore, the food choices of people with different BMI may be connected to their preference for specific tastes and moreover nutrients which are represented by taste (Drewnowski & Greenwood, 1983; Mela & Sacchetti, 1991).

Many researches have been performed on the relationship between the BMI and the perception of the taste, but results are unclear and the need for more reliable information is urgent. Studying the possible affect that BMI has on taste choices in human, may lead to important conclusions about the preferences not only of tastes but also of the nutrient content that they represent. This research purpose is to investigate how BMI influences the preference for different food tastes and taste intensities. In addition, we are willing to investigate how BMI affects the amount of consumption for different tastes and taste intensities. If the results of this research show that people with higher BMI may choose to eat a higher amount of low taste intensity foods, that may be explained by the low taste satisfaction and moreover signaling the hypothalamus (Wright, Li, Fallon, & Crookall, 2016) for low satiation level which enables them to consume a higher amount of food. Another study conducted in 2011 supports that energy intake and BMI were inversely related to reward-related signaling, and findings indicated that reward deficiency may have the most significant effect while satiated, which is in agreement with the theory that states that reward deficiency leads to reward seeking that may result in eating while satiated and consequently overeating (Born, Lemmens, & Martens, 2011). Furthermore, lower satisfaction of the taste could lead to overconsumption of food, in order to fulfill that need. Investigating the possible connection between lower taste intensity and consumption could be a valid indicator for their interaction.

Focusing on the **main question**, this research seeks to answer if there a relationship between the taste intensity, the dominant taste, the frequency of consumption and the amount of consumption? Do these relationships change for people in different BMI Groups? (BMI groups: $BMI<25\ kg/m^2$, $BMI\geq25\ kg/m^2$)

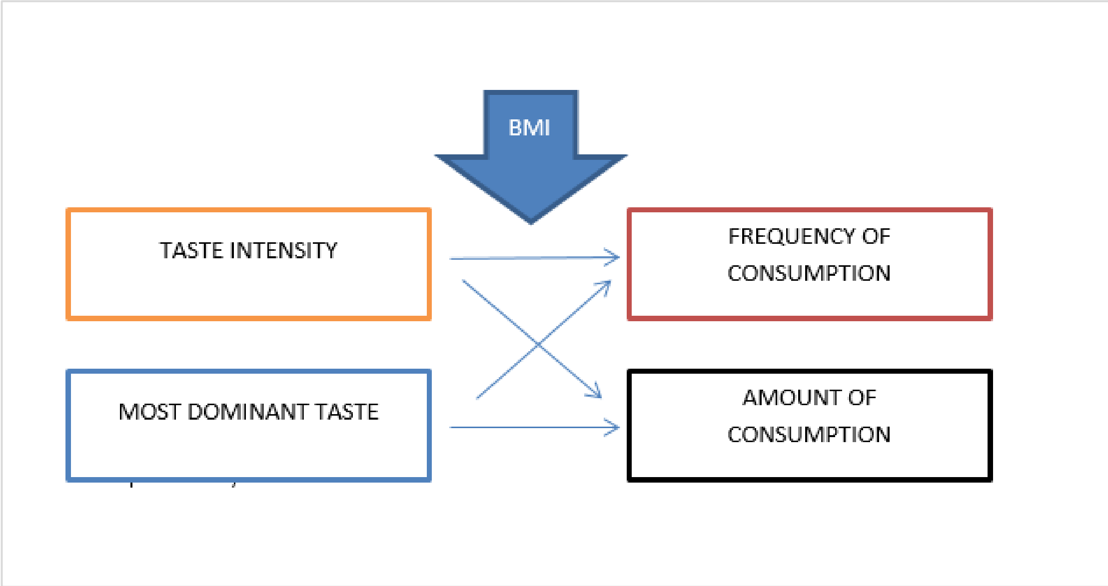

Figure 1 The diagram of the main research question - How BMI affects these relationships?

4. Literature review

4.1. How is taste defined?

Taste is defined as the ability of human body to convert dissolved molecules and ions of foods we eat, to sensation. The main organ of this ability is tongue, which is consisted of thousands of aggregates gustatory cells and the taste buds, that receive tasty stimulus and transport them to the brain. Each taste bud contains approximately 100 taste cells, but a taste to be recognized, must be first solubilized in the saliva and the resulting solution must get in touch with the pili of taste buds (Mela & Mattes, 1988). When the solubilized molecules get in touch with the pili of taste buds, these nerves transfer the gustatory signals to the brain and digestive tract via the nucleus of solitary tract (NST) in the brainstem leading to adaptations in eating behavior and digestive function (Passilly-Degrace, Chevrot, Bernard, & Ancel, 2014).

4.2. Which are the six tastes?

Four primary taste modalities (sweet, salty, bitter and sour) were initially described, to which umami was recently added. Over the last decade, compelling evidences were accumulated supporting the implication of a taste component in the oro-sensory detection of dietary lipids, in addition to textural and olfactory cues (Chalé-Rush, Burgess, & Mattes, 2007). Below, there is a figure representing the papillae of the tongue which are responsible for the perception of different tastes. The basic tastes are perceived in a different degree on each papillae area, but all tastes can be sensed by all areas of the tongue.

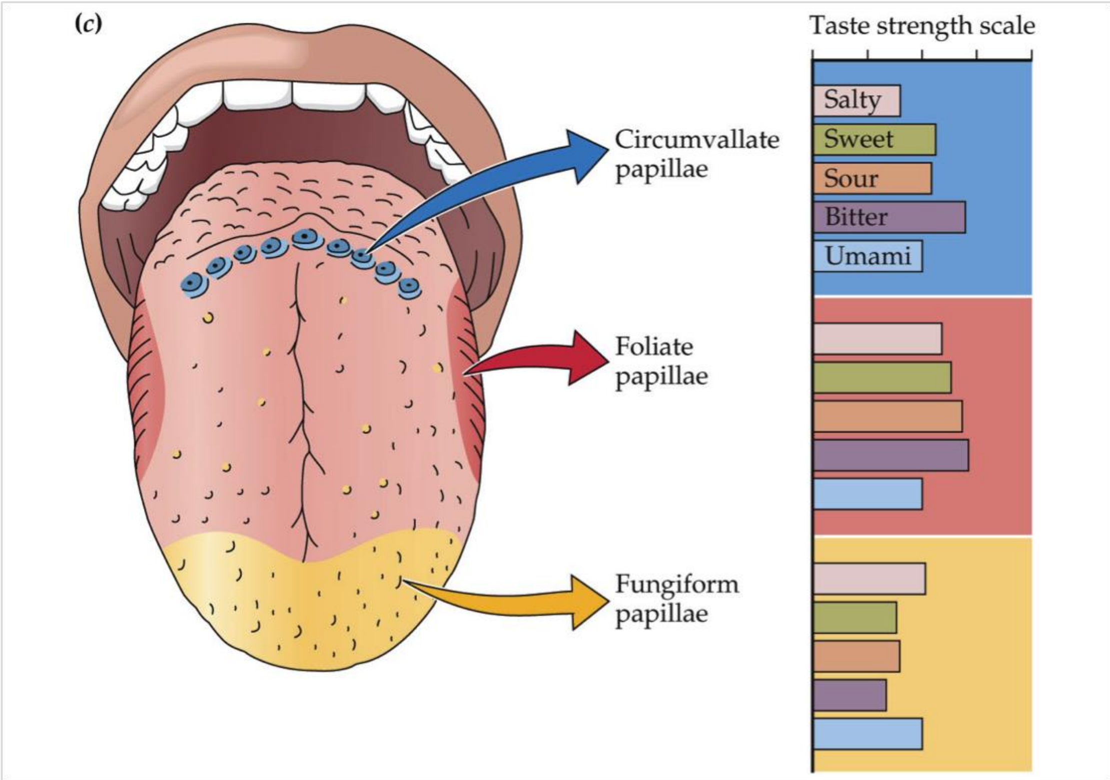

Figure 2 Structure of the papillae found on the upper surface of the tongue

4.2.1. Sweet taste

The sweet taste receptor is a heterodimer of T1R2 and T1R3 (Nakagawa, Nagasawa, Yamada, & Hara, 2009) which are found in circumvallate papillae and foliate papillae near the back of the tongue and palate taste receptor cells in the roof of the mouth (Nelson, Hoon, Chandrashekar, & Zhang, 2001). Natural sugars are more easily detected by the T1R3 receptor than sugar substitutes. This may help explain why sugar and artificial sweeteners have different tastes (Zhao, Zhang, Hoon, & Chandrashekar, 2003).

4.2.2. Fat taste

Expression of fat preference requires first that it be detected. The mechanisms by which this occurs are rapidly being clarified. One observation is undoubtedly true, fats are perceived by multiple mechanisms (Mattes, 2005). Recent evidence suggests that dietary fat, especially free fatty acids, may be perceived chemically in taste bud cells as well as the basic tastes. Recently, it was suggested that long-chain fatty acids accepted into CD36/FAT, a long-chain fatty acid transporter, in circumvallate papillae of the tongue play an extremely important role in the palatability of dietary fat (Mizushige, Inoue, & Fushiki, 2007). GPR120 and GPR40 have been implicated to respond to oral fat (DiPatrizio, 2014), and their absence leads to reduced fat preference and reduced neuronal response to orally administered fatty acids (Cartoni, Yasumatsu, & Ohkuri, 2010).

4.2.3. Umami taste

The umami taste receptor is a complex of two G protein-coupled receptors, T1R1 and T1R3 (Zhang, Klebansky, Fine, & Xu, 2008). T1R1 and T1R3 expressing cells are found mostly in the fungiform papillae at the tip and edges of the tongue and palate taste receptor cells in the roof of the mouth (Breslin & Spector, 2008).

4.2.4. Bitter taste

Bitterness is the most sensitive of the tastes, and many perceive it as unpleasant, sharp, or disagreeable, but it is sometimes desirable and intentionally added via various bittering agents. Common bitter foods and beverages include coffee, unsweetened cocoa, tea etc. The TAS2R proteins function as bitter taste receptors (Chandrashekar, Mueller, Hoon, & Adler, 2000). These proteins, have short extracellular domains and are located in circumvallate papillae, palate, foliate papillae, and epiglottis taste buds, with reduced expression in fungiform papillae.

4.2.5. Sour taste

While sour taste has historically been regarded as the domain of ion channels, receptors for sour taste are now being proposed. HCN1 and HCN4 (HCN channels) were two such proposals; both of these receptors are cyclic nucleotide-gated channels (Stevens, Seifert, Bufe, Müller, & Kremmer, 2001). The two ion channels suggested to contribute to sour taste are ACCN1 and TASK-1. Sour taste detection functions as an important sensory input to warn against the ingestion of acidic (for example, spoiled or unripe) food sources (Huang, Chen, Hoon, & Chandrashekar, 2006).

4.2.6. Salt taste

It is well established from psychophysical and electrophysiological measurements that both Na and Cl contribute to the taste response to NaCl (Elliott & Simon, 1990). An important early event in mammalian gustatory transduction with respect to sodium chloride has been found to be the passage of sodium ions through specific transport pathways in the apical region of the taste bud. The data shows that the sodium and potassium gustatory systems are largely independent at the peripheral level, and that the classical ion taste "receptor" is actually a specific transport pathway permitting the cation to enter the taste-bud cell and thereby to spread depolarizing current (Heck, Mierson, & DeSimone, 1984).

4.3. The importance of taste in food choice

The 'taste of food' plays an important role in food choice. Based on a research of 2016, involving 1306 participants, taste was rated as being a very or extremely important factor for food choice by 82% of participants. Participants who rated taste as highly important, had a poorer diet quality and were more likely to consume less fruit and vegetables. Furthermore, they were significantly more likely to consume foods high in fat, sugar and salt, including chocolate and confectionary, cakes and puddings, sweet pastries, biscuits, meat pies, pizza, hot chips, potato chips, takeaway meals, soft drink, cordial and fruit juice. These findings suggest that the importance individuals place on taste plays an important role in influencing food choice, dietary behaviors and intake (Kourouniotis, Keast, Riddell, & Lacy, 2016).

4.4. BMI and taste sensitivity

A characteristic that has been implicated in earlier meal termination is a higher perceived sensory intensity of food. The effect of sensory intensity on satiety has been shown both for sweet and salty foods (Forde, Kuijk, Thaler, Graaf, & Martin, 2013). Higher sensory intensities may lead to lower ad libitum food intake through a lower bite size (Forde et al., 2013) and longer subsequent oro-sensory exposure. This fact is also supported by a research conducted in Wageningen University, suggesting that longer orosensory exposure and higher saltiness intensity both decreased food intake, although orosensory exposure had more impact than intensity. Prolonging the orosensory exposure per food unit may be helpful to reduce food intake (Bolhuis, Lakemond, & Wijk, 2011). This may be explained by the fact that during a meal, consumption is driven by signals of reward in the brain. These reward signals will finally be overruled by signals of satiation and establish meal termination. This interaction of signals influences meal size. Orosensory exposure is essential for establishing feedback signals of food intake (Bolhuis et al., 2011). To specify, the term orosensory is a compound word derived from oral and sensory, which refers to taste sensation. Orosensory exposure is therefore the degree that people are exposed in taste sensation.

One postulated mechanism behind this effect may be that higher taste intensities signal higher macronutrient density (Yarmolinsky, Zuker, & Ryba, 2009).The perceived sweet, savoury and salt intensities of foods have been shown to relate to the sugar and protein content in an array of 45 commonly consumed foods (Dongen & Berg, 2012). The impact of taste intensity on ad libitum food intake within a solid-savoury hot meal has yet to be shown. To simplify, higher taste intensity of foods may lead to lower consumption of these foods, but the question lies on the possibility of existing differences in taste thresholds in different BMI groups. This is implying that if people with higher BMI have higher detecting thresholds of taste perception, then this mechanism of earlier food termination of high taste intensity foods, won't apply effectively in these groups. Most recent articles demonstrated that a low orosensory exposure is associated with a high food intake, supporting a positive relationship between high threshold detection levels of taste and obese subjects.

A contemporary study of 2015, involving 66 obese subjects concluded that body weight influences gustatory and olfactory perception in healthy adults. Increasing BMI is associated with a decrease in olfactory and taste sensitivity (Deglaire, Méjean, & Castetbon, 2015). Another study in 2015, established that the gradual increase of the orosensory detection threshold of lipids leads to progressive enhancement of the BMI or waist circumference (Cox, Hendrie, & Carty, 2015). Furthermore, the markers of obesity are sensibly enhanced as the BMI. This work suggests different lipid thresholds between BMI categories, a statement which is supported by an additional study in 2014 (Skrandies & Zschieschang, 2015), as under conditions of repeated testing thresholds declined for lean and overweight but remained stable in the obese. Increased dietary fat intake was positively associated with decrease in the taste sensitivity.

On the other hand, there is a contradiction in literature on the relationship of taste preferences and BMI, and as far as it concerns the umami taste, there is incomplete bibliography referring to this taste, although a high quality study conducted in 2012 suggests that obese women have lower monosodium glutamate taste sensitivity and prefer higher concentrations than do normal weight women (Pepino, Finkbeiner, & Beauchamp, 2010). Another research, involving 144 participants, examined if there is a connection between BMI and hedonic food consumption, but the results show no significant difference between different BMI groups (Brondel, Romer, & Wymelbeke, 2007). Also, a contemporary study, conducted in 2016, shows that sweet taste function is not associated with anthropometry (Low, Lacy, McBride, & Keast, 2016).

4.5. BMI and taste preferences

Except for the oresensory differences that are observed in people with different BMI status, the preference for specific tastes in different BMI groups are mentioned in many studies. A study conducted in 2015 involving 46909 participants examined the associations between weight status and the choice for sweet, salt and fat tastes according to gender (Deglaire et al., 2015). The conclusion is that the choice for salt and fat were positively linked to BMI in both genders, and the choice of sweet was positively linked to BMI in women unlike in men. A comprehensive review focused on the food choices of basic tastes among people with different weight, concluded that there is a positive relationship between fat preference and BMI, but results for the sweet, salty, sour or bitter preferences are unclear, as well as the relationship between sensitivity/perception and body weight (Cox et al., 2015). While the need for further investigation is noted, it may worth to be mentioned that the review is based on articles published before 2012, which is possible to lead to lack of contemporary results.

4.6. The aim of the study

The main aim of this study was to investigate the implication of subjects' weight measured as a Body Mass Index (BMI), on the preference for different food tastes, taste intensities and amount of consumption. Because this study analyzes detailed information, the procedure had to be accurate and prestige. For this purpose, we combined the results of two studies: The SVT Study and the NQ Plus Study.

5. Methods

5.1. The SVT Study

We assured the accuracy of results by relying on an excessive and successful study conducted in Wageningen UR called SVT Study. The SVT study, has built a database that contains the tastes of 550 commonly consumed foods in Netherlands. This information can be a useful tool as the database has been built by a trained sensory panel it can also be very reliable. Connecting the database of commonly consumed food tastes and the choices of people with different BMI in real life will be a springboard in understanding this relationship.

5.1.1. The subjects of the SVT Study

The taste intensities of foods were recorded by a trained sensory panel, consisted by 12 members, 3 males and 9 females at the ages between 19-48 with a normal BMI. The panelists were Dutch, non-smokers, mentally healthy with no dietary restrictions.

5.1.2. The rating scales

The rating scales used were the ones created by Martin et al. using the Spectrum Method. The reference solutions contained increasing concentrations of sucrose for sweet taste, caffeine for bitter taste, sodium chloride for salt taste, citric acid for sour taste, monosodium glutamate (MSG) for umami taste and for fat taste a scale of increasing levels of reference foods was used, that were decided through mutual consent of the panel. The solutions with different concentrations of chemical compounds helped the researches create a rating scale of different taste intensities between 0 and 100. A visual analogue scale was used for response of panelists and reference solutions.

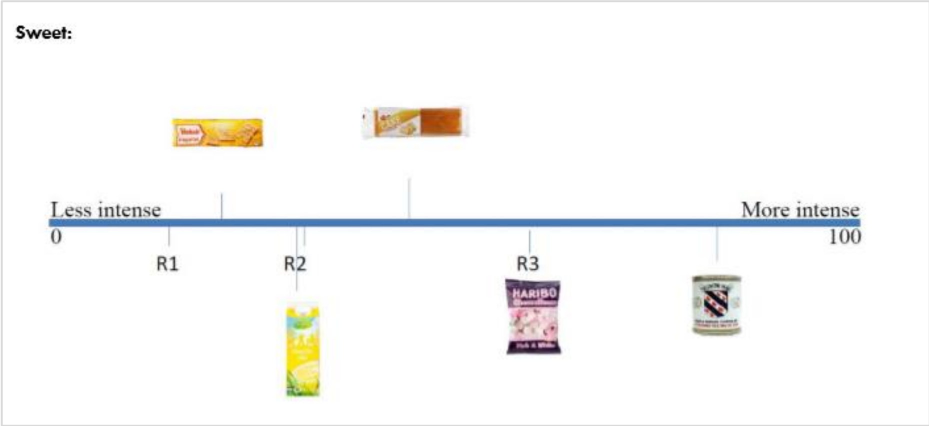

Figure 3 Rating scale for sweet taste

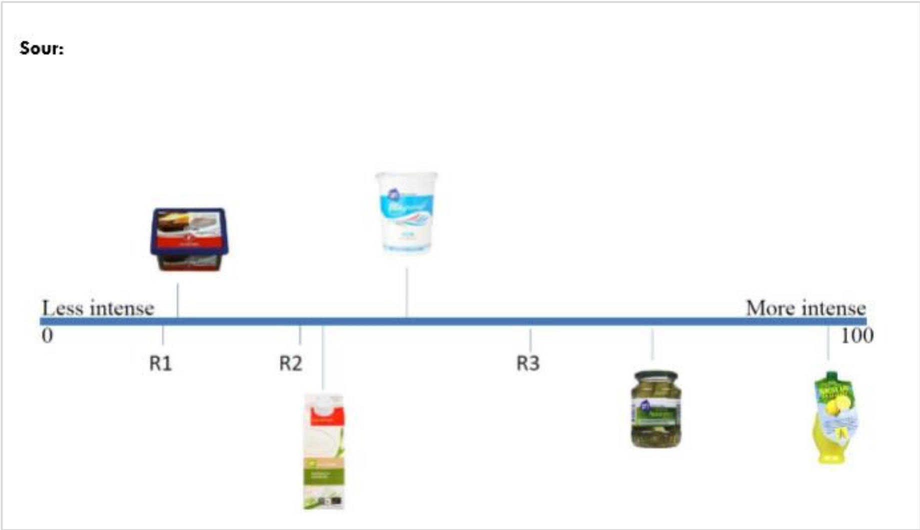

Figure 4 Rating scale for sour taste

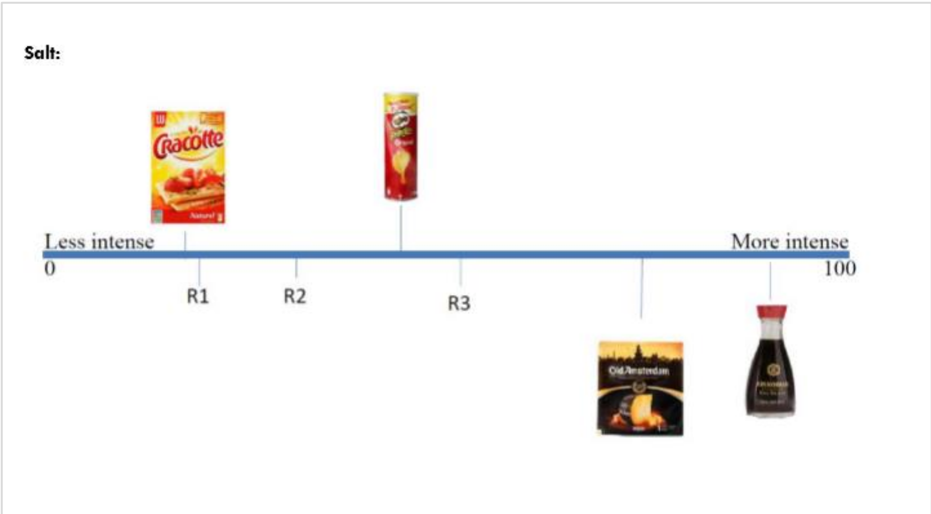

Figure 5 Rating scale for salt taste

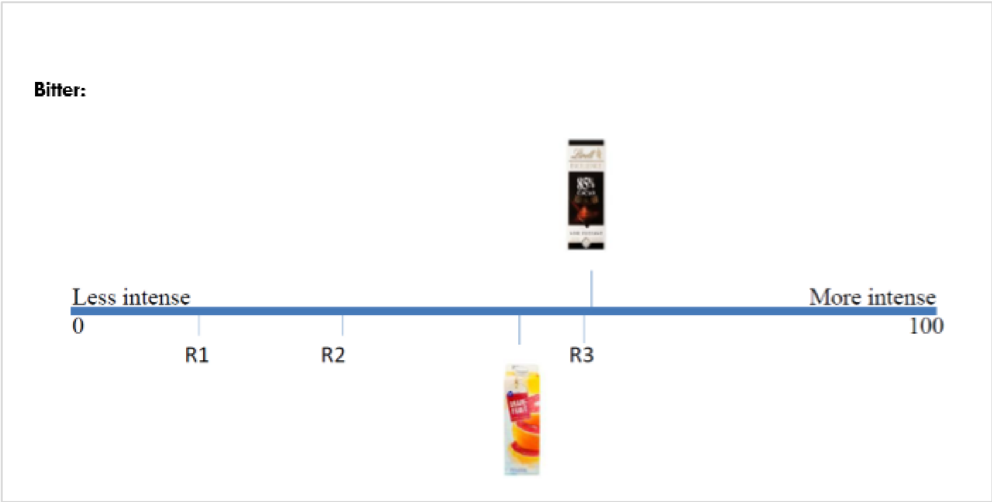

Figure 6 Rating scale for bitter taste

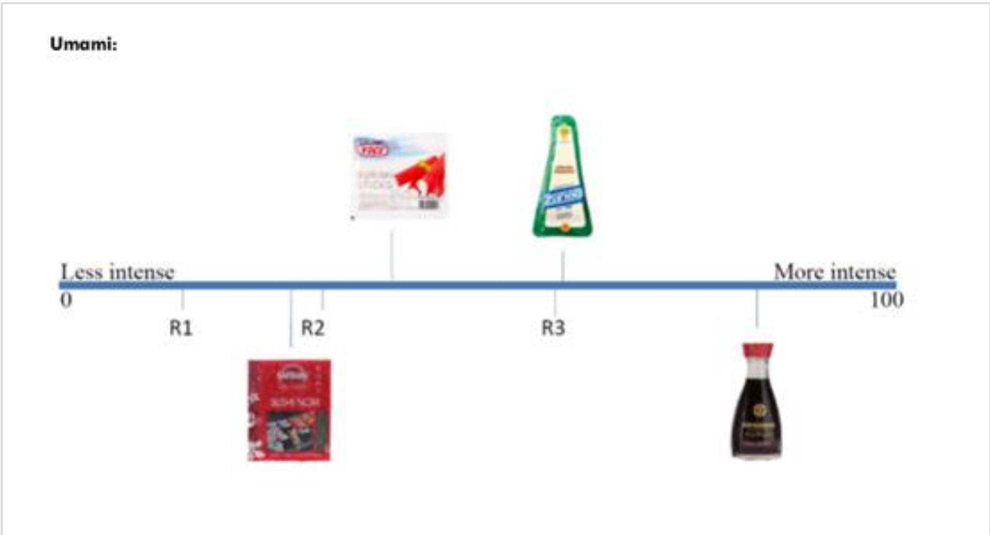

Figure 7 Rating scale for umami taste

Figure 8 Rating scale for fat taste

5.1.3. The training of the sensory panel

The sensory panel was achievably trained by tasting and rating foods in a 65-hour course during a period of 5 months, which enriched them with deep knowledge of the tasting procedure and taste rating abilities. Panelists were trained to assess the taste, texture and fat sensation of foods, regardless the complexity in food items. It is clear that with the immense amount of training and the tasting procedure conducted through experiment with the SVT study we were provided with indisputable information about the taste of commonly consumed foods.

5.1.4. The profiling of the food products

The profiling took place in Wageningen University in the sensory laboratory and lasted 2 years. During this period the trained sensory panel was tasting and profiling the products, succeeding to analyze 550 commonly consumed Dutch foods.

5.2. The NQ Plus Study

The aim of the NQ Plus Study was to pin-point the specific dietary factors that may be responsible for the rise of cardiometabolic conditions, leading to health related problems. For this purpose, the Nutrition Questionnaires plus study was initiated.

5.2.1. The subjects of the NQ Plus study

The NQplus study is a prospective cohort study among Dutch adults aged 20-70 years. In total, 2048 Dutch men (52%) and women (48%) - able to speak, read, and write in Dutch - were enrolled.

5.2.2. The subjects of the present study

For the collection of subjects' information, we used a database of 902 participants indicating the foods consumed the last 24 hours. Although we had available 902 participants, 651 of them were missing important information so we had to exclude them and finally we used a sample of 251 subjects. More specifically, 455 subjects were older than 55 years old, 191 subjects had less than 3 recalls and 5 subjects were excluded because the consumption moment of two beverages was the same, while at the same moment they consumed sugar, but it is not clear whether the sugar was added in coffee or tea. These subjects were excluded because the participants that were involved were 20-55 years, who belonged in different BMI categories: Group 1: BMI<25 kg/m² (Mean = 22.65 and Standard Deviation = 1.76), Group 2: BMI≥ 25 kg/m² (Mean = 28.03 and Standard Deviation = 3.14) and had three 24hour recalls, with clear recall consumption moments. We involved participants that had three 24h recalls to make sure that the results are reliable, since the more recalls conducted the closer to reality the analysis will be. Combining the two databases and analyzing the elements in the statistical analysis program SPSS, was the method of analysis. Figure 9 is a detailed diagram that reflects the screening procedure in order to select the most suitable candidates for our study.

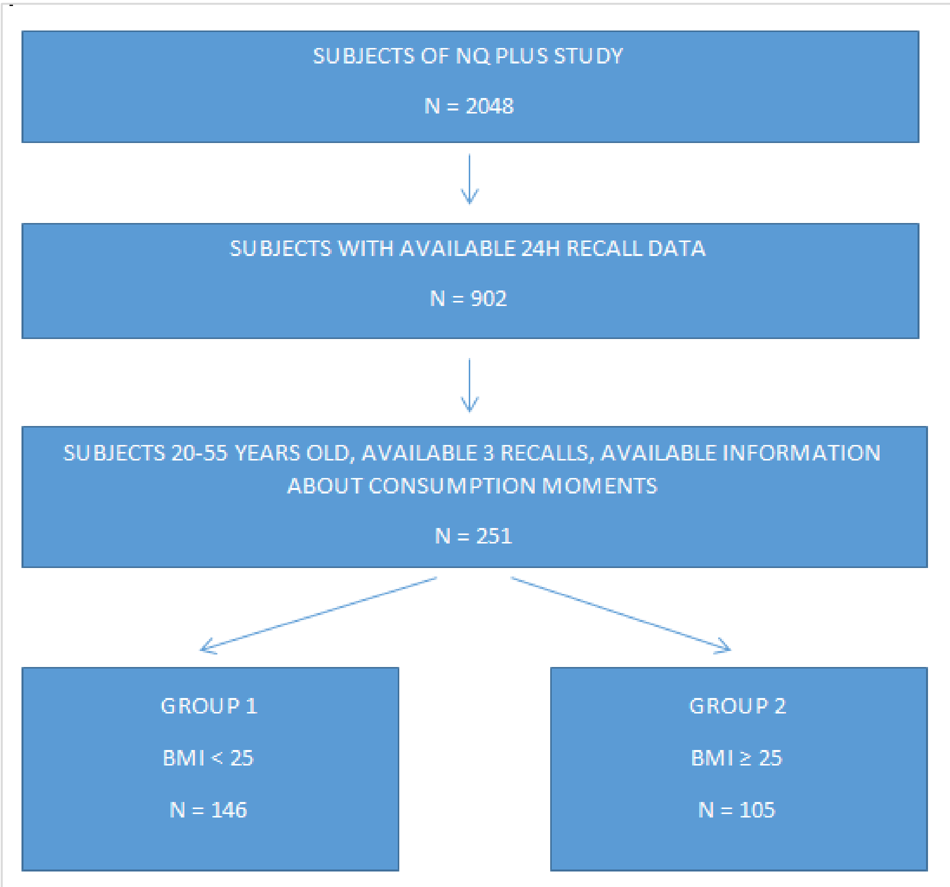

Figure 9 Flow diagram of the screening procedure

5.2.3. The dietary intake assessment

This method involves a structured interview. A trained interviewer asked the participants to recall all foods and drinks consumed during previous 24 hours. The 24-hour recall was administered with a computer-assisted program. Prompts for quantification of portion size were employed. In more details, the questionnaires were self-administered and filled out online using the open-source survey tool LimesurveyTM (LimeSurvey Project Team / Carsten Schmitz. Hamburg, Germany). 24-Hour recalls were telephone-based as well as web-based. Telephone-based 24-hour recalls were performed by dieticians who were trained in interviewing skills, while dieticians used a standardized protocol. Web-based recalls were self-administered using the software program Compl-eat.

5.2.4. Anthropometrics

Height was measured with a stadiometer (SECA, Germany) to the nearest 0.1 centimetre, participants were asked to take off their shoes. Weight was measured using a digital scale (SECA, Germany) to the nearest 0.1 kg; participants were asked to take off their shoes, sweaters and to empty their pockets. Waist and hip circumference was measured twice by measuring tape (SECA 201, Germany) to the nearest 0.5cm; the average of the two measurements was included in the dataset.

5.3. Statistical analysis

Statistical analysis was conducted with the SPSS and Microsoft excel softwares.

To examine the preference for dominant tastes we used frequency analysis. To evaluate existing differences regarding the frequency of consumption of each taste between the two groups, we used Pearson chi-square test.

For the examination of possible differences in the amount of consumption of each dominant taste for the two groups, we practiced One-way ANOVA analysis.

Taste intensity in relation with the amount of consumption was represented by a dot plot. A total of 12 figures were designed, one for each taste and one for each group.

The preference for specific intensities was tested using a frequency analysis, while any significant differences were analyzed with a Pearson chi-square test. To understand the correlation between the taste intensity and the behavior of consumption for each group, we used Pearson correlations. The results were depicted by histogram graphs.

To evaluate the most commonly consumed products for each group, as well as for the total population we used frequency analysis.

Based on these studies, we have a total of 20.500 food choices of which we have available taste information for 13.301 food choices. By excluding 7.199 choices whose taste intensities are not provided, we conclude that we have available taste information for 64.88% of the food choices.

Analysis of Coffee and tea combined with sugar or milk:

In the 24hour recall, people mentioned the beverages as different food choices that sugar, sweeteners or milk, although the consumption of them happened simultaneously by adding these products inside of the beverages. The taste of the combined products differs from the tastes of the products consumed separately, so the tastes of the products had to be combined. To resolve this problem, we replaced the two or three different products consumed simultaneously, by the product which contained the final taste. The tastes of the final products were derived from the database of the SVT-Study, as well as all the other tastes of the products. To specify, the products that were replaced are mentioned below:

Coffee prepared

1. Coffee creamer full fat and coffee
1. Coffee creamer semi-fat and coffee
2. Coffee creamer powder and coffee
3. Sugar granulated and coffee
4. Sweetener aspartame/acesulfame p tablet and coffee
5. Stevia and coffee

Tea prepared

1. Sugar granulated and tea

To be more detailed in a statistical point of view, we used SAS as a statistical program for this venture. Only if the products mentioned above were consumed by the same subject at the same time of the day, then we assumed that the consumption of them happened simultaneously. For example, if there was coffee mentioned in the same consumption moment as sugar, then we assumed that they consumed sugar in the coffee. In this case, we created a new column for each combined occasion, while as well we created new nevocodes, which were the combination of the individuals nevocodes. Conclusively, these separated products were considered as one food choice in this research.

Figure 10 Example of simultaneous consumption of coffee and sugar

6. Results

6.1. The relationship between frequency of choice and dominant taste for the total population

For the total subject's population, the group 1 and 2 combined, we analyzed the taste preferences which are chosen more frequently, based on the dominant tastes of food products. By analyzing the frequency of consumption for each dominant taste, we can clearly see in Figure 11 that fat taste is the dominant taste which the total population chooses to consume the most, compared to the other dominant tastes of foods, sweet, sour, bitter, umami and salt. The valid percent of the taste choice frequencies for fat is 27%, for bitter 24.6% , for sweet 25.3%, for sour 11.1%, for salt 11.8% and for umami 0.2%.

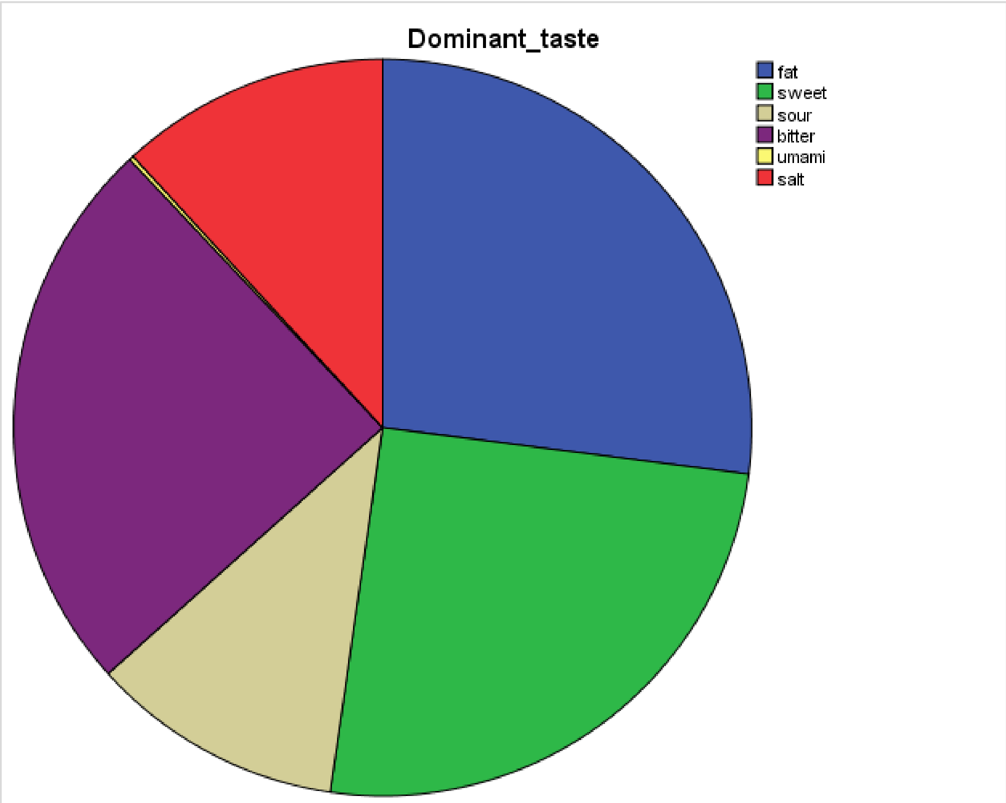

Figure 11 Pie graph representing the taste choices of the total population

6.2. Specific product preferences for the total population

Additionally, we analyzed the preferences for specific products for each dominant taste. Moreover, the results of our study are presented in tables 1, 2, 3, 4, 5 and 6, which are pointing the most frequently consumed foods included in the fat, bitter, sweet, sour, salt and umami taste categories respectively.

Table 1 Most frequently consumed fat food products in Netherlands

	Fat taste food products		
Classification	***Product Name***	***Nevocode***	***Valid Percent***
1	Milk semi-fat	286	11.3%
2	Potatoes without skin average boiled	982	3.2%
3	Chicken eggs average boiled	84	3.1%
4	Gouda cheese 48+	513	2.9%

Table 2 Most frequently consumed bitter food products in Netherlands

	Bitter taste food products		
Classification	***Product Name***	***Nevocode***	***Valid Percent***
1	Coffee	644	38.2%
2	Tea	645	33.8%
3	Coffee with sugar	377/644	6.8%
4	Cappuccino	2477	4.9%
5	Coffee with coffee creamer semi-skimmed	285/644	4.4%
6	Beer	390	4.3%

Table 3 Most frequently consumed sweet food products in Netherlands

	Sweet taste food products		
Classification	***Product Name***	***Nevocode***	***Valid Percent***
1	Banana	151	6.6%
2	Gum without sugar	447	5.2%
3	Honey	443	4.1%
4	Jam	445	3.9%
5	Dutch Cake Spiced	240	3.4%
6	Chocolate confetti plain	1963	3.2%

Table 4 Most frequently consumed sour food products in Netherlands

	Sour taste food products		
Classification	**Product Name**	**Nevocode**	**Valid Percent**
1	Apple with skin average	875	10.9%
2	Red wine	422	10.9%
3	Mandarin	165	7.4%
4	Skimmed yogurt	301	7.5%
5	Orange juice pasteurized	410	7.2%

Table 5 Most frequently consumed salt food products in Netherlands

	Salt taste food products		
Classification	**Product Name**	**Nevocode**	**Valid Percent**
1	Bread multi grain average	2350	11.4%
2	Bread wholemeal average	246	11%
3	Bread brown wheat	236	9%
4	Ham lean boiled	784	4.3%
5	Sandwich with chicken fillet	2654	3.9%

Table 6 Most frequently consumed umami food products in Netherlands

	Umami taste food products		
Classification	**Product Name**	**Nevocode**	**Valid Percent**
1	Soup with meat and vegetables	792	78.3%
2	Tomato juice	413	21.7%

6.3. Differences in taste preferences between groups

One of the main goals of this study was to identify if the two groups differ in the preferences for specific tastes. We found that the values for salt as a dominant taste were significantly different for the two groups ($\chi^2 = 4.684$, $p < 0.05$, Pearson chi-square test). This significant finding reflects that 95% of people with higher BMI (Group 2) eat more frequently salty foods that people with lower BMI (Group 1). Therefore, we can conclude that the BMI significantly affects the choice of salty foods. In addition, the values of the sweet taste preferences for the two groups differ significantly from each other ($\chi^2 = 5.661$, $p < 0.05$, Pearson chi-square test) as people with lower BMI (Group 1) consume more frequently sweet foods, than people with higher BMI (Group 2). This finding is pointing that people with lower BMI (BMI<25 kg/m^2) will consume more frequently foods, which their dominant taste is sweet, compared to the people with higher BMI (BMI>25 kg/m^2). Fat as a dominant taste choice appears more frequently in people with higher BMI, but no significant difference was found between the two groups ($\chi^2 = 1.217$, $p = 0.27$, Pearson chi-square test). Umami taste choice also reveals a small difference between the groups, but no significant difference was found ($\chi^2 = 2.285$, $p = 0.131$, Pearson chi-square test). For bitter and sour tastes there were no significant differences between the groups, concluding that BMI does not affect the preferences for these specific tastes. The Figure 13 is a bar graph comparing visually the differences between the two groups.

By analyzing the frequencies of dominant taste choices we reveled that in Group 1 (BMI ≤ 25 kg/m²) the percentage of fat taste was 26.8%, sweet taste 26%, sour taste 11.1%, bitter taste 24.6%, umami taste 0.3% and salt taste 11.3%. In Group 2 (BMI > 25 kg/m²) the percentages were as followed, 27.3% for fat, 24.3% for sweet, 11.1% for sour, 24.6% for bitter, 0.1% for umami and 12.5% for salt.

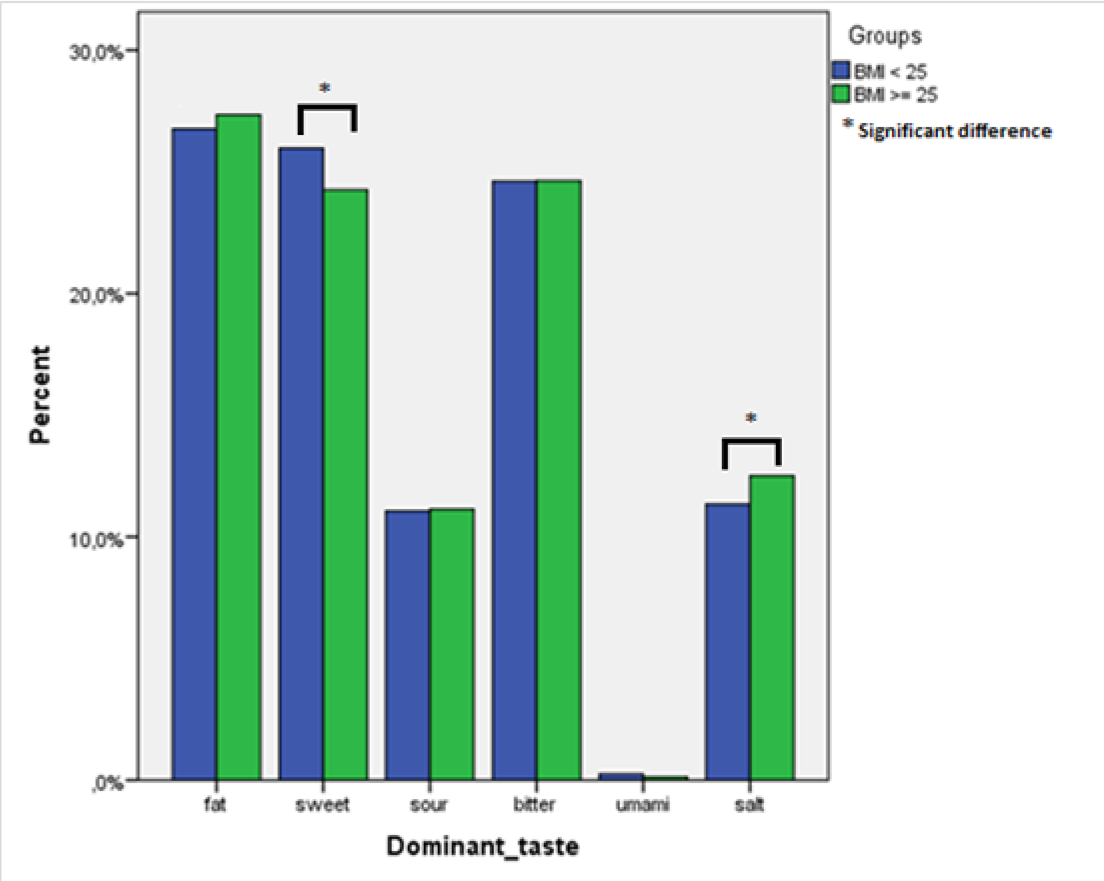

Figure 12 Bar graph representing the preferences for dominant tastes based on the valid percent of the samples for the two groups

6.4. Differences in the amount of consumption for each dominant taste between groups

Although there are some differences in the choice frequency of dominant tastes for the two groups, another important factor is the amount of consumption of each dominant taste. The results indicate that people with higher BMI consume higher amounts of fat taste foods with a statistical significant difference ($p = 0.053$, One-way ANOVA). For sweet taste the amount of consumption for group 2 is higher than the amount of consumption for people with lower BMI, with a statistical significant difference as well ($p < 0.05$, One-way ANOVA). Sour taste is consumed in higher amounts by people with higher BMI, pointing a significant difference ($p < 0.05$, One-way ANOVA). On the other hand, bitter taste products are consumed in a significantly higher amount by people with lower BMI ($p < 0.05$, One-way ANOVA). Umami taste is consumed by both groups at similar amounts since there is no significant difference ($p = 0.249$, One-way ANOVA). Finally, salty foods seem to be consumed by both groups at same amounts ($p < 0.76$, One-way ANOVA). The results are also presented in Appendix 16.

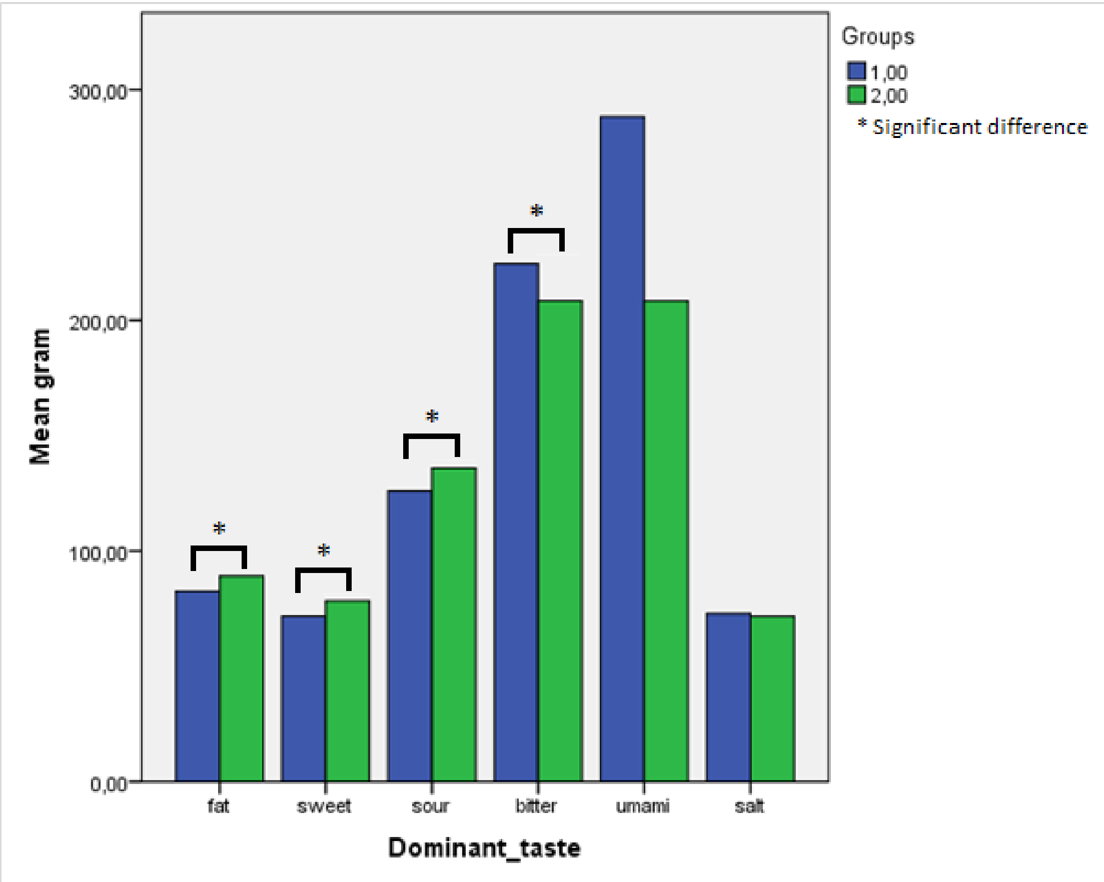

Figure 13 Bar graph representing the mean amount of consumption in grams for each dominant taste for the two groups

6.5. Taste intensity and frequency of consumption: Comparing the two groups

The observation of the histograms which are presenting the taste intensity and the frequency of consumption, is reflecting a clear preference for lower taste intensities in total population (see appendix) ($p < 0.05$, negative correlations for intensities: sweet, sour, fat, salt and umami, Pearson correlation).

Exception is the bitter taste which exhibits a sharp increase in taste intensity levels 18-21 and 63-66. People with higher BMI show higher preference for bitterness intensity of 63-66 while people with lower BMI show higher preference for bitterness intensity of 18-21. The main reason for the preference for these specific intensities is coffee and tea, which have bitter taste intensities of 63.35 and 20.03 respectively. It is clear that people with higher BMI have a preference for coffee while people with lower BMI have a preference for tea (χ^2 = 106.122, $p < 0.05$, Pearson chi-square test).

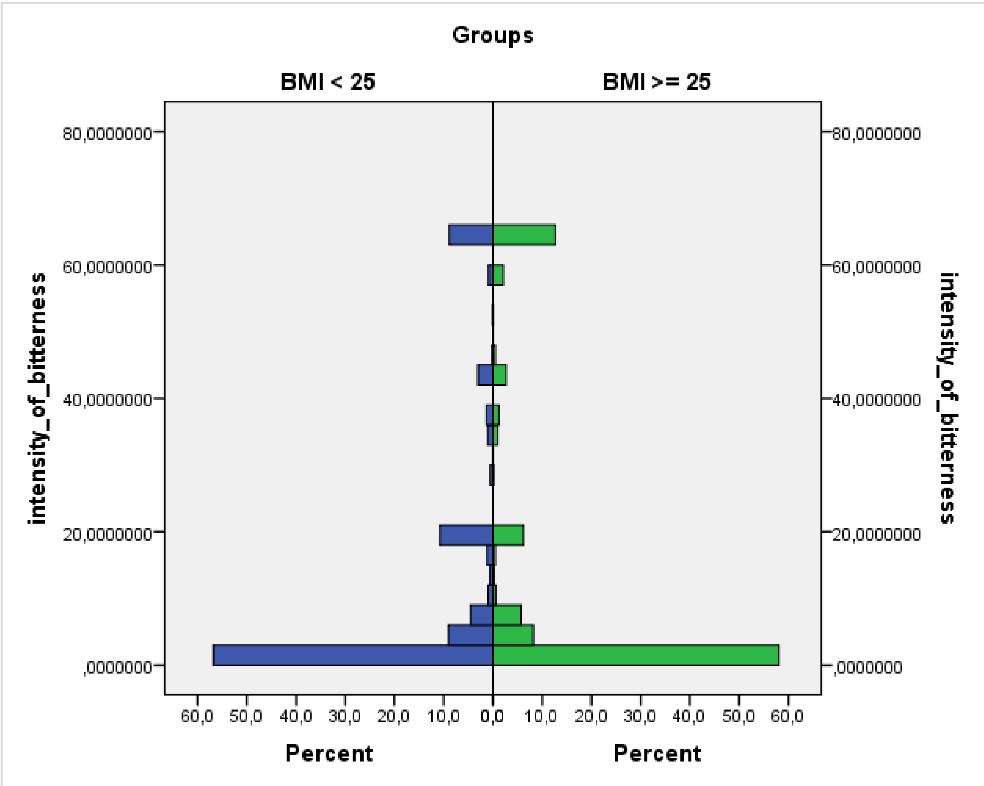

Figure 14 Double histogram representing the valid percent of the frequencies for the two groups regarding the intensity of bitterness

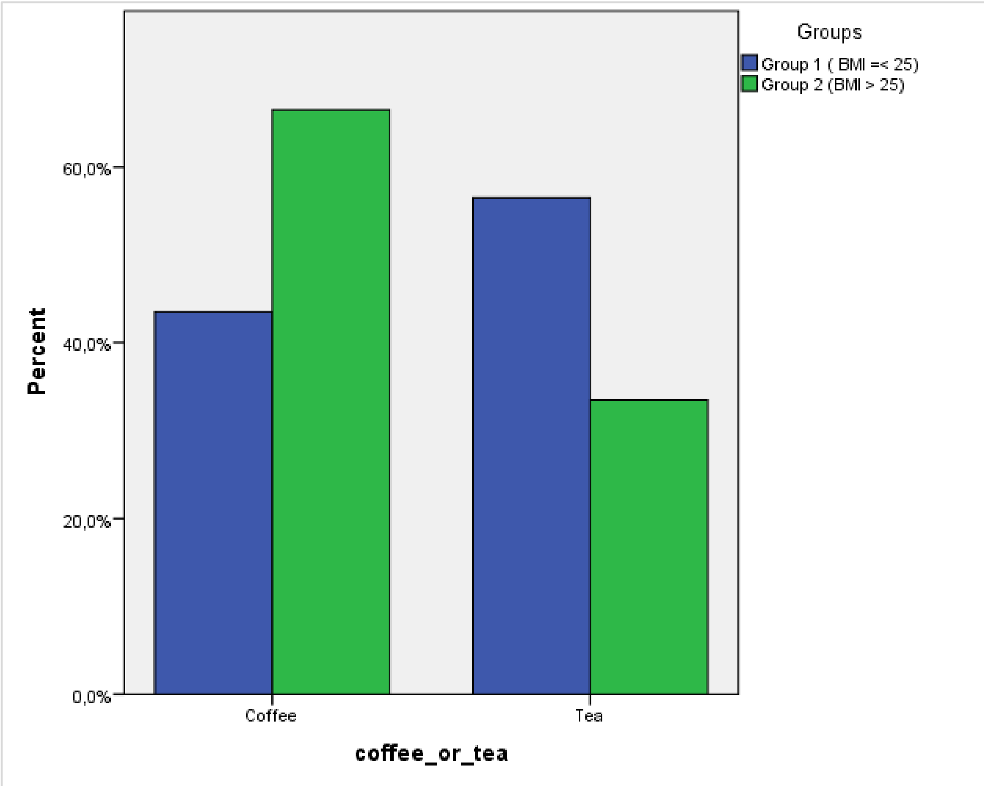

Figure 15 Bar graph representing the differences between the two groups in the preferences of coffee versus tea

6.5.1. Sweet taste intensity

As it appears in the Figure 16 below, we observe an elevation at taste intensities of sweetness at points 0-3 and 3-6. This elevation of frequency is due to the fact that coffee has a sweetness taste intensity of 2.34, which falls within the boundaries of 0-3. Simultaneously, tea has a sweetness intensity of 4 which falls within the boundaries of 3-6. The preference for sweet taste intensities 0-3 for people with higher BMI, confirms the previous results by showing that people with higher BMI have a higher preference for coffee. In the same way, tea confirms that people with lower BMI have a preference for this beverage. It may be worth to be mentioned that cheese also falls into the sweetness intensities of 3-6, which is a product often consumed in Netherlands. Cheese, coffee and tea are the main products consumed by both groups equally frequently and are the main reasons for the elevation of this specific intensity. The results are also presented in appendix 17.

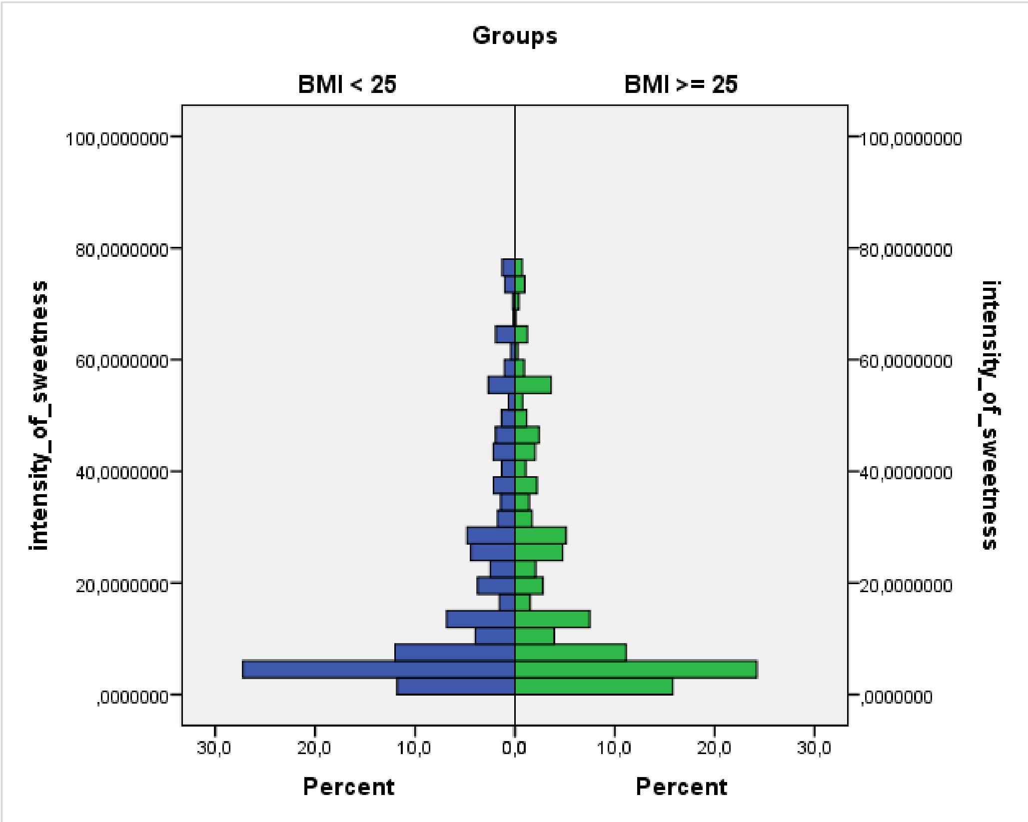

Figure 16 Double histogram representing the valid percent of the frequencies for the two groups regarding the intensity of bitterness

6.5.2. Fat taste intensity

People show a preference for fat intensities of 0-3 and 3-6 as we observe in Figure 17. Coffee and tea are again of the main factors causing this elevation, since fat taste intensity of coffee is 3.79 and of tea is 1.85. Although these are important factors, two additional products seem to affect the percentage elevation. These products are gum without sugar with a fat taste intensity of 4.39 and pepper mint with a fat taste intensity of 1.5, which are widely consumed by both groups.

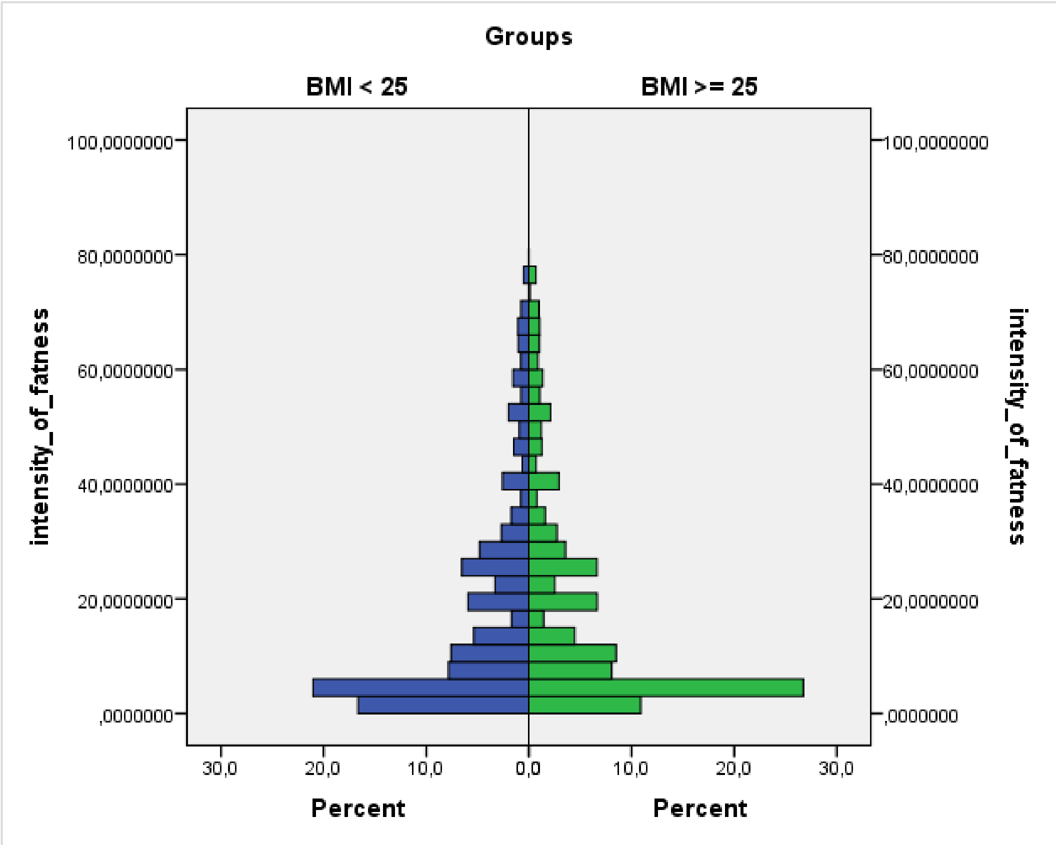

Figure 17 Double histogram representing the valid percent of the frequencies for the two groups regarding the intensity of fatness

6.5.3. Other taste intensities

Sour, umami and salt taste intensity preferences do not show significant differences between the two groups. People tend to choose lower salty intensity foods, lower sourness intensity foods and lower umami intensity foods (see appendices).

6.6. Taste intensity and amount of consumption

Based on the Figures 21-32 (see appendix), we can see that many people choose to consume high amounts of low intensity foods. As far as it concerns the sweet taste in relation with the amount of consumption, there are unclear results for people with higher BMI, while results for people with lower BMI seem to be more united. No clear results can be drawn. As mentioned in the previous session, the amounts of consumption for people with higher BMI are higher than the amounts of consumption for people with lower BMI.

7. Discussion

7.1. Taste choices

Many researches have been performed on the relationship between the BMI and the perception of the taste, but results are unclear and the need for more reliable information is urgent. Studying the possible affect that BMI has on taste choices in human, may lead to important conclusions about the preferences not only of tastes but also of the nutrient content that they represent. This research purpose was to investigate how BMI influences the preference for different food tastes and taste intensities.

Liking for certain food does not exclusively determine food choice, hedonic response is an influential personal factor that reinforces food intake, along with other factors including health and weight concerns, preference for convenience (Mela, 2001). Because of this fact, this research focused in real life choices in a more practical and less theoretical way, to ensure that exported results are corresponding to real life circumstances. To further strengthen our results, we involved participants with at least three 24h recalls, to make sure that an average of their food choices has been recorded, while we recruited as many suitable participants as possible, by finally including a more than adequate number of 251 subjects.

Overall, notable findings from this research include differences in people with lower BMI (BMI≤25) and people with higher BMI (BMI>25) which are observed not only regarding the taste preferences, but the amount of consumption as well. To summarize our findings, fat taste is consumed more frequently and in higher amount by people with higher BMI. Sweet taste is consumed more frequently by people with lower BMI, but in higher amounts by people with higher BMI. Salt taste is consumed in the same amounts by both groups, but people with higher BMI consume it more often. Sour taste is equally often consumed by group 1 and 2, but people with higher BMI eat higher amounts of sour products. Bitter taste is consumed at the same frequency by both groups, but people with lower BMI consumes higher amounts. Finally, umami taste is consumed by both groups the same.

Surprisingly, people with lower BMI tend to consume more frequently sweet foods than people with higher BMI, although the amount of consumption for people with higher BMI is significantly higher. This can be explained by previous researches which support that as sugar levels increased, participants reported moderately decreased craving (Gearhardt et al., 2014). It is also well known that sweet taste is associated with simple sugars content (Dongen & Berg, 2012). Based on these facts, it could be hypothesized that people with higher BMI consume higher amounts of sweet products in order to fulfill their craving feeling, while people with lower BMI could have lower need of fulfilling craving feelings.

As far as it concerns fat taste, it is clear that people with higher BMI consume higher amounts of fatty foods and more frequently as well. Drewnowski identified that foods linked with "carb craving" were frequently high in fat as well as carbohydrates (Drewnowski, Kurth, Holden-Wiltse, & Saari, 1992) . Findings of a contemporary research appear to support Drewnowski's proposal that the fat level may have a stronger association with food craving than certain types of carbohydrates (i.e., sugar) (Gearhardt et al., 2014). It is well established that obesity has been associated with diets containing high levels of both fat and sucrose (Drewnowski, Grinker, & Hirsch, 1982; Simchen, Koebnick, & Hoyer, 2006) , a fact that is supported by our findings.

The results about fat and sweet tastes come to an agreement with previous studies, while it seems that people with higher BMI consume more frequently fat but not sugar(Gibney, Sigman-Grant, & Stanton, 1995). Studies on sugar and fat preferences among obese women showed that preferences for fat increased with body weight(Drewnowski, Brunzell, Sande, & Iverius, 1985). Massively obese women selected fat-rich taste stimuli in sensory studies and listed high-fat foods as their favorites on food preference checklists (Drewnowski et al., 1992).

Moreover, based on our findings, people with higher BMI consume more frequently salt taste foods, while the amount of consumption for salty foods is the same for both. Added salt has been found to increase palatability of foods and is associated with increased consumption of foods containing high quantities of this ingredient (Kourouniotis et al., 2016). Shepherd and Farleigh (Shepherd & Farleigh, 1986) found that taste preference is a strong predictor of salt use and that being aware of the health consequences of added salt did not impact participant intake. Obese adults also take in more dietary energy in food they classed as salty (Cox et al., 1999) , suggesting that altered salt sensitivity or liking or both may also affect eating behaviour. BMI was recently reported to correlate with reported liking for salt-and-fatty food (Keskitalo, Tuorila, & Spector, 2008) . Taking into consideration the previous articles mentioned, it could be possible that people with higher BMI consume more frequently salty foods because of the fact that taste liking is more important for them than people with lower BMI.

The frequency and amount of consumption for umami taste seems to be the same for both groups, but this specific taste is considered to be a limitation in our study since we do not obtain enough information to draw clear conclusions. Only 17 umami choices were made by people with lower BMI and only 6 choices by people with higher BMI, a fact that characterizes the sample very small for making us capable of having specific conclusions upon this taste. The lack of enough samples may be due to the fact that umami taste is rarely found as a dominant taste in commonly consumed products. Sodium glutamate is usually inserted as an additive (E621) to many products in order to enhance the taste properties of the products and less usually considered as the main taste of them. On the other hand, it could be possible that Dutch people don't consume often umami taste foods.

Sour as a dominant taste is consumed equally frequently by both groups but in a higher amount by people with higher BMI. Foods belonging in this category are wine, kiwi, apples, orange, yogurt etc. People with higher BMI are found to be consuming high amounts of chewing gum, a product which belongs in sour taste category, and this may be the main cause of the higher sour consumption of this group. Based on previous studies, taste perception was reported as significantly reduced in subjects with BMI ≥28, only for bitter and sour tastes (Simchen et al., 2006), since based on this study people with higher BMI have higher thresholds detection levels of sour and bitter tastes. This could be the reason why people with higher BMI consume higher amounts of sour products, in order to fulfil their need of sour taste stimulation.

Bitter taste foods are consumed at the same frequency by people with high and low BMI as well, but in higher amounts by people with lower BMI. As mentioned before, coffee and tea are the main products representing this category, which were widely consumed multiple times per day by many participants. Coffee is preferred by people with higher BMI, while on the other hand tea was seen more frequently in people with lower BMI. Caffeine increases weight loss by inducing thermogenesis and stimulating lipid oxidation in humans (Dulloo, Geissler, & Horton, 1989). It could be suggested that people with higher BMI are drinking more coffee while trying to lose weight. Although for caffeine to produce thermogenic effects the dosages must exceed 600–1000 mg caffeine, which means at least 3-4 cups of “strong” coffee per day (Dulloo et al., 1989) . On the other hand, people with lower BMI drink more tea and in higher dosages. Abdul G. et al. proved that oral administration of the green tea extract stimulates thermogenesis and fat oxidation and thus has the potential to influence body weight and body composition. These effects are not caused by caffeine contained in green tea, but by other components found inside it since the same amount of caffeine in coffee was orally given to the subjects did not lead to the elevated thermogenic results of green tea (Dulloo, Duret, Rohrer, & Girardier, 1999) . In other words, green tea can promote weight loss in lower amounts than coffee, which may be the explanation why the people with lower BMI drink more tea in higher amounts, while people with higher BMI drink more coffee in lower amounts. Unfortunately, though, this could only be a conjecture since in our research the kind of tea consumed was not mentioned.

Another important conclusion conducted through our research is that people with higher BMI consume a higher amount of food which is probably the most important difference between the two groups.

Taste intensity in comparison with the amount of consumption could not lead us to any notable conclusions since the results were unclear. Given the facts, further investigation is needed which will provide us reliable evidence in order to be able to draw clear conclusions about the relationship of food’s taste properties in relation with the weight status in human.

The research question of this study was if there is a relationship between the taste intensity, the dominant taste, the frequency of consumption and the amount of consumption? Do these relationships change for people in different BMI Groups? (BMI groups: BMI<25 kg/m², BMI≥25 kg/m²) In conclusion, to answer to the research question, BMI is a valid indicator of peoples taste choices and these relationships change for sweet and salt tastes. Additionally, BMI is a valid indicator for the amount of consumption too for fat, sweet, sour and bitter tastes. As far as it concerns the relationship between the amount of consumption and the taste intensity, no results could be drawn.

7.2. Specific Product choices

Bitter is the second most frequent dominant taste, and the products consumers choose to eat more frequently are "prepared coffee" by 38.2% of the bitter taste foods, "prepared tea" by 33.8%, "coffee with sugar" by 6.8%, "instant prepared cappuccino coffee" by 4.9%, "coffee with milk semi skimmed" by 4.4% and beer by 4.3%. It is notable to mention that bitter is the second most frequent choice because of coffee, tea and beer which belong in this category. Coffee and tea are commonly consumed by a large group of people but it is often sugar, honey or other sweeteners that may be added in coffee or tea, although the frequency of consumption of these sweeteners as dominant tastes is very low compared to the consumption of these beverages. This fact leads us to conclude that most of these beverages are consumed without added sweeteners, except for honey whose frequency is high as a sweet food choice and may be more often added to tea. Given these facts, we can observe that the highest percent of Dutch people have health awareness and they avoid consuming frequently sugar in their coffee or tea. On the other hand, beer is an alcoholic drink consumed very frequently. Moderate consumption of beer can be beneficial but overconsumption is related to health problems (Baum-Baicker, 1985).

Sweet foods consumed more often is banana by 6.6% of the sweet taste foods, chewing gum without sugar by 5.2%, honey by 4.1%, jam by 3.9%, cake by 3.4% and chocolate confetti by 3.2%. A fruit being in the first place as the most consumed sweet food is a pleasant surprise. Although the first product is healthy choice (Singh, Singh, Kaur, & Singh, 2016) the third most frequent consumed product even before honey is chewing gum which contains high amounts of sweeteners (Sadler, 2014). At this point should be mentioned that although people avoid consuming sweeteners as a separate food choice, that doesn't prevent them from consuming sweeteners hidden inside other food products. Additionally, cake and chocolate confetti are desserts usually consumed in Netherlands, while the second is mostly consumed as breakfast combined with bread and margarine. It was expected that a dessert would take a high rated place in sweet taste foods, but classified below banana, jam and honey is pretty surprising, proving once again the healthy nutrition habits of the Dutch population.

Sour is the fourth most dominant taste while sour foods consumed more frequently are firstly apples and red wine by 10.9%, mandarins by 7.4%, skimmed yogurt by 7.5% and pasteurized orange juice by 7.2%. The fact that the percentages are comparatively high suggests that there is a small diversity between the sour food choices. All of the food choices are outstandingly healthy, since red wine is proven to prevent from heart diseases (Di Castelnuovo, Rotondo, Iacoviello, Donati, & Gaetano, 2002), increases bone density in menopausal women (McLernon, Powell, & Jugdaohsingh, 2012) by moderate consumption. Apples and mandarins are fruits containing high amounts of antioxidants and dietary fibers and yogurt contains probiotics which reduce the toxin-producing bacteria in the gut and that this increases the longevity of the host (Schrezenmeir & Vrese, 2001). Orange juice would be healthier if it was freshly made since while processed it losses high amounts of antioxidants.(Gil-Izquierdo, Gil, & Ferreres, 2002)

Salty foods chosen by the population more often are multigrain bread by 11.4% of the total foods that their dominant taste is salt, whole meal bread by 11%, brown wheat bread by 9%, boiled lean ham by 4.3% and chicken fillet sandwich by 3.9%. Bread is at the top of food choices since it is an easy accessible and a low priced food. The fact that is pleasantly surprising is that most people don't choose white bread but multigrain, whole meal or brown wheat bread which have higher amounts of dietary fibers. The percent of ham consumed does not reach half of the percent of bread consumed, pointing that there is a notably lower frequency of consumption for meat.

Finally, umami taste is limited to two food products because umami as a dominant taste is not frequent at commonly consumed foods. More specifically, umami taste as a dominant taste covers only the 0.2% of the choice frequency, while tomato juice takes 70.5% of the two foods that their dominant taste is umami and low fat mayonnaise (40% oil) covers the 29.5%.

Clarifying, most of the people choose more frequently to consume food products whose dominant taste is fat taste and more specifically, the products that they prefer are semi-skimmed milk by 11,3% of the fat taste foods, boiled potatoes by 3.2%, boiled chicken eggs by 3.1% and Gouda cheese 48+ by 2.9%. Although fat taste is the most frequent choice we observe that the food products that belong in this category and which people choose more often to consume are healthy foods necessary for a healthy eating behavior (Barr, McCARRON, & Heaney, 2000; Brown, 2005; Kritchevsky, 2004; Schrezenmeir & Vrese, 2001). We can clearly understand that Dutch people avoid choosing fried food or high processed foods as a fat taste choice.

7.3. Considerations

7.3.1. Methodological

In this point it is necessary to be mentioned that our database did not include sugar as a separated product, a fact that could alternate the results of sweet taste preferences between the two tested groups. Additionally, some sweeteners that subjects consumed were not available in our taste database, so they were considered as sweeteners whose tastes we had available.

As a dominant taste we defined the taste of each product that was higher rated by the SVT Study Sensory Panel. This may be considered as a limitation in this study since a product may have almost equally detectable dominant tastes. For example, potatoes are included in the fat taste category, although that is not entirely correct. There was a small difference between the other tastes and fat taste, but the way we decided to conduct this research, leaded potatoes to be in fat taste category. In reality, potatoes have a pretty neutral taste, based on SVT Study.

Also, many subjects did not mention the exact time of consumption, so in these cases we had to exclude the participants due to the fact that we could not be objective about the simultaneous consumption of these products.

7.3.2. Future recommendations

For future relevant studies, a consideration should be distinguishing the foods based on their form, by investigating separately the liquids and the solids, since it could be possible to lead to unclear results. In this study, the foods were not separated based on their form, a fact that may be interfering with the results concerning the amount of consumption, since liquids are the reason that specific dots on the graphs (see appendices) seem very high.

An additional recommendation would be the dietary recalls to be more detailed, by including the specific brands of the products that the participants consumed. There are differences between the products of different brands, and this could be a factor affecting the preferences of the subjects.

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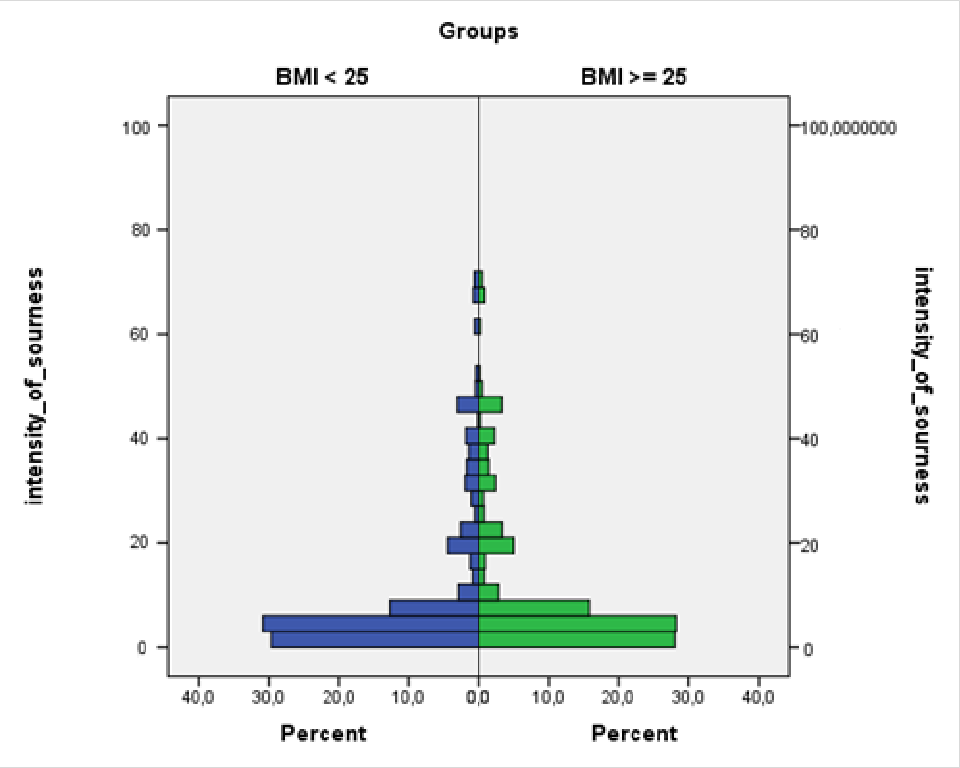
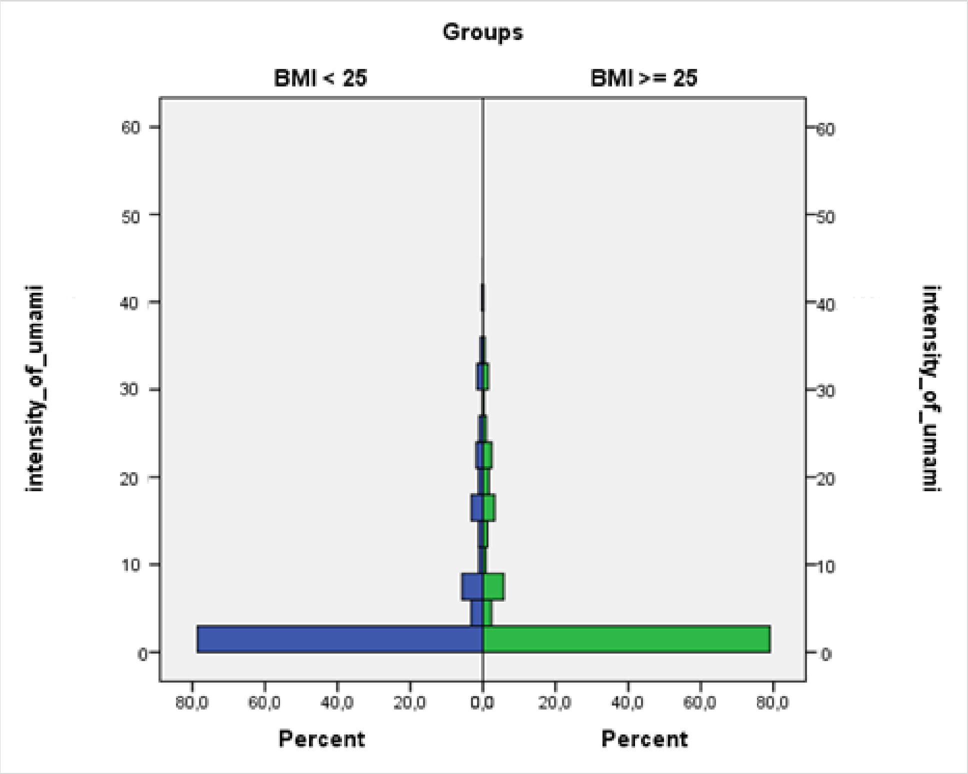
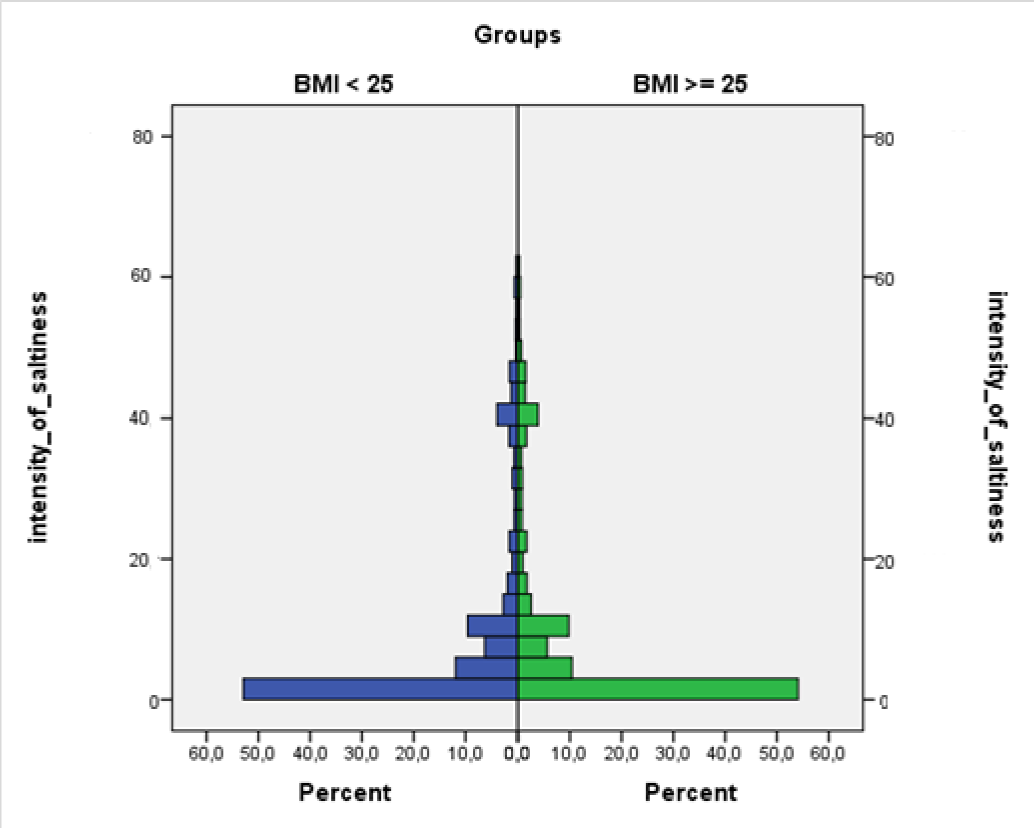
9. Appendices



Appendix 1 Double histogram representing the valid percent of the frequencies for the two groups regarding the intensity of sourness

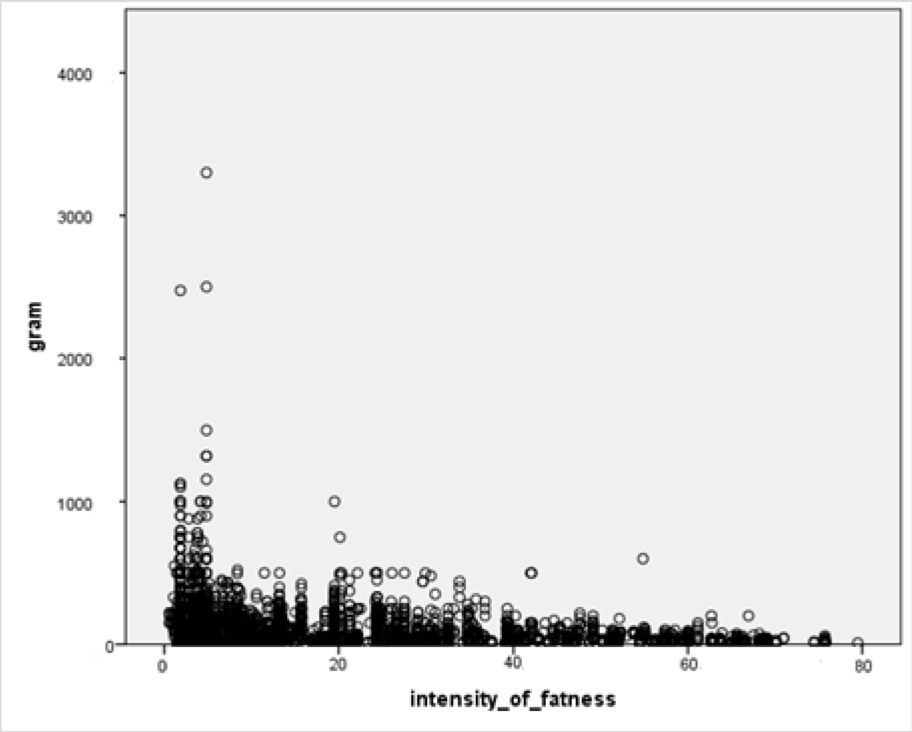


Appendix 2 Double histogram representing the valid percent of the frequencies for the two groups regarding the intensity of umami



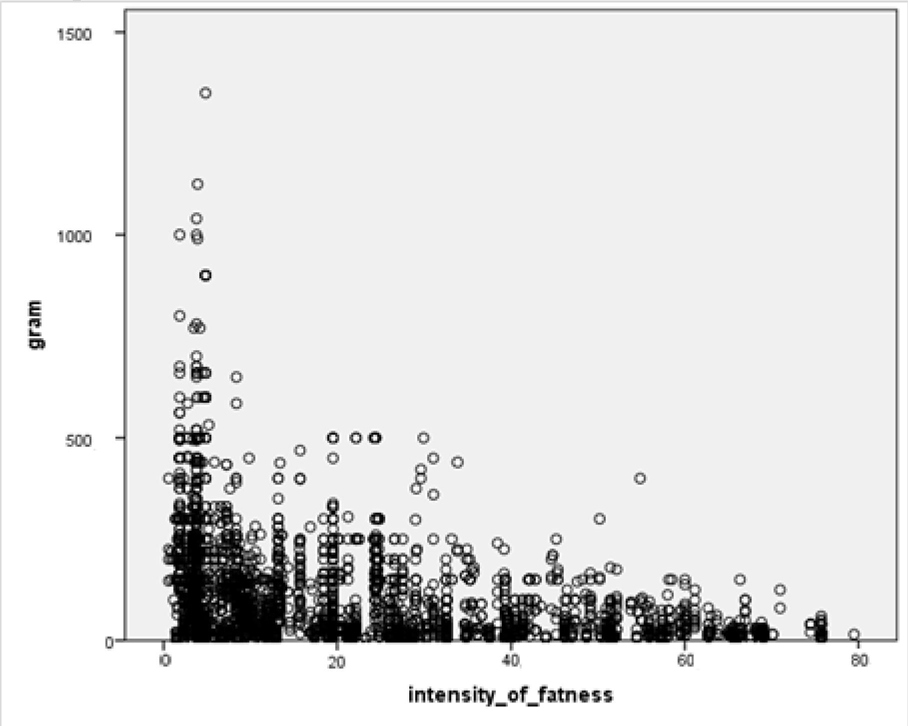
Appendix 3 Double histogram representing the valid percent of the frequencies for the two groups regarding the intensity of saltiness

Group 1



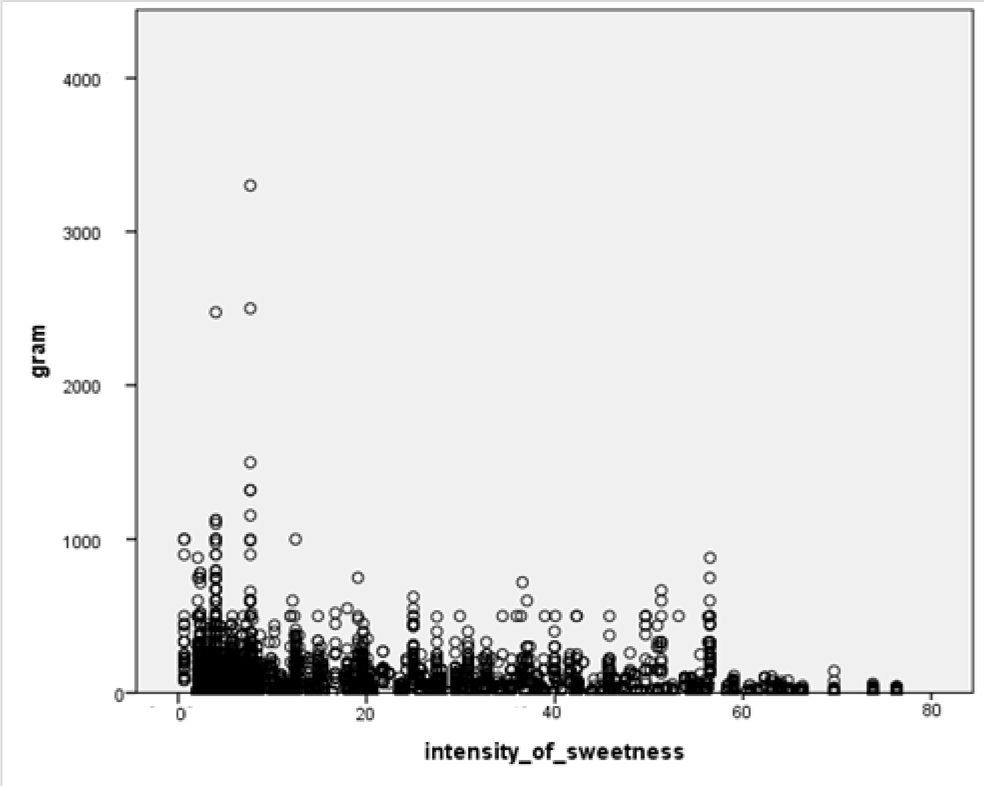
Appendix 4 Dot plot representing the relation between the amount of consumption and the taste intensity of fatness for Group 1

Group 2



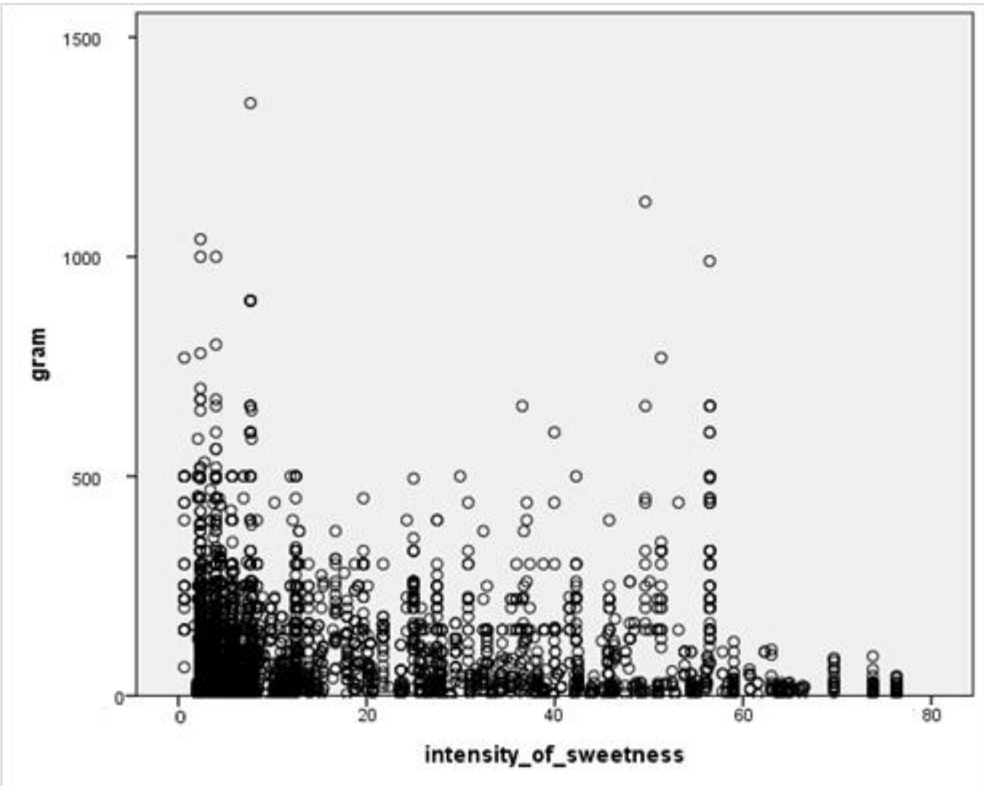
Appendix 5 Dot plot representing the relation between the amount of consumption and the taste intensity of fatness for Group 2

Group 1



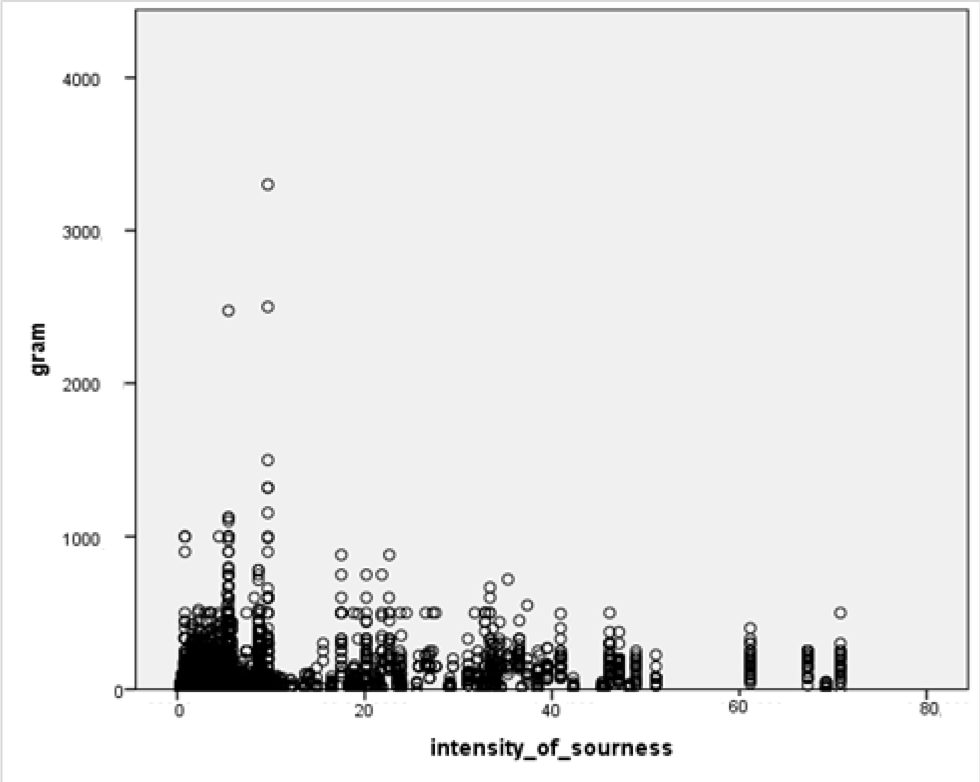
Appendix 6 Dot plot representing the relation between the amount of consumption and the taste intensity of sweetness for Group 1

Group 2



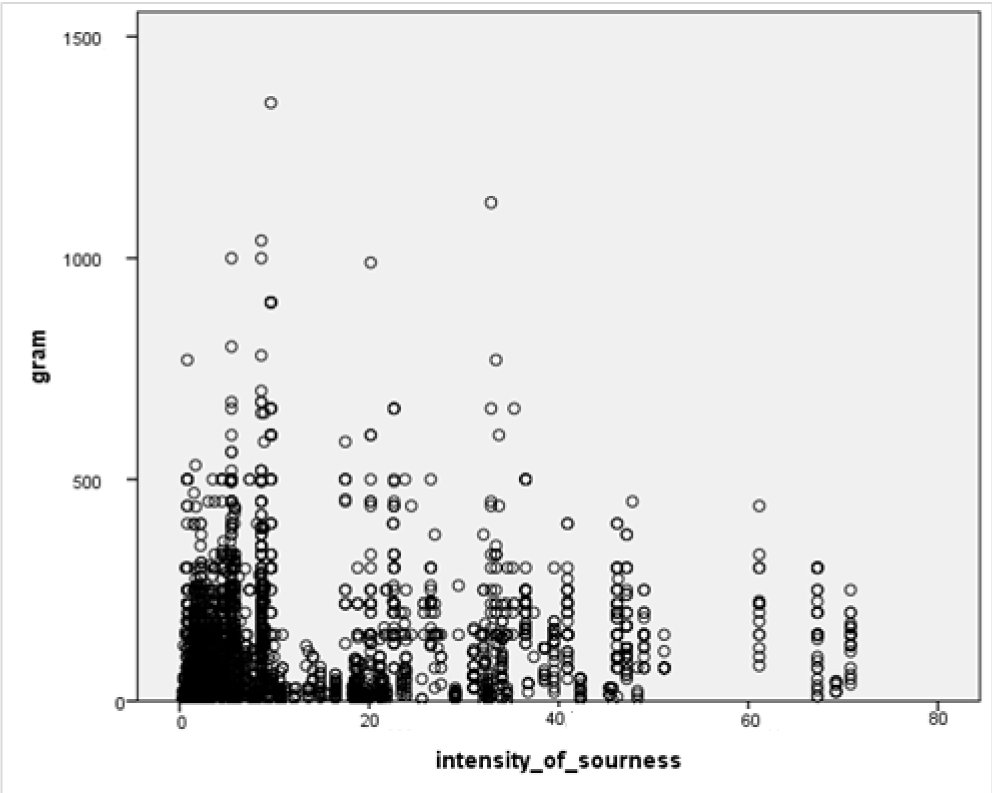
Appendix 7 Dot plot representing the relation between the amount of consumption and the taste intensity of sweetness for Group 2

Group 1



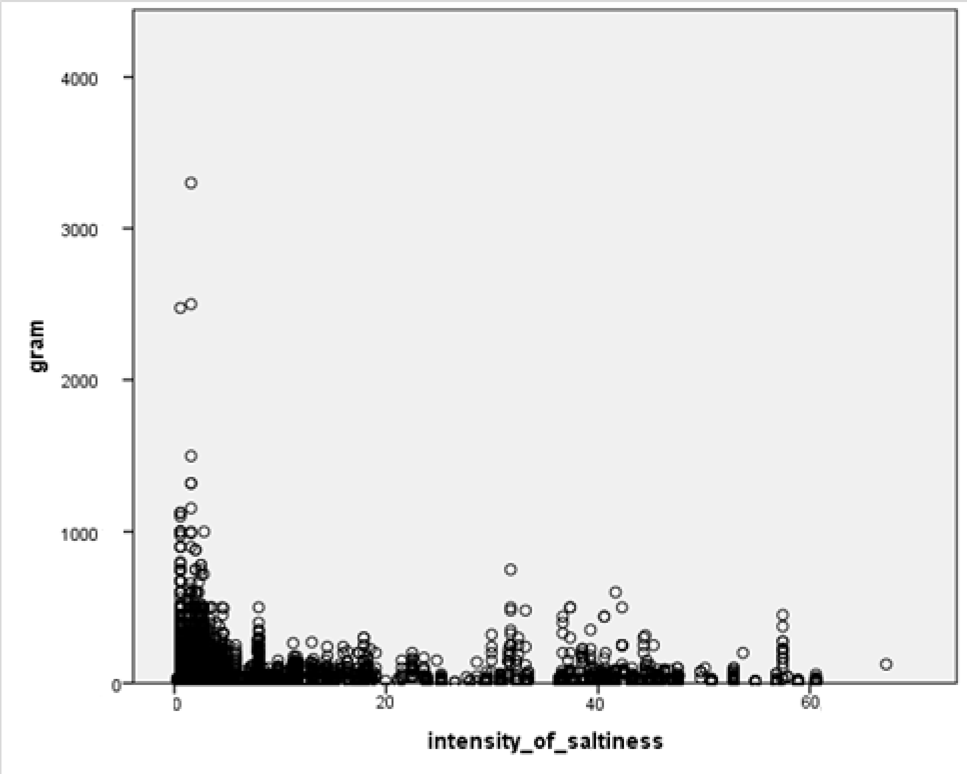
Appendix 8 Dot plot representing the relation between the amount of consumption and the taste intensity of sourness for Group 1

Group 2



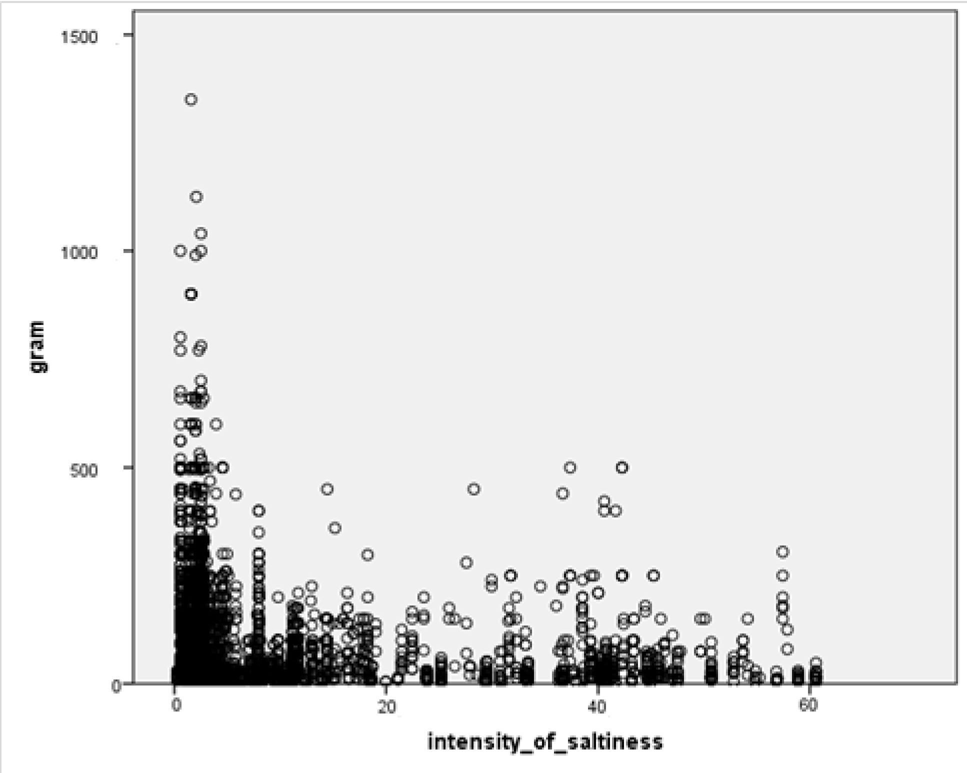
Appendix 9 Dot plot representing the relation between the amount of consumption and the taste intensity of sourness for Group 2

Group 1



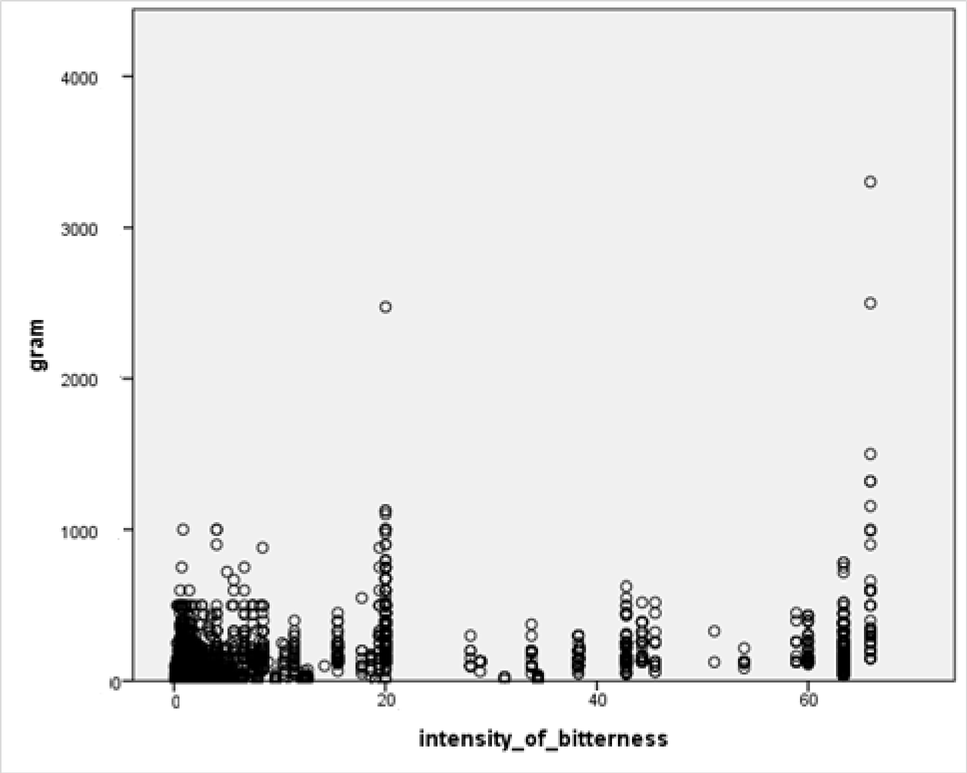
Appendix 10 Dot plot representing the relation between the amount of consumption and the taste intensity of saltiness for Group 1

Group 2



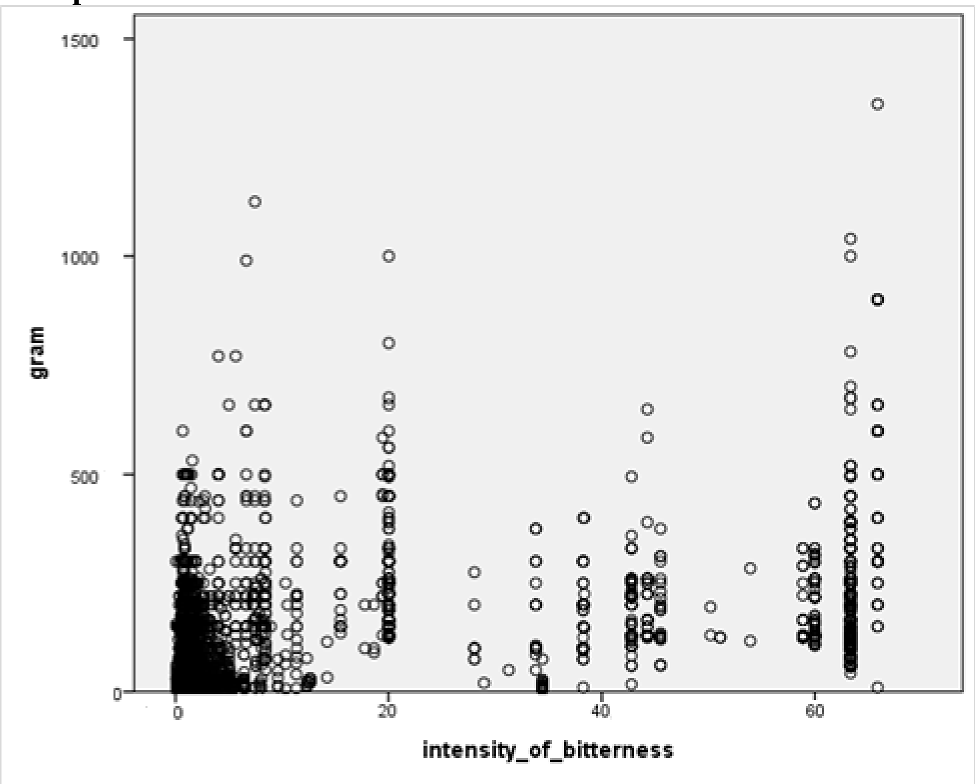
Appendix 11 Dot plot representing the relation between the amount of consumption and the taste intensity of saltiness for Group 2

Group 1



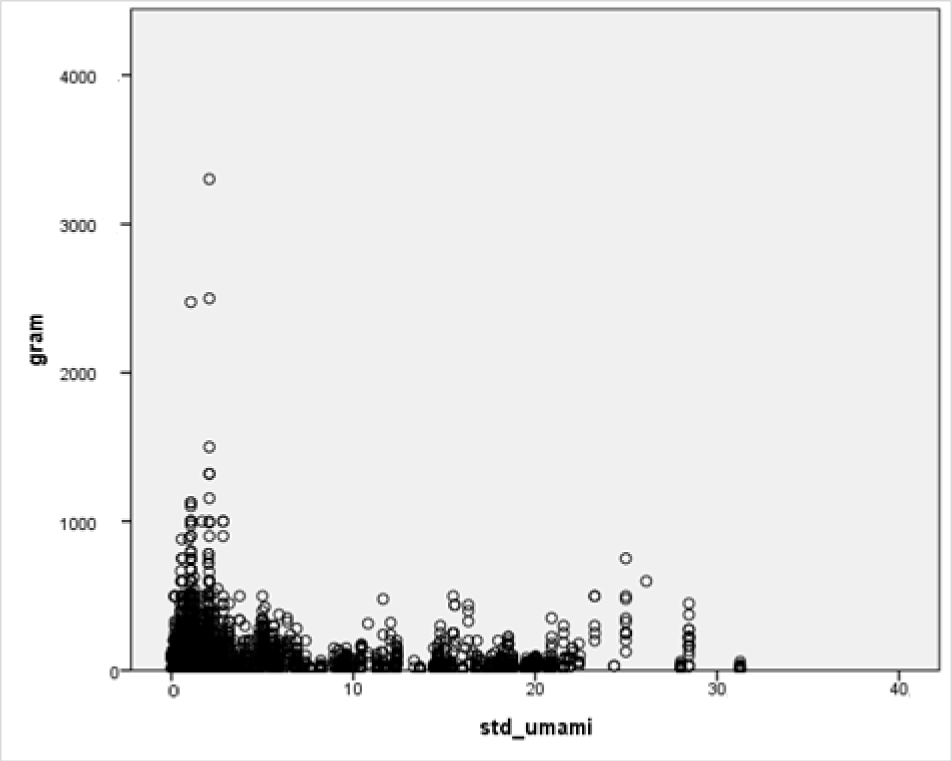
Appendix 12 Dot plot representing the relation between the amount of consumption and the taste intensity of bitterness for Group 1

Group 2



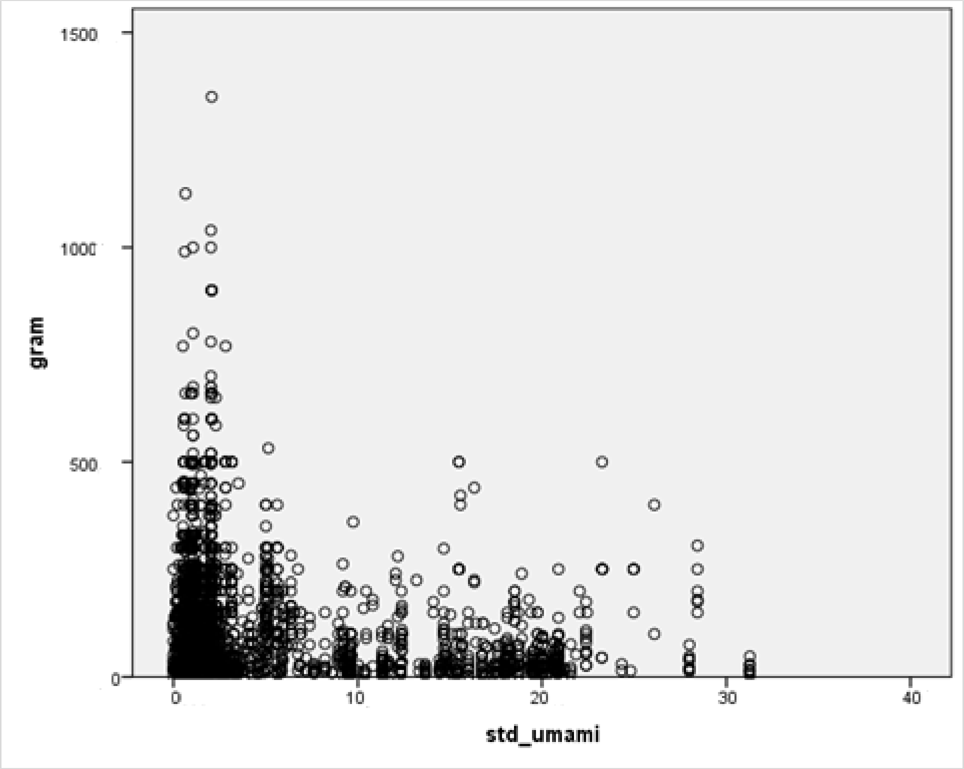
Appendix 13 Dot plot representing the relation between the amount of consumption and the taste intensity of bitterness for Group 2

Group 1



Appendix 14 Dot plot representing the relation between the amount of consumption and the taste intensity of umami for Group 1

Group 2



Appendix 15 Dot plot representing the relation between the amount of consumption and the taste intensity of umami for Group 2

Dominant Taste	Valid Percent 1	N1	Valid Percent 2	N2	χ^2 Value	P Value
Fat	26.8%	1802	27.3%	1332	1.217	0.270
Sweet	**26%**	**1748**	**24.3%**	**1182**	**5.661**	**0.017**
Sour	11.8%	744	11.8%	542	0.160	0.689
Bitter	24.6%	1657	24.6%	1200	0.255	0.613
Umami	0.3%	17	0.1%	6	2.285	0.131
Salt	**11.3%**	**763**	**12.5%**	**609**	**4.684**	**0.030**

Appendix 16 Significant differences between the two groups based on chi-square test for the dominant taste preferences

Dominant Taste	Mean 1	N1	Mean 2	N2	F Value	P Value
Fat	**82.57**	**1802**	**89.09**	**1332**	**3.762**	**0.053**
Sweet	**65.38**	**5989**	**69.81**	**4131**	**5.561**	**0.018**
Sour	**125.98**	**744**	**135.89**	**542**	**4.872**	**0.027**
Bitter	**224.50**	**1657**	**208.41**	**1200**	**6.529**	**0.011**
Umami	288.23	17	208.33	6	1.405	0.249
Salt	72.90	759	71.68	609	0.094	0.760

Appendix 17 Significant differences between the two groups based on One-way ANOVA analysis for the amount of consumtion of each dominant taste